OPERATIVE SURGERY

TH. KOCHER

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Rickman J. Godlee

TEXT-BOOK

OF

OPERATIVE SURGERY

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R. L. Godlee

TEXT-BOOK

OF

OPERATIVE SURGERY

BY

DR. THEODOR KOCHER

PROFESSOR OF SURGERY AND DIRECTOR OF THE SURGICAL CLINIC
IN THE UNIVERSITY OF BERN

THIRD ENGLISH EDITION

AUTHORISED TRANSLATION FROM THE FIFTH GERMAN EDITION

BY

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WITH 415 ILLUSTRATIONS

LONDON
ADAM AND CHARLES BLACK
1911

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TRANSLATORS' PREFACE

No apology is needed for the endeavour to render more accessible to the profession in this country a work on operative surgery by so eminent an authority as Professor Kocher.

The book is essentially a record of the author's personal experience and of his own methods of operation. To avoid an appearance of egotism he has written in the first person plural, and this plan has been followed in the translation.

The first English edition, which appeared in 1895, was translated from the second German edition, while the second English edition, which was twice the size of its predecessor, was translated from the fourth German edition. The present volume is a translation of the fifth and latest German edition.

The amount of new material that has been added, the rearrangement and revision of the text, and the great number of new illustrations introduced have been responsible for an increase of 300 pages. The work now covers the whole field of operative surgery. In the first of the five parts into which the volume is divided, the preparation of the patient, the disinfection of the surgeon and his assistants, the methods of sterilisation, surgical technique, treatment of wounds and anæsthesia have been greatly amplified, local and regional anæsthesia being dealt with at length.

In the second part the surgery of the vascular system has been systematically considered, no less than 106 operations on the arteries being described, while the suture of veins receives full attention.

The third part, dealing with the surgery of the nervous system, has been rearranged as well as largely amplified. The portion devoted to the operations on the brain and cranial nerves has been practically rewritten, and full acknowledgment is given to the work of the present-day neurologists, especially in connection with the removal of tumours and of the Gasserian ganglion. Operations on the peripheral nerves are also described

in a systematic manner, and emphasis is laid on their topography in relation to conduction anæsthesia.

In the fourth part Professor Kocher writes with authority on the surgery of the extremities. Fresh material has been introduced in connection with the operative treatment of paralysis and deformities, while his well-known descriptions of arthrotomies, resections, and amputations have been revised and enlarged. As excision of the wrist-joint has been unaccountably omitted in the German, we have thought it desirable to insert it in the form of an appendix at the end of the book.

The fifth part, which forms the second half of the volume, is devoted to the surgery of the head and trunk. The section on the surgery of the thorax has been practically rewritten, and the recent advances in the treatment of the thoracic viscera receive full attention.

As regards the section of the abdomen, special mention should be made of the chapters on the liver and bile ducts, which have been rewritten and occupy nearly thirty pages of the text. The operations on the intestines, including the rectum, as well as those on the kidney and ureters, have also been dealt with much more fully than in the former editions.

For the time and labour expended in the translation the writers derive no inconsiderable reward from the consciousness that the teaching and methods of so great a master as Professor Kocher will be welcomed not only by senior students and practitioners, but also by all who are actively engaged in the teaching and practice of surgery.

We have much pleasure in expressing our indebtedness to Mr. W. J. Stuart, F.R.C.S. Edin., for kindly assisting us with the translation of some of the more difficult passages, and we again desire to thank Mr. George Stronach, M.A., for the literary care with which he has read the proofs. To Miss A. C. Hutcheson, M.A., we would express our thanks not only for compiling the index, but for much general assistance.

HAROLD J. STILES.
C. BALFOUR PAUL.

EDINBURGH, *February* 1911.

AUTHOR'S PREFACE TO THE FIFTH EDITION

In the prefaces to the former editions of this work on operative surgery I have specially emphasised the fact that the more surgery has become the common property of medical men, the more it is incumbent on any one who intends to devote himself to practical surgery to take every opportunity of improving his technique. This is essential, because any general practitioner of repute may be suddenly called upon to take charge of a surgical department in a country hospital. The responsibility of such a position must weigh heavily upon the conscientious practitioner if he has not had a thorough training as a clinical assistant in a hospital, as he may be required at any moment to decide instantly on a course of action on which may depend not only the future health but even the life of the patient. Unless he wishes to be classed among those who resort to exploratory incisions on all occasions regardless of risk, he must learn how to make an exact diagnosis and to establish precise indications for treatment. This necessitates the stern discipline of a long clinical assistantship. The requisite dexterity in operating is acquired in a shorter apprenticeship to a good practical surgeon.

The possession of these requisites would destroy the favourite arguments of those physicians who are inclined to disparage surgery and belittle its successes. They maintain that the cases are innumerable in which unnecessary and even injurious operations are performed, and they are apt to hold the whole profession responsible for such unwarranted operations undertaken by men of little experience.

Just as the physician is not permitted to write prescriptions without a knowledge of the action and effects of drugs, so the surgeon should not be allowed to perform operations unless he is capable of first making an exact diagnosis and prognosis.

Even if we admit that the surgeon is responsible for the results of his operations, it must never be forgotten that omissions and blunders in the

previous treatment on the part of the public and the physician respectively account for an infinitely larger number of victims than do the errors of the surgeon. The surgeon's task is hard enough, and his difficulties ought to be lessened as much as possible—indeed, we consider it justifiable to raise the question: What particular considerations are due to the surgeon from physicians and from the public? I wish to call special attention to these in the interest of the patients.

1. In every case where there is any question of operation the surgeon ought to be summoned in the first instance for the purposes of examination and consultation. Surely the time will come when cases of ileus will receive operative treatment at once, and will not be left until gangrene of the intestine and perforation make it impossible to deal successfully with the cause of the condition. Every ileus ought to be examined at the beginning by both the physician and the surgeon. If two consultants are unnecessary, it is the surgeon who is indispensable.

A case of acute appendicitis can be easily and entirely cured by an operation on the first day, but without an operation the life of the patient may be very seriously endangered by the rapid supervention of perforative peritonitis. The relations of the patient should therefore be informed at once of the possibility of a cure by operation: it is unwarrantable to omit to call in the surgeon until peritonitis has become advanced. In cases in which carcinoma is suspected, a succession of specialists should not allow the best time for a radical cure to slip away by wasting weeks and months in establishing a diagnosis. The statistics which we shall produce in this book clearly prove that if patients suffering from malignant mischief receive operative treatment at an earlier stage of the disease, an important addition to the number of permanent cures would certainly be obtained.

If suspicious symptoms appear in a case of brain-tumour the general health of the patient should not be reduced by preparations of mercury for several months on the assumption that syphilis exists: it is no use handing the patient over to the surgeon when the operative treatment is certain to fail.

These are all experiences I have had, and I could easily add to them.

2. The choice of where the operation is to be done, as well as the manner of its performance, should be left entirely to the surgeon.

It is no easy matter to arrange all the preparations for an operation so as to ensure complete asepsis. We have made such strides since the days when sepsis prevailed, that when a patient inquires if the operation is serious, we can assure him there is no danger. In the days of sepsis such an assertion would not have been strictly true, even with small operations.

A surgeon cannot guarantee the satisfactory progress of his patient after an operation unless it be done in a place where he can make all his own arrangements, where he can thoroughly depend on his staff, and where he has entire control of all details, such as the previous treatment of the patient, the preparation of ligatures and sutures, of bandages, of instruments, and of everything which comes in contact with the wound ; and lastly, he must be sure of the cleanliness of the assistants' hands.

How often does the doctor write to say that he has prepared everything most punctiliously and that there is no necessity to bring instruments, ligatures, sutures, or bandages. Accordingly, the trusting surgeon arrives and finds that some very necessary instruments are wanting, that there are no drainage tubes, and that the well-sterilised dressings have been handled in such a way that they are no longer sterile.

It has frequently been my lot to see doctors disinfect their hands before an operation almost to the extent of injuring their skin, while the theatre-nurse, after disinfecting her hands, quietly helps the patient to take off his dirty clothes and to place him properly on the operating table. She often wears a regulation dress which quite prohibits a purification in the surgical sense of the word, and when the well-sterilised thread is handed to her, she lets it trail over all manner of towels and articles of clothing.

The surgeon can only guarantee a successful issue in its full sense, *i.e.* aseptic healing, when the patient is brought to his own hospital where he has thorough confidence in the staff and the appliances, and, moreover, where he has authority.

Many times I have bitterly repented having embarked upon a serious operation under conditions over which I had no control, in consequence of having undertaken a distant journey to the patient because his doctors and relations could not make up their minds to let him be moved. If the patient cannot be moved, the surgeon should be allowed to bring his own staff and appliances. I cannot admire those itinerant surgeons who place themselves at the service of general practitioners and offer to operate on their patients on the spot.

3. I have already shown that it is absurd to call in the surgeon when a patient has become moribund, according to the custom expressed in the well-known words of the physician—"The patient is lost at any rate, now we can hand him over to the surgical clinique." And it is equally unwarrantable to call in the surgeon to perform merely secondary operations.

A small carcinoma of the skin will often be excised, perhaps even a small recurrent nodule removed, but directly the growth has spread and deepened the case is thrust upon the hospital surgeon. Or a primary

carcinoma is removed and subsequently the adjacent glands become enlarged; the patient is then handed over at this late stage to a surgeon who has to perform an operation which was plainly indicated at the beginning.

How frequently a tuberculous abscess is merely incised, with the result that mixed infection from staphylo- and streptococci arises. The prognosis is now fundamentally altered and only at this late period is the surgeon called upon to remove the disease from its foundation.

In order to participate fully in the benefits of surgical therapy, doctors and surgeons must regard the smallest operation as an important matter, and must give it the most careful consideration. There is no objection to a general practitioner performing an operation himself, but if he is not quite clear as to the possible results his conscience ought to lead him to consult any experienced surgeon in order to gain a clear idea of the indications, dangers, and technique of the operation. Young general practitioners who are fresh from the examination room undertake cheerfully quite big operations simply because in the clinic, they have seen the largest wounds heal uninterruptedly under aseptic treatment, and because they have observed how regularly a simple abdominal or appendix case, or even one of goitre, can be dismissed after eight days. They have had too little opportunity of realising that such an uninterrupted recovery is dependent on certain definite rules which must on no account be broken.

It is the aim of this work on operative surgery to bring these fundamental principles to the knowledge of the medical profession: physicians and surgeons must, however, co-operate if the best results are to be obtained. In our opinion, the doctor is most to be commended who establishes a correct diagnosis at once, and, regardless of other considerations, sends his patients for early operation to the place where there is the best prospect of a permanently successful result; he can then consider that he has been the chief cause of the success, and he is certainly much more to be congratulated than the man who cannot resist the temptation of trying to prove his ability as an operator under conditions where the requisites for success are unattainable.

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ERRATA

Page 22, Fig. 8, *for* "basilic v." *read* "post. ulnar v."
Page 25, Fig. 11, *for* "post. tibial n." *read* "int. popliteal n."
Page 162, *for* description of Fig. 72 *read* description of Fig. 73, and *vice versa.*

GENERAL CONSIDERATIONS

INTRODUCTION

Compared with that of former times, the practice of operations on the cadaver has become a less important factor in the education of the surgeon in operative technique. Such practice must be supplemented by a thorough knowledge of operations on the living subject. But even that is not invariably sufficient, as a practitioner during an operation cannot satisfactorily discuss all the features of a case and the sometimes intricate details of the technique in an ordinary or even difficult emergency.

This want can be supplied by text-books. A text-book on operative surgery should include all that can be gathered from practice on the cadaver, and all that can be observed during operation on the living subject. It should, in addition, discuss the indications which point to the necessity of this or that operation, decide the choice of method, and, finally, explain the conditions which tend to secure a good result from operative interference.

We do not altogether share the opinion that operative training on the cadaver can be neglected by the clinical surgeon and relegated to a tutor with but little experience in operating. The performance of operations on the cadaver affords an excellent method of revising topographical anatomy, and is specially valuable to the student when supervised by an operator who is also an experienced clinician.

Some anatomists deserve the credit of having lost no opportunity of inculcating surgical anatomy in their text-books; but one feels that the pure anatomist may go too far in this direction and attempt to take up points which can only be dealt with by one possessing a practical experience of surgery. The interest of anatomists in surgical matters would meet with greater appreciation if they would enter into anatomical detail more fully than has hitherto been the practice.

Surgeons nowadays require a more accurate description of the course of the vessels and nerves than is contained in the majority of anatomical handbooks. At the present time we are called upon to do more than simply expose an artery at the seat of election for the purpose of ligaturing it. The veins, too, have to be ligatured, sutured, or excised. It is necessary also to possess an accurate knowledge of the course of even the smaller nerves, of the layers in which they lie, and of the regions in which they are distributed, as it is by injection into the nerves that local anæsthesia (conduction) is obtained.

The position, relations, and attachments of the organs are far too superficially studied by anatomists for us to content ourselves with descriptions from that source. It is, for example, still an undecided question how the normal kidney is held in position. This is surely a subject of inquiry for anatomy to decide first of all.

The surgeon must fall back on his own resources in determining the incisions which will produce least harm in opening into joints or in exposing some deeply-situated structure. Anatomical text-books give us little or no help in this matter, a manifest reason why there is still such a multiplicity of methods in use, all of them aiming at the same object. There is surely only one method that can be the best, namely, that founded on anatomical and physiological grounds. In this

work we shall restrict ourselves to describing certain operations as typical. We do not intend to compare all the alternative methods, merely because they have a famous man as sponsor. A young surgeon who has mastered the anatomical and physiological principles on which operative surgery is based, can readily draw his own conclusions as to the merits of different methods authorised or preferred by experienced surgeons, if he watches them operating on the living subject.

It is a very serious matter for patients if a junior surgeon disregards the necessity for method in operating. In operations on the face we have seen incisions used which damaged the facial nerve and inflicted on the patient an unnecessary lifelong disfigurement.

As we pointed out in the preface, it is even more reprehensible to undertake an operation without having established definite indications and instructions for its performance. Apart from giving an accurate description of individual operations, supplemented by intelligible illustrations, we consider it one of the chief requirements of a text-book of operative surgery to afford full information on this point. Young practitioners often come straight from a course of operative surgery on the cadaver—generally a cram-course before an examination—without the slightest knowledge of the conditions which call for the performance of an operation.

SECTION I

GENERAL RULES

A. PREPARATION FOR OPERATION

(a) The Preparation of the Patient

It is evidently not the practice everywhere to prepare patients before operation, but it is certainly not always advisable to operate on the patient the day after admission. We were once consulted by a lady who informed us that ovariotomy had been performed on her twice, and that on each occasion she had made a very rapid recovery. She was suffering from an abdominal swelling of recent development. When we pointed out that it would be necessary to make a careful examination of her, and that she would have to be properly prepared for the operation, she became so impatient that she consulted another surgical authority, who next day performed a laparotomy. Within twenty-four hours we were present at the autopsy. It was found that she had been suffering from cirrhosis of the liver with ascites, and that there were extensive intestinal adhesions as a result of the previous "ovariotomies." The bowel had been incised. Both ovaries were found to be intact! She had thus been three times subjected to exploratory operations. This is an example of what may result from undue haste in operating on an importunate patient.

1. **Preparation to be carried out in the Ward.** Our ward staff are provided with printed instructions regarding the preparation of patients for special operations; and general instructions insure that every patient is properly prepared for the administration of anæsthetics, the prevention of accidents, and the conduct of an aseptic operation.

(1) Every patient should be made to take a bath, and submit to a thorough wash with soap and warm water. The head should not be omitted from the cleansing process, and the skin in the region of the operation should also be shaved.

There is no reason why every patient should not have the benefit of a vigorous cleansing from head to foot in the surgical sense of the term. If he is accustomed to pay attention to the skin in the British manner, he will be interested to know that his habits are in accordance with the methods of aseptic surgery. On the other hand, those who have always regarded washing as superfluous will find themselves quite rejuvenated after the unusual experience of a bath.

When the whole body has been surgically cleansed, there should be no trace of dirt about the scalp, nails, mouth, throat, or genitals. This washing process, which is carried out in a warm bathroom on the day before the operation, is to be preferred to the practice of some surgeons who apply antiseptic poultices to the skin at the site of operation. We regard the latter treatment as not devoid of danger, as poultices may give rise to skin-irritation and eczema. It is sufficient to wash the infected part

with soap and water, then with ether and alcohol to remove the fats, as an aseptic dressing has to be subsequently applied.

Antiseptic treatment of the skin is to be brought into operation when the skin is the seat of an eczema or other form of skin eruption. In these circumstances it is obvious that the wound cannot be treated on aseptic lines, and antiseptic treatment must be resorted to throughout. It is impossible to make an unhealthy skin aseptic in a short space of time.

Special care must be taken in cleansing parts of the body covered with hair, as shaving and scrubbing with a brush are indispensable aids.

(2) All accessible mucous membranes must be subjected to a process of direct cleansing similar to that applied to the skin.

Mechanical cleansing is of primary importance. Special attention must be given to the buccal and nasal cavities. All sordes and tartar must first of all be removed from the teeth, as otherwise it is impossible to keep the mouth clean. This performance may be undertaken by a dentist. The repeated use of a tooth-brush with soap and warm water is sufficient to cleanse the teeth, and prevent fur from accumulating on the tongue and gums. If an antiseptic must be used, salol or a weak solution of carbolic constitutes a suitable wash for the nose, mouth, and throat. Stronger solutions, by inducing excessive secretion, may do more harm than good. Crusts in the nostrils and deposits on the tonsils must be removed and the parts painted with iodine.

The disinfection of the mouth is a matter of so much importance in the prevention of pneumonia from aspiration during anæsthesia that it should never be neglected.

Besides the upper air and alimentary passages, the vulva, vagina, and rectum must have attention paid to them. All discharges should be removed by washing with soap and water, or alternatively by swabbing with a weak solution of lysol. Subsequent soiling can be prevented by repeated irrigation with warm water previously boiled, or with a weak aqueous solution of lysol.

There should be no difficulty in making the patient understand that the cleansing must not be made illusory by inoculating the prepared region with possibly infected hands.

No patient should come to an operation with a full bladder or rectum. On the morning of the operation a warm soap and water enema should be administered : the patient should empty his bladder, and when necessary a catheter should be employed.

(3) The intestinal canal must be emptied. The bowels, however, should not act more than twice in the twenty-four hours previous to the operation.

Many surgeons dispense entirely with preliminary purgation. The reason for this is quite intelligible. The worst condition of all is when the patient is suffering from an artificial diarrhœa at the time of operation. It has been shown that when an aperient is given the number of bacteria increase as the intestinal contents become more liquid, while they only diminish in a material degree with the abatement of the diarrhœa. It is important, therefore, that the action of the purgative should have ceased by the day of the operation. Soiling of the body will thus be avoided.

Two days before the operation the patient is given either 1 to 2 tablespoonfuls of castor oil or a dessertspoonful of natural Karlsbad salts in a glass of warm water. The nature of the subsequent diet is important : it should consist of meat rather than eggs. Fluids may be freely taken. Vegetables and carbohydrates (with the exception of sugar) are to be avoided. In adults we allow practically no milk, as it produces copious stools. In operations on the alimentary canal, it is safer for some time previously to limit the diet to artificial foods such as tropon, or fluid somatose.

When the intestine has been emptied as far as possible, an intestinal antiseptic should be given to limit decomposition and gas formation. We prefer subnitrate of bismuth (6 gr. six times daily). This imparts a black colour to the motions, and removes the offensive smell in a remarkable manner.

2. Preparation by the Medical Attendant. (4) A thorough examination must be made of the respiratory organs, and special attention should be given to the treatment of any existing bronchitis.

The lungs, if already the seat of bronchitis, are only too liable to develop broncho-pneumonia. The aspiration of solid substances and bacteria during anæsthesia, the influence of the ferments of hæmorrhage, small emboli, or finally impairment by the anæsthetic of the epithelium of the lung, individually or collectively, tend to the production of this condition—broncho-pneumonia,—which not infrequently proves fatal. If the operation cannot be postponed till the bronchitis is cured, it is advisable to administer creosotal. Our former assistant, Dr. Rollier, who has carefully investigated the action of this drug for some years, has shown that it prevents complications and acts beneficially on the course of a pneumonia.

We do not hesitate to give large doses of creosotal when necessary. $2\frac{1}{2}$ dr. may be administered night and morning in the form of an enema with milk. The dose has occasionally to be increased to one ounce at the onset of pneumonia, followed by a stimulant such as camphor-benzoate.

Sluggishness of the pulmonary circulation, which does not yield to treatment, is one of the worst complications as regards the anæsthetic and adds considerably to the risk of an operation. It is dealt with in the following summary :—

(5) Preparation as regards the circulatory system. The importance of the condition of the heart with regard to the administration of an anæsthetic is known to every surgeon ; but there is considerable diversity of opinion as to the application of the anæsthetic. Many practitioners do not hesitate to anæsthetise a patient who is the subject of heart disease, because they have found such patients inhale the anæsthetic innocuously ; and it is a matter of common occurrence to find that patients affected with valvular disease of the heart and irregular cardiac action can undergo an operation with as satisfactory results as those who are physically more fitted for the ordeal. Everything depends, however, on the extent to which the heart is competent to cope with any increased demands which may be made on it, additional to that exerted by the action of the anæsthetic and possibly that of the antiseptics. A cardiac examination to ascertain if the increased strain is able to be met is of no little importance.

When a heart lesion is fully compensated, and a moderate amount of exertion fails to excite any untoward symptoms, operative interference can be safely undertaken under a general anæsthetic. Marked venous congestion, even without any discoverable cardiac lesion, indicates a much more serious condition. We have not infrequently seen cases, for example, of obstruction caused by enlargement of the mediastinal glands producing signs of œdema of the lung by interference with the pulmonary and general circulation.

Katzenstein[1] has described an effective method of testing the function of the heart prior to operation. He puts a considerable force of resistance in the course of the circulation and observes the resultant effect on the action of the heart. In a normal heart, the functional activity is maintained without any increase, usually with a decrease, in the heart's contraction. Insufficiency, on the other hand, is shown by an increase in the pulse-rate with a fall, instead of a rise, of blood-pressure after compressing both external iliac arteries at Poupart's ligament for a space of from $2\frac{1}{2}$ to 3 minutes.

We had once an interesting case of atheroma of the coronary arteries in a woman who suffered great distress after sudden movements, and died suddenly a week after she had been submitted to examination. Here the insufficiency of the heart muscle was indicated by a marked diminution in the pulse-rate whenever the patient raised herself in bed on several occasions. In Basedow's disease it is a frequent and noteworthy symptom to find a considerable increase in the pulse-rate when greater demands are made on the heart.

Considerable alteration in the frequency of the heart's contractions under increased strain affords a valuable means of forming an opinion on the efficiency of the action of the heart, in cases of dilatation, in cases with toxic changes in the heart muscle, in Basedow's disease, and in infective diseases, in cases with atheromatous changes in the coronary arteries and their results, and especially in cases distinguished

[1] *Deutsche med. Wochenschrift*, 1904, 22.

by the presence of fatty heart. A practitioner not infrequently sees death occur with unaccountable rapidity in connection with somewhat prolonged anæsthesia and severe operations in stout people, chiefly as the result of impairment of the heart muscle by poisons and ferments both during and after the operation.

The Riva-Rocci apparatus is an indispensable means of estimating the blood-pressure. When it is applied during rest as well as after exertion, an even better indication is obtained of the efficient action of the heart. By the simultaneous use of the Riva-Rocci apparatus and the sphymograph we find the average pressure in robust individuals corresponds to 150 mm. Boari[1] puts it at 120 to 140 mm. In any case a blood-pressure over 160 mm. is to be regarded as high, and one below 110 mm. as the reverse.

The use of the Riva-Rocci instrument not only gives us valuable information regarding the strength and resistance of the heart but also indicates the state of the vasomotor centre. We have twice seen patients with slight manifestations of Addison's disease die suddenly, where a preliminary estimation of the blood-pressure might have induced the surgeon to pause in his endeavour to bring the operation to a successful issue.

The condition of the veins must also be examined before an operation is undertaken, so that sudden accidents from this source may be prevented. Careful attention must be paid to varices and thromboses in the lower extremities, as the production of thromboses and emboli is assisted by the action of the anæsthetic, the fixation of the patient during the operation, and the position subsequently assumed, as well as by the action of blood ferment and other poisons.

Lennander has emphasised the necessity of elevating the legs in the cases we have instanced. It is even more important to see that constriction of the lower extremities by straps is avoided and that the legs are not allowed to be left in suspense during the operation. The legs must be massaged while the patient is in bed, and completely swathed in firm flannel bandages before a foot is allowed to be put on the ground.

(6) Preparation with reference to the function of the urinary organs. We have already alluded to the necessity of the nurse observing that every patient's bladder is emptied before operation.

The efficient action of the kidneys must also be estimated by cryoscopy of the blood and urine. Since Koranyi's important discovery, this is recognised as an essential item in surgical operations.

The kidneys play so important a part in the elimination of all poisons present in the blood during or after operation, even if they are only due to the anæsthetic or derived from the absorption of effused blood in a purely aseptic case, that the assurance of the patient's progress to recovery can only be certified when the kidneys are found to be acting efficiently. A thorough examination of the urine must always be undertaken by the assistant before every operation.

It is advisable to stimulate the kidneys by administrating fluids by the mouth, and by subcutaneous or rectal injections of normal saline, in order to ensure a rapid excretion of the toxic products that have been set free in the tissues as the result of the operation or the matter administered.

(7) Lastly, there are a few general conditions which must be regarded as contraindications to operative interference.

Besides such pathological conditions of the blood as pernicious anæmia and leucæmia, diabetes, Addison's disease, the status thymicus and lymphaticus are some of the most frequent causes of sudden accidents after operative interference. In these cases the operation can only be safely undertaken after the patient has undergone prolonged treatment specially adapted to the condition, *e.g.* the treatment which has been carefully studied and described by Kausch for diabetes (pushing sodium carbonate till the reaction of the urine is alkaline) which, *mutatis mutandis*, is no less indicated in certain anæmias, Addison's disease, Basedow's disease, and status lymphaticus.

[1] *Gazz. d. osped.*, 1902.

(b) Preparation of the Operating Room

The surgeon will be saved every difficulty if he follows our advice and operates only in well-appointed rooms. It is, however, advisable to consider what should be done when one has to operate in a room which is used for other purposes.

(1) The room must be completely cleared of all pieces of furniture (including the chandeliers and curtains) which are not required for the operation. All articles that cannot be removed, *e.g.* stoves, fireplaces, etc., must be covered with large damp cloths. The floor and walls are to be washed with soap and hot water and the ceiling is to be whitewashed. After satisfactory ventilation and purification have been ensured, the room should be closed till the performance of the operation.

The disinfection of a room preparatory to operation may have far-reaching results. No one would ever select a room in which there had been a case of infectious disease. Disinfection of the walls with sublimate, carbolic, or formol necessarily gives rise to vapours which must act injuriously on the patient during a long operation.

We were once asked to operate in a room which had been so thoroughly disinfected with formol that it was almost impossible to breathe in it even after a thorough course of ventilation. The effect of such an atmosphere on the lungs of an anæsthetised patient can be well imagined.

Mechanical cleansing is all that is required, but it must be of a thorough nature. For an ordinary room, scrubbing with soap and hot water, or with bread (Esmarch), is more effective than disinfecting with corrosive sublimate. The chief matter for attention is that no dust should be left which can be disturbed and fall on the operating table or dressings. It is therefore sufficient if the tables and chairs which are to be used are washed with soap and hot water. Disinfection by means of antiseptics is only harmful. Before any piece of furniture is brought into use it must be completely covered with sterilised towels.

One thing must be understood, and it is this—the room is to be emptied, thoroughly washed from corner to corner, including all cornices, ledges, etc., and must be then closed.

(c) Preparation by the Assisting Staff of the Materials required for Operation

The knowledge that all infective germs can be destroyed by sufficient boiling, and that all materials which have been effectively boiled are rendered sterile for surgical purposes, has enormously simplified the preparations for an operation.

The nurse who is entrusted with the preparations has to be informed that all the materials which are to be used in an operation are to be previously boiled for a time ranging from ten minutes to two hours, or, as an alternative, are to be placed in a current of steam.

(1) In the first place a large number of sterilised cotton sheets are necessary, a number sufficient to cover completely all the furniture in the operating chamber.[1]

If one is not sure that, in spite of washing, dirt will not be forced through, "impermeable" washed in lukewarm water must be placed under the cloths.[2]

Similarly the clothing both of the patient and of all those taking part in the operation must be cased in sterile coverings so that only those parts—such as arms, hands, and face, which can be thoroughly washed, are left uncovered. In operations about the head and face, the scalp and beard must be shaved, so that no hair can come in contact either with the instruments or the wound. The scalp should be covered with a boiled rubber cap over which a sterile bandage should be applied, to prevent any hair from appearing round the edges.

[1] Our large cotton cloths and cloaks, when not sterilised by steam, are boiled for an hour and a half in water which has already been boiled for half an hour. After use they can be immediately washed out in tepid water, then in soap and water, and then in soap and soda lye, and boiled in this for half an hour, washed out with hot water, then with cold water, and afterwards dried.

[2] "Impermeable" does not withstand the action of hot water.

The patient's face must be concealed by means of a screen (Fig. 1), *i.e.* a cloth suspended from a nickel-plated hoop such as we first introduced for use in goitre operations. "Drop" infection (Flugge) is thereby prevented should the patient vomit, cough, or sneeze. The most effective screen is composed of cloth, lined with wadding, so that no deleterious matter can obtain an entrance. This is as important a precaution as enveloping the head and face of the surgeon in a mask like that of a Turkish woman. An operative mask is only effective when the mouth is covered with a layer of wadding (Mendes de Leon[1]). If the surgeon is suffering from a cold, he should protect his nose and mouth effectively with wadding (Leon's helmet).

We have often been interested in watching an operation where the surgeon was covered up to the eyes, while his assistants, who were charged with the supervision of instruments, swabs, and ligatures, and for whom surely masks were still more necessary, were unprovided with so important a paraphernalia. In such a case it is

Fig. 1.

plain that the risk of infecting the wound by speaking or coughing has not been properly appreciated.

(2) All compresses, swabs, and bandages which come in contact with the patient, as well as the gloves of the operator and his assistants, must be boiled for an hour and a half, or sterilised by steam, previous to the operation. They should be boiled in small separate bundles, only to be opened immediately before use. Swabs and muslin compresses should be boiled in ·75 per cent physiological salt solution.

The operation sister should be trained to pack the bundles so that, by simply unfolding the wrappings immediately before the operation, the contents can be spread out at once in proper order on an aseptic surface. The sheet for spreading on the tables should be packed on the outside of the bundle, which contains separate packets of large and small gauze dressings, swabs, gloves, drainage-tubes, threaded needles, and instruments.

[1] Langenbeck's *Archiv*, Bd. 72.

(3) The necessary instruments are sterilised in a separate compartment of a Schimmelbusch or other steriliser (Braatz, Skirving), and previous to use are laid out on the sterilised cloths, with the basins at hand. The knife is wrapped up so as not to blunt the edge.

When one has no special apparatus, the instruments are wrapped in gauze and packed like the dressings, so that they may be properly laid out when the coverings are undone. The instruments, which should be kept entirely free from dust, are best boiled in a 2 per cent soda solution or in 2 per cent solution of borax, the latter treatment, however, causing a white deposit to appear on them. If they cannot be removed from the steriliser immediately before the operation, the instruments should be left wrapped in the gauze in which they were boiled, or the outer wrapping should be further covered with sterile gauze. After an operation the instruments must be washed in soda and water, afterwards in hot water, and finally dried.

The knives, which ought to be made perfectly smooth, may be simply immersed in strong lysol, washed in absolute alcohol, and dried with sterile gauze.

(4) Sutures, after having the fats removed by soaking for twelve hours in ether and twelve hours in alcohol, are boiled for five minutes in a 1 per cent solution of perchloride of mercury, loosely wound on spools with clean hands protected by sterilized towels, and placed in fresh perchloride in which they are again boiled for ten minutes before use. Glass is cleansed with absolute alcohol. The sutures are best left in the solution in the glass vessel in which they were boiled. To avoid the trouble of threading needles at the operation, they may be threaded beforehand, arranged in order, and wrapped up in one or two layers of sterile gauze. They are again boiled for a minute in perchloride, and are then laid on the table still wrapped in the gauze in which they were boiled. The operator himself unrolls the gauze and takes the threaded needles one after another as they are required. Ligatures may be dealt with in a similar manner.

Every theatre nurse must be taught that she may only handle sutures with perfectly clean hands and sterilised gloves. It is difficult to thread needles with rubber gloves.

The surgeon and his assistants must exercise equal care, and never handle the sutures without putting on gloves; boiled rubber gloves with cotton gloves over them are the most serviceable.

(5) Drainage-tubes, like the sutures, are boiled for ten minutes in 1-1000 perchloride, in which solution they are retained and from which they are lifted direct previous to use. When this is not practicable, they should be wrapped in gauze before the operation and boiled or steamed for one minute. The surgeon himself then unrolls the gauze and lays it on the sterilised sheet covering the table.

(6) Preparation of sterile physiological salt solution. A ·75 per cent salt solution is prepared beforehand by boiling for an hour in a kettle with an overhanging lid. If there is no suitable vessel at hand for preparing large quantities of solution, the apparatus in which the saline has been boiled must be rendered dustproof by an immediate covering of boiled cloths. Part of the saline should be prepared some time beforehand and allowed to cool, so that the lotion may be used at a proper temperature.

If no suitable apparatus fitted with a stop-cock is available, a ladle with which to serve the lotion must be boiled and kept immersed up to the handle.

B. THE BEGINNING OF THE OPERATION

(d) The Position of the Patient

All well-appointed clinics and hospitals are now furnished with operating tables the segments of which can be raised or lowered so as to alter the position of the body. Many tables, however, do not always fulfil the equally necessary condition of placing the patient in a comfortable position.

To attain this end, it should be possible quickly and easily to secure the legs above the knees, to place the arms and hands close to the body and fasten them securely without hurting the patient. This position of the hands and arms is specially advocated by Rothe of Breslau in order to prevent anæsthetic paresis, and we agree with him that it is advisable that the arms should not be fixed above the head.

In addition, the Trendelenburg position must be readily available, for in many laparotomies it is necessary to displace the intestines upwards towards the diaphragm. This is the chief value of the Trendelenburg position, but there are other important points in its favour.

During anæsthesia, when laryngeal reflex is abolished, it is of importance to prevent saliva, blood, and other extraneous matter from being conveyed into the lungs. All fluids should gravitate to the pharynx and mouth, from which they can readily escape or be removed. Elevation of the pelvis is therefore of special value in preventing aspiration pneumonia in operations in the region of the mouth, pharynx, nose, and larynx.

The Trendelenburg position has the additional advantage of preventing cerebral anæmia when the blood-pressure has been reduced either from severe loss of blood or by the use of an anæsthetic such as chloroform. Its advantages are so evident that the Trendelenburg position has frequently been overdone, especially by gynæcologists.

One occasionally sees the position adopted in operations with the patient suspended almost vertically. Kraske has drawn attention to the dangers of so exaggerated a Trendelenburg position. That a man cannot be expected to stand on his head for half an hour to an hour without his circulation being seriously affected is obvious to any one who has a knowledge of the mechanics of the circulation, and who has witnessed the copious venous hæmorrhage associated with a dependent position of the head, as in Rose's operation.

Kraske instances two cases of death occurring from strain thrown on a heart already weakened as the result of myocarditis, without the use of chloroform. Eiselsberg and Duhrssen have also observed apoplexy result from the employment of the high pelvis position. An operator must therefore be careful not to elevate the hips without due consideration in patients who are obese, or who have disease of the heart or vessels (arteriosclerosis). Such patients, apart from those under operation, can often obtain sleep without respiratory embarrassment only when the head and shoulders are elevated.

Further, in obese persons, Kraske has pointed out that the fat-laden omentum may slip upwards, and by interfering with the portal circulation give rise to hæmorrhage into the stomach. It may also be responsible for intestinal obstruction by dragging on the colon, of which he has seen one fatal case. The omentum should always be replaced after a laparotomy even when the patient has been occupying the ordinary position during operation.

The position in which the shoulders are raised and the feet lowered is of less frequent necessity. We regularly employ this position in operations on the thyroid, while Horsley recommends it for operations on the skull and brain, its object being to diminish the hæmorrhage from the veins in the head and neck.

Elevation of special parts of the body is frequently of great assistance during operations, especially those on the gall-bladder, stomach, and pancreas, when the epigastric region is raised, and in kidney operations, when the loin is elevated.

Proper precautions must always be taken to keep the patient's body warm, for which purpose we use a table heated by hot water. Krönig conveys heat directly to the patient by means of sixteen electric lamps placed under the operating table. Henle has shown experimentally the prejudicial effect produced by cooling of the body during an operation.

To avoid this loss of heat by overheating the scene of operation as was formerly done cannot be recommended, because there is too great a variation in the temperatures of the operating room, the corridor, and the bedroom. It is also inadvisable for the surgeon and his assistants to operate in an atmosphere charged with moist heat like that of a Turkish bath.

An operating table must satisfy the following conditions:—To warm the patient directly; to change rapidly the position of the whole or of special parts of the body; to prevent the constriction of any part of the body, especially of the lower extremities; and lastly to give comfort to the patient.

The position of the patient after operation will be considered in the chapter on after-treatment.

(e) Asepsis of the Patient and Operators. The Final Cleansing

The following recommendations apply only to those who enter the operating room as scrupulously clean as if they were entering a drawing-room. The patient is prepared the day before the operation as we have described. The surgeon and his assistants have already bathed and washed and guarded themselves from all possible sources of infection. Everything necessary for disinfection must be carried out previous to the operation. The operator and his assistants must disinfect their hands immediately after contact with infective matter, such as fæces, mucous secretions, saliva, etc., which should be effected before the hands become dry by immersing them in an antiseptic, and afterwards washing them thoroughly with soap and water.

This is the explanation of our dictum that gloves should be worn in the intervals between operations and should be removed before an operation, by which means contact with infective matter will be prevented. But when such matter has touched the skin, it must be removed immediately and thoroughly.

With these precautions, the final cleansing is initiated by washing all parts of the body that are left exposed, especially the face, eyebrows, beard, and hair. The teeth must be brushed with soap and water, and the mouth, pharynx, and nose syringed with sterile water or a weak antiseptic ($\frac{1}{4}$ per cent carbolic). The hands and arms are again washed with soap and water, and then scrubbed under a somewhat warmer stream of water, without the soap.

The chief fault at this stage is that sufficient care is not ensured that the assistants, nurses, and the patient are as thoroughly purified as the surgeon himself. It is not sufficient to purify the patient's skin only in the area of the operation: every part that is not entirely covered must be as carefully cleansed. Further, it is remarkable how many people at the present day refuse to be convinced that dirt can be really and readily removed by means of simple running water.

In conclusion, the reprehensible practice of using nail-cleaners must be abandoned. The nails can only be thoroughly cleaned when they are cut so short that there is no recess between them and the pulp of the finger. It is then as easy to clean them with a nail-brush and soap as it is to wash the rest of the hand.

When the hands have been thoroughly scrubbed with a nail-brush and soap under a stream of warm water, they are afterwards washed and scrubbed in warm sterile saline solution, and finally cleansed with alcohol, which removes fat, and which, as K. Fett[1] has shown, has a more penetrating action than watery solutions. By the drawing of a swab soaked in ether over the skin, even after it has been thoroughly washed with soap and water, a stain will always be found on the gauze. It is more advisable, therefore, to cleanse the patient's skin with ether after it has been washed with soap and before alcohol has been applied. The surgeon's hands should be thoroughly scrubbed with a brush in 85 per cent alcohol (Ahlfeld uses 96 per cent, while Leedham Green recommends 70 per cent as the most useful strength), after which they should be dried with sterile gauze. The hands should not be washed in sterile water after the ether and alcohol have been used, as the process interferes with the action of the alcohol. Fig. 2 illustrates the stand we have used for many years, which enables us to do our necessary ablutions under a stream of alcohol and sterile water. We would direct attention to the small rubber caps attached to the upper jars, which are slipped over the stop-cocks when they are

[1] *Zeitschrift f. Geburtshilfe*, Bd. 47.

opened and shut. The brushes, like the rubber caps, are kept immersed in 5 per cent carbolic solution in one of the three basins.

Antiseptics do not come under survey in an aseptic operation. They are no more effective than the method of cleansing we have described, and they are often responsible for their toxic effects and causation of eczema. Soaking the skin of the patient and of the operating staff in corrosive sublimate, carbolic, or iodine is only to be adopted when previous preparation has been omitted, or when the disinfection is considered to have been incomplete. This will be discussed in a later chapter.

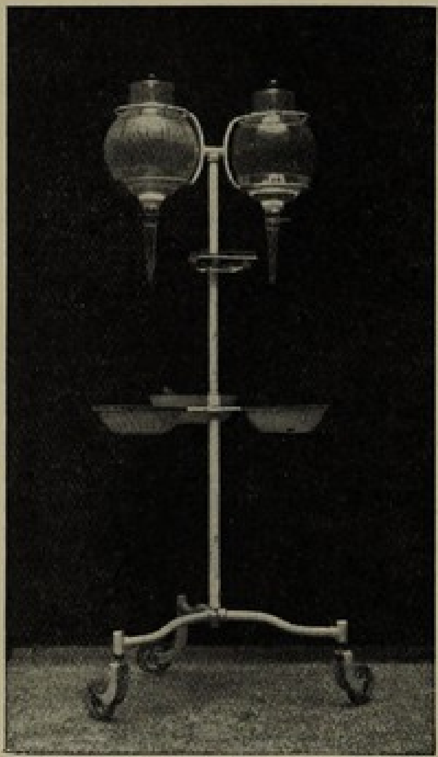

FIG. 2.—One of the glass vessels contains five litres of warm sterile saline solution, the other is filled with 85 per cent alcohol. Each has an empty basin under it. The third basin contains the nail-brushes in 1·20 carbolic solution. In the small dish, the rubber caps, which are fitted over the glass vessels, are kept in 1·20 carbolic when not in use.

During the course of the operation the hands should be frequently dipped in warm sterile water to remove any blood, and washed in 50 per cent alcohol. If the latter solution is too strong and affects the skin, 25 per cent alcohol, as proposed by Schlaffer, may be used instead, the hands being afterwards dried with sterile gauze.

It is necessary to use corrosive sublimate, carbolic, or lysol only in case of the hands becoming infected with pus, the contents of viscera (fæces), or secretion from a mucous membrane. Then, the employment of an antiseptic is necessary, but it must always be afterwards removed from the hands with sterile water. As it is impossible to foresee such cases of infection, it is advisable to protect the hands with rubber gloves, which can be dipped in an antiseptic from time to time and then rinsed in sterile water.

Whenever a ligature has to be applied, it must only be handled with sterilised gloves. Cotton gloves are useful for this purpose, and are much more pleasant to work with than those made of rubber, especially when the fingers have to be utilised for inserting the needle. The gloves should be donned after the bleeding has been arrested and the hands have been cleaned. By this means the ligature is prevented from coming in direct contact with the skin of the surgeon or that of his assistants.

(f) Anæsthesia

1. *General Anæsthesia.* It is assumed that a thorough examination of the patient has been made prior to the administration of a general anæsthetic. If there are any contraindications to a general anæsthetic, local anæsthesia must be employed, or if the former has to be administered, the attendant risks must be carefully considered. All conditions in which the circulation or respiration is seriously affected are to be regarded as contraindications.

Mikulicz[1] has given an admirable account of these conditions. His views and ours are in complete correspondence. General anæsthesia is dangerous in all cases of heart disease where the efficiency of the cardiac muscle is seriously impaired. Cardiac

[1] *Deutsche Klinik*, 1901, von Leyden und Klemperer.

lesions that are fully compensated, and functional disorders are not so dangerous as a fatty degeneration of the heart with myocarditis and a weak irregular pulse.

We would lay more stress, however, than Mikulicz does, on the dangers of those conditions of the heart and lungs which are associated with chronic venous congestion, accompanied by œdema and cyanosis. Included in these are certain cases of dilatation of the heart, especially of the right side, marked emphysema, narrowing of the thoracic cavity by tumours, effusions, and notably empyema. Further, a general anæsthetic is dangerous in all conditions in which the blood pressure is seriously reduced, *e.g.* in Addison's disease, severe anæmia, and an advanced stage of Basedow's disease.

Auto-intoxications and general disturbances of nutrition are contra-indications to the introduction of a new poison in the form of the anæsthetic. Sepsis, by producing fatty changes in important organs, must receive particular consideration in this respect. Diabetes, Basedow's disease, the status thymicus and lymphaticus, as well as all renal conditions characterised by a diminished excretion of urinary solids, are cases in which a general anæsthetic involves a certain amount of risk.

In short, a general anæsthetic should not be administered if the patient is suffering from any serious impairment of the circulation or respiration, or from a toxaemia, either of an acute or chronic nature.

If attention be paid to the above contraindications, and care be taken to see that the stomach is empty,[1] and the patient's body kept warm, anæsthesia with ether (if we assume it is properly administered) presents no risk of an accident. The result may be otherwise with chloroform, however. Not long ago we were asked to operate by one of our colleagues, an able and busy practitioner, who, in spite of our objection, insisted on giving the patient chloroform, because in all his long experience he had never had a death resulting from its administration. The patient, however, died before the commencement of the operation.

Yet in many places chloroform is almost exclusively employed. In a small town where we had a recent operation, the use of chloroform had to be resorted to, as there was no practitioner at hand who had any knowledge of ether administration.

Inexperienced anæsthetists are inclined to give too much ether, while debarring the admission of a necessary amount of air. We hold with Mikulicz, Hofmann, Sudeck, Koblank, and others, that the suffocation method of giving ether should be abandoned in favour of administering it in small doses with free access of air. The disadvantages accompanying the administration of ether, such as excitement, cough, and severe salivation, will then disappear.

Given according to Hofmann's drop method, *i.e.* where it is dropped on a mask simply covered with gauze (with no waterproof material), the administration of ether becomes as easy as that of chloroform. Sudeck has shown that ether intoxication [2] is by this means rapidly produced, and that during this period of analgesia, which appears before the stage of excitement and previous to the complete loss of consciousness, a minor operation can readily be performed. Sudeck recommends the use of Czerny's mask, which consists of a cylinder open at both ends with several layers of flannel stretched across it, into which are poured 1 to 1½ ounces of ether. The patient is requested to make deep inspirations, and the mask, to which a pneumatic face-piece has been attached, is placed over the nose and mouth, when after a few inspirations the intoxication stage occurs. By this method, however, a very small quantity of air is at first admitted, so that the question arises as to whether asphyxia, to some extent, is not produced. When the stage of excitement appears, the mask should be at once removed, at which stage Kronecker takes the mask away and begins the operation.

[1] It is absolutely necessary to empty the stomach before an anæsthetic is administered. We recently saw a patient die of suffocation when this precaution had been omitted, a sudden attack of vomiting of a large quantity of the contents of the stomach leading to "aspiration."

[2] Joteyko and Stefanowska (*Dissociations des phénomènes de sensibilité, etc.*, Acad. royale de méd. de Belgique, 1902) have shown that analgesia commences much earlier than the loss of any other sensation and continues for a longer period.

This method, though entirely unattended by danger, has the disadvantage of not inducing sufficiently-deep anæsthesia in many patients, especially in males and others of an excitable temperament. It cannot be maintained that "ether-intoxication" produces anæsthesia when the patient is only enjoying pleasant dreams and when he makes vigorous ejaculations. Witzel and other surgeons who favour the drop-method employ, as a matter of fact, a mixed anæsthesia.

Witzel and Hofmann administer an injection of morphia ($\frac{1}{6}$ to $\frac{1}{2}$ grain) one hour previous to the operation, and a larger dose if the patient has become inured to the drug. Witzel's uniformly-good results have to be attributed to the addition of the morphia. Kuttner[1] also, who is accustomed with success to operate under simple ether-intoxication (in Braun's clinic), regards "the combination of ether and morphia" as essential. As Witzel very properly remarks, Nussbaum's method of producing morphia-chloroform anæsthesia does not correspond with his own method since he (Witzel) gives the morphia one hour previous to operation, as recommended by Riedel and practised by Juillard.

A mixture of chloroform and ether can also be employed. Whenever it is evident that the necessary degree of anæsthesia cannot be obtained by means of ether alone chloroform should be administered in drops. Kionka[2] refers to the experiments of Honigmann and Kochmann, which show that the anæsthetic properties are materially raised when the two anæsthetics—chloroform and ether—are combined. Willy Meyer,[3] on Weidig's authority, asserts that when ether and chloroform are mixed, a new chemical compound is produced which has a special molecular weight of its own. The addition of 20 to 30 drops of chloroform is sufficient to induce sleep during the administration of the ether. After a single experience of the method, we cannot recommend it as entirely free from danger. The only fatality attributable to administration of the anæsthetic which we have had in the course of private practice during thirty-five years occurred when chloroform was used because the anæsthesia produced by ether was not sufficiently deep.

When the combination of chloroform and ether is to be employed, it is necessary to follow Braun's advice and use either his own or the Roth-Dräger oxygen apparatus (Fig. 3), which prevents the administration of the anæsthetic in too concentrated a form. In a review of Dumont's handbook on anæsthesia,[4] Rose declares that the introduction of Junker's apparatus is the most important advance that has been made in the matter of anæsthetics.

On the authority of Honigmann's preliminary work, Braun emphasises the fact that dilute ether vapour does not produce cyanosis or stimulate the secretion of saliva or mucus. The latter results only occur when concentrated ether is used. With his apparatus, which is adapted for the alternate or simultaneous administration of ether and chloroform, Braun estimates that on every occasion on which the bag (which holds 500 c.cm. of air) is emptied on inspiration the air the patient breathes contains 1·7 per cent of chloroform or 6 per cent of ether.

A great advantage of Braun's apparatus (Fig. 3) is, that by the addition of a catheter it can be used at once in all operations connected with the nose, mouth, jaw, and pharynx. Both Rose and the author (with Arnd's apparatus) drew attention to this fact so far back as 1878.

Finally, there is another anæsthetic of a mixed nature to be considered, viz. that in which ethyl bromide is used as a preliminary to the administration of ether. We are well aware that deaths have occurred from the use of ethyl bromide, but they scarcely outnumber the fatalities for which ether is responsible. Witzel has described in full detail a fatal case which occurred in the practice of one of his colleagues. It is a significant fact, however, that we have never had a single accident in the thousands of cases in which ethyl bromide was used to induce the anæsthesia. We will certainly never dispense with its use, and we regard it as a less dangerous

[1] "Operation in Ätherintoxication," *Beitr. z. klin. Chir.* Bd. 35.
[2] *Deutsche Klinik*, v. Leyden und Klemperer, 1903.
[3] *Journal of the American Med. Association*, Feb. 1903.
[4] "On Mixed Anæsthesia with Ether and Chloroform," *Munch. med. Wochenschr.* Bd. 20, 1901.

method than that of administering chloroform in unmeasured quantities. A recent death in the Canton of Bern was attributed to the use of ethyl bromide in the case of a child affected with status thymicus.

The use of ethyl bromide calls for a closer attention to contraindications than does that of ether alone, but the same demand applies to the use of every mixed anæsthetic, such as morphia, but more especially chloroform. It is satisfactory to note that it is unnecessary to administer a mixture instead of pure ether when dealing with children or feeble anæmic patients, who can be readily brought under the influence of the latter anæsthetic. It is only in cases where the action of pure ether is not efficient, when administered to powerful men or excitable persons with a high blood-pressure, that ethyl bromide provides an excellent means of inducing rapid and quiet anæsthesia.

Many years ago we recommended, and for a long time made it our practice, that the anæsthesia should commence with chloroform and be continued with ether, in order to bring on sound sleep rapidly in strong and resistant patients, who constitute a large number of those who come under operation; for—as Braun has proved—once anæsthesia is obtained, the majority of patients can be kept under its influence by merely giving small but repeated administrations of ether. We are now convinced that it is safer to induce the anæsthesia with ethyl bromide than with chloroform.

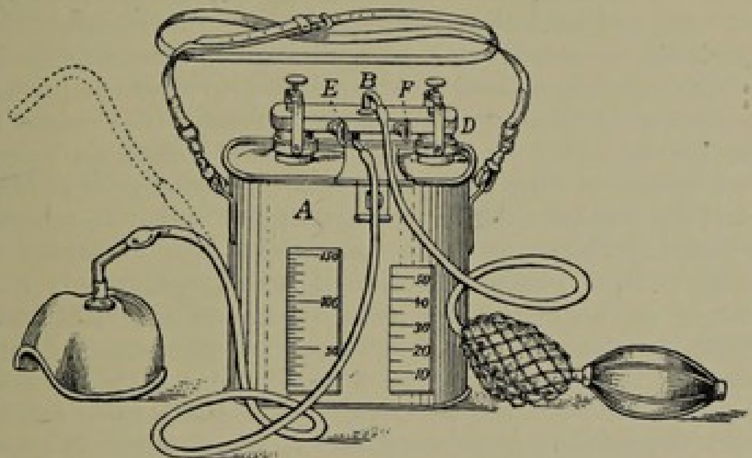

Fig. 3.—Braun's apparatus for the administration of chloroform and ether.

It may be mentioned that one of the last deaths we had under chloroform occurred in an old woman who had previously received an injection of morphia. In this case the aggregation of the poisons seemed to be responsible for the fatal effect of a minimal dose of chloroform administered in drops.

Witzel, in whose method morphia is the chief agent, has adopted and even exaggerated our practice of giving stimulants before operations. One or two hours before operation he gives a rectal injection of strong tea with red wine and brandy, one ounce of each with five to six drops of opium, or about a quarter of a wineglass of brandy to the same quantity of tea and wine. For many years it has been our practice to give a small cup of tea with brandy half an hour or an hour before the administration of the anæsthetic. With the same object Lennander gives a hypodermic injection of 1 mg. ($\frac{1}{64}$ gr.) strychnine nitr. and 2 g. (35 drops) of camphorated oil (1 : 4) half an hour before the operation. Poncet also gives a subcutaneous injection of brandy (with one-third to two-thirds of water) during the operation; while Kümmel gives large doses of brandy.

The anæsthetic should be administered with attention to the following conditions: The patient, if he has been properly prepared—if his stomach is empty, and the mouth and pharynx have been disinfected—is placed upon the table, care being taken to see that cooling of the body is prevented and that respiration is quite unimpeded. About three quarters of an hour before the operation he is given half

a cup of tea, with two tablespoonfuls of red wine or brandy, which, in the case of alcoholic subjects, is perhaps best administered by the rectum, after Witzel's method. It is only in the case of powerful adults that we give a hypodermic injection of morphia ($\frac{1}{6}$ to $\frac{1}{2}$ gr.) half an hour before operation.

The anæsthesia is induced with ethyl bromide dropped on a special mask, 5 c.c. being used for women, 20 to 30 c.c. for robust men. Narcosis is obtained in from 60 to 90 seconds, after which it is maintained with ether administered by the drop method, or with Braun's apparatus. In children and weakly subjects, ether alone should be used from the commencement of the operation. In the latter case, if the mixture of ether and air fails to produce sufficiently-deep anæsthesia, diluted chloroform vapour may be given for a short time with a regulating apparatus, such as that of Braun or Roth-Dräger.

When there is any reason for anxiety it is an excellent practice to combine the influence of a local anæsthetic by means of an injection of cocain when the patient is under ethyl bromide, or in the stage of analgesia which, according to Sudeck, follows the early administration of ether. The pain of incising the skin can thus be prevented, while sensation in the deeper portions of the wound is destroyed by infiltration (Schleich), or by endoneural injections into the exposed nerves (Cushing).

Lennander generally combines local anæsthesia with repeated administrations of ether or chloroform in cases where sensitive tissues like the parietal peritoneum have to be divided or torn, and again when the wound has to be closed.

In maintaining the anæsthesia it is of advantage to adhere to the minimum dose. Young and inexperienced anæsthetists are inclined to over-administration; and, if the truth were told (v. Mikulicz's interesting statistics), it is chiefly from this overstepping of the permissible dose that deaths under anæsthesia occur.[1] The chief advantage of an apparatus such as Braun's (and the earlier ones of Geppert, Kionka, Wohlgemuth, and the present Roth-Dräger apparatus) is that it makes it impossible for an inexperienced practitioner or an unqualified man to exceed the anæsthetic limit. The drop method possesses a similar advantage, but it not infrequently becomes a "pouring method," as a result of inexperience or youthful zeal.

Insensibility to pain is the test of sufficient anæsthesia. The large majority of anæsthetists consider it their duty to take observations of the expansion and contraction of the pupil of the eye, the disappearance of the corneal reflex, the variation of the pulse, and the relaxation of the muscles, very interesting experiments in the anæsthetising of animals, but not advisable in the case of operations on the human subject. The production of analgesia is the only object in view in the latter case, although it is a matter of some difficulty to convey this instruction to the mind of a young and impulsive practitioner.

2. *Local Anæsthesia.* Before depriving a patient of the benefits of a general anæsthetic, a surgeon must decide under what conditions general anæsthesia can be dispensed with. The first request made by the generality of patients is that they may be able to "sleep" during the operation. Not only do they wish to be free from pain, but they want to be spared the excitement usually entailed by an operation. The analgesic effects of the early stage of ether narcosis will often prove sufficient. We agree with Mikulicz (*loc. cit.*) and Küttner that on sensitive people the psychic effects of the excitement associated with local anæsthesia may have results more dangerous than those of a general anæsthetic.

Local anæsthesia has invariably to be carefully considered where there are conditions present which render the administration of a general anæsthetic dangerous, as in cases of advanced disease in internal organs, blood changes, low blood-pressure, intoxications, diabetes, Addison's disease, advanced Basedow's disease, sepsis, status lymphaticus, and diseases of the cardiac muscle, liver, both kidneys, etc. When an operation cannot be performed by means of local anæsthesia, the means may be combined with narcosis, as we have already described.

The question further arises — To what extent should general anæsthesia be

[1] It is not by chance that we have had only one fatality in thirty-five years in private practice, where for most of the time we have employed the same anæsthetist.

restricted (provided of course it is effected by a safe method) when there are no contraindications to its employment? Schleich, who has won many adherents to the use of local anæsthesia (after Koller had enriched the world in 1881 with the discovery of cocain), has evidently far overshot the mark in regard to the indications for its use.

Minor operations may certainly be undertaken under local anæsthesia. It is, however, just these so-called minor operations that make patients fight shy of further surgical measures which may be deemed necessary. The local anæsthesia process is not always so painless as its description would lead us to believe, and even Schleich candidly admits that he occasionally has to have recourse to the use of the chloroform mask. If a patient has suffered pain, for instance, from the excision of a small primary cancerous tumour, he is almost certain to refuse to allow the removal of the glands to be undertaken subsequently, at the proper time.

Further, there is the risk that, in removing a small malignant primary tumour with local anæsthesia, the operation may not be sufficiently thorough. Schleich, in a monograph on the subject, mentions 75 cases where malignant growths were removed by means of a local anæsthetic without recurrence of the malady, but one looks in vain for the exact details of the operations, which ought surely to be produced in dealing with results of so marvellous a description.

If the thoroughness and accuracy of a surgical undertaking are at all prejudiced by the use of a local anæsthetic, general anæsthesia must be substituted, provided its use is not contraindicated. This point must be plainly understood by the physician whose attitude in regard to early operation at the beginning of the disease so often influences the ultimate fate of the unfortunate sufferer from cancer.

The full significance of the words "local anæsthesia" is, in our opinion, most clearly demonstrated when the analgesia is produced at the site where the anæsthetic is injected. In this form local anæsthesia was first exclusively developed, and was brought into most extensive use by Reclus and others. It is still the principal method of rendering the skin insensitive prior to incision.

At the present time this method is extensively employed, especially in the majority of our operations on the thyroid. It consists in infiltrating the skin and subcutaneous tissues along the line of incision, which is marked on the skin by a fine scratch with the point of the knife, so that the cocain can be injected with accuracy. An angled canula is used, and 1 to 6 grammes (20 to 100 min.) or more of a 1 per cent solution of cocain in normal saline are injected, the solution being sterilised by boiling once. It must be remembered that cocain loses a considerable part of its anæsthetic effect when heated to boiling point.

The needle is inserted immediately under the skin, and the injection is made while the needle is gradually withdrawn, the point, at the same time, being kept in contact with the skin. In a minute the incision can be made without pain, and without any risk of poisoning, as there is not sufficient time for absorption into the blood stream.

The infiltration anæsthesia of Schleich [1] is quite distinct from this process, as he does not regard his method as a cocainization of the tissues in the same sense as in the older method. According to Schleich, the ·2 per cent saline solution he uses produces analgesia by purely physical means, the cocain being added only to make the process of infiltration painless. It is the flooding of the tissues with a heterotonic fluid (·2 per cent instead of the normal ·75 or ·8 per cent) that causes loss of sensation.[2]

Schleich's injection consists of a solution of cocain (1 to 1000) in saline (2 to 1000), with morphia ($\frac{1}{4}$ to 1000). A quantity not exceeding 50 g. ($1\frac{3}{4}$ ounces) of this solution may be injected without harm, till an œdema similar to that in acute Bright's disease is produced. When required, the solution may be strengthened by the addition of a trace of tropococain, or diluted to a tenth with saline lotion, when

[1] *Deutsche Klinik*, v. Leyden und Klemperer, 1901.

[2] Gans (*New York Med. Record*, 1904) uses only sterile water to produce anæsthesia in operations about the rectum. 1 to 15 c.cm. are injected.

a very extensive œdema is desired. Schleich admits that he has often seen "the early stages of cocain intoxication" produced by these means.

It is only in exceptional cases that we employ Schleich's method. Like Braun, we consider that so marked an œdema, as well as the injection of heterotonic fluid, in what Braun calls "Quellungsanæsthesie," cannot fail to impair the tissue vitality and may retard the healing process. It is true that in Schleich's solution the irritative effects of the heterotonic solution, so far as pain is concerned, are masked by the addition of cocain. Nevertheless the irritative effects are there. C. Ritter,[1] in discussing the method by which nature relieves pain, has shown that inflammatory exudates, on account of their high concentration (with a freezing point of 0·76 compared with 0·56 of normal serum), induce a reaction with hyperæmia and œdema till the difference in concentration is equalised.

In our opinion the older method of producing local anæsthesia is sufficiently effective, because the deeper tissues and organs are mainly insensitive. Lennander[2] deserves great credit for his excellent work on the sensitiveness of the viscera and tissues, in which he shows that a large number of deeply-situated organs can be dealt with without any form of anæsthesia. We shall refer to this point more fully in a later chapter.

A second reason why infiltration anæsthesia should not be carried to extremes is to be found in the increasing importance and practical value of "conduction" anæsthesia.

3. "*Conduction*" *Anæsthesia.* To H. Braun[3] of Leipzig belongs the credit of having, as a result of careful researches, brought this method of producing analgesia into more general notice.[4]

If "conduction" anæsthesia has not been sufficiently adopted by the profession, it is because a more accurate knowledge of anatomy is required for its practice than for that of the infiltration method. No one, however, should operate by either method without considerable anatomical experience. Braun makes use of Spalteholz's excellent illustrations of the course of the nerves, more especially those of the extremities of which the majority of anatomical atlases are singularly neglectful.

"Conduction" anæsthesia is produced by a perineural or—after the nerve trunk has been exposed—by an endoneural injection of an isotonic saline solution of cocain. It is therefore essential that the operator must have a capable anatomical knowledge of the course of the nerves. Following Braun's example, we have introduced illustrations to show the points where the nerves will be encountered.

The method is almost identical with that described by Oberst in 1888, in which constriction was brought into use. Krogius utilised the method without constriction (v. History). Braun, however, was the first to demonstrate in the clearest manner that "conduction" anæsthesia is really produced by influencing the nerve trunk, and is not a variety of infiltration anæsthesia, while he further proved the advantages of simultaneous constriction, a point which had already been alluded to by Kummer.

For "conduction" anæsthesia less concentrated solutions of cocain are required, and the anæsthesia is produced more rapidly if the limb is constricted before making the injection. The constricting agent need not be firmly applied, for obstruction to the venous return is all that is necessary. A rubber band is placed round the root of the finger, into which, in the position of the four nerves there, 2 c.c. (30 minims) of a 1 per cent cocain solution are injected. Complete peripheral anæsthesia of all the tissues is produced within the space of five minutes. The addition of 1 to 3 drops of a 1 to 1000 solution of adrenalin acts in the same way as constriction by aiding and prolonging the action of the cocain.

The method of "conduction" anæsthesia may be employed in three different ways :—

[1] C. Ritter, *Arch. f. klin. Chir.* Bd. 69.
[2] *Grenzgebiete*, Bd. 10, and *Deutsche Zeitschrift f. Chir.* Bd. 10.
[3] *Arch. f. klin. Chir.* Bd. 71.
[4] We refer to his new handbook *Die locale Anästhesie*, Leipzig, 1905.

(*a*) In portions of the body, like the hand and foot, where the peripheral nerves occupy a superficial position, anæsthesia can be produced by a circular (Hackenbruch) or semicircular injection of cocain (Braun).

An injection transversely across the back of the hand produces insensibility in the

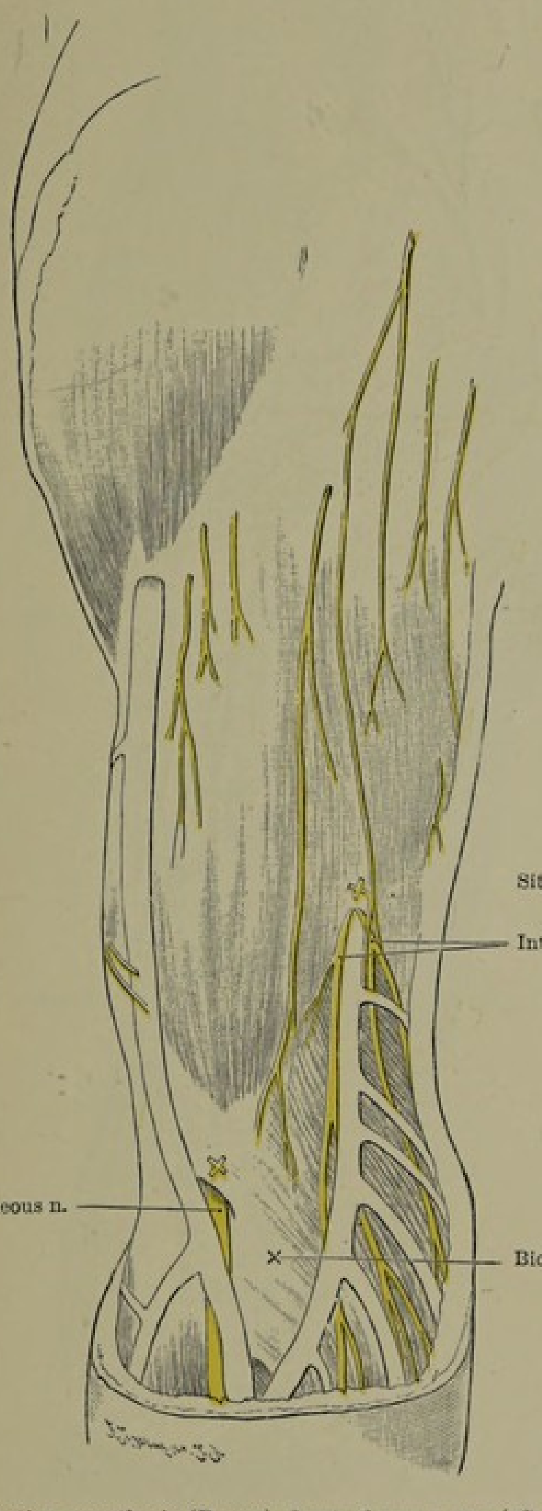

FIG. 4.—Conduction anæsthesia (Braun), front of upper arm (after Spalteholz).

dorsal surface of the fingers and hand. A circular injection round the elbow joint renders the skin of the forearm insensitive, and a similar injection round the limb below the knee-joint has the same effect on the skin of the leg. The toes and the anterior part of the foot are made insensitive by an injection at the bases of the

metatarsal bones. If no cutaneous nerve has become superficial by piercing the deep fascia in the area to be anæsthetised, this area may simply be encircled by a

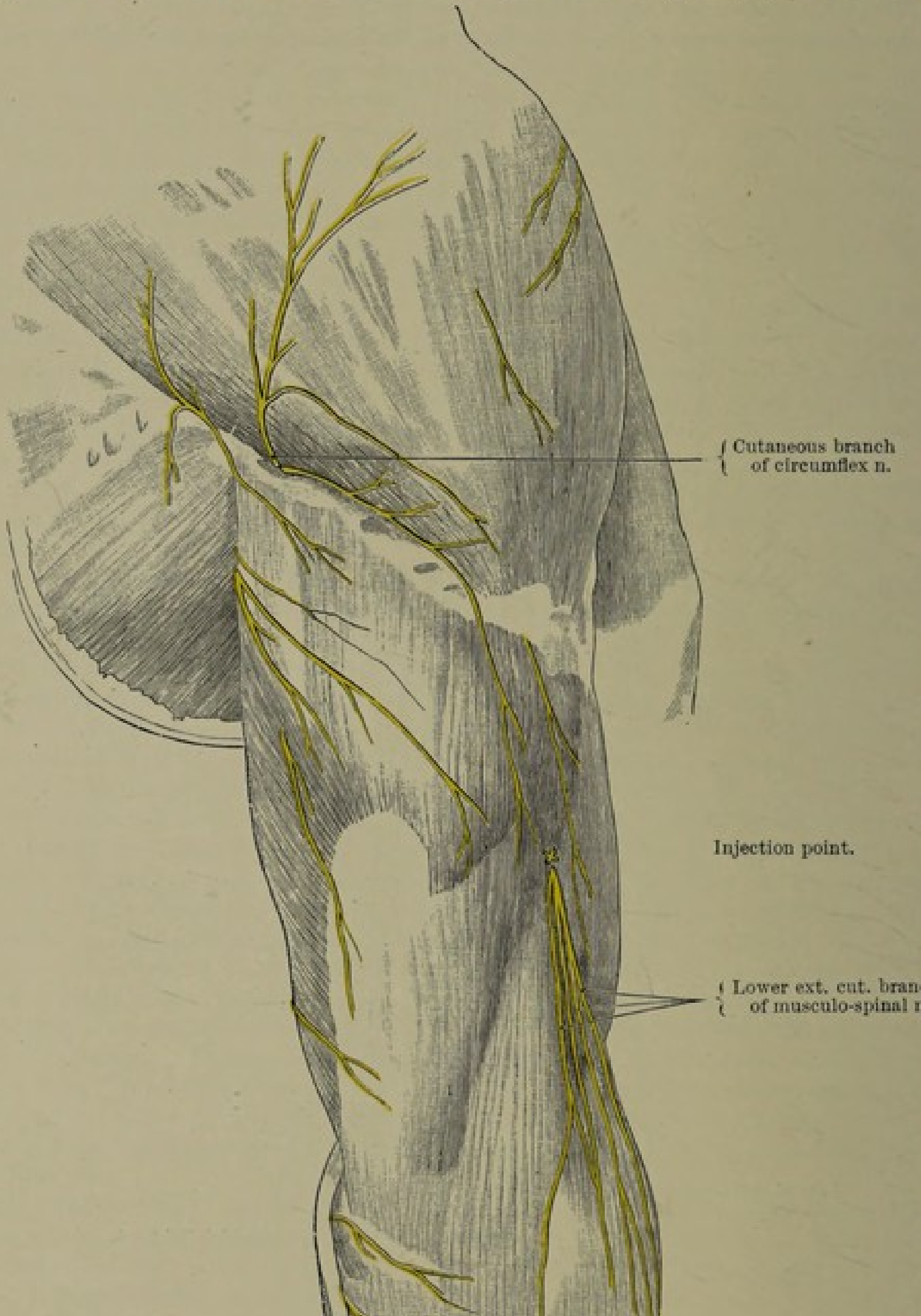

Fig. 5.—Conduction anæsthesia (Braun) of back of upper arm (after Spalteholz).

ring of cocain injections (Hackenbruch). The accompanying figures after Spalteholz indicate the site at which the cutaneous nerves can be treated with injections after they have pierced the deep fascia (Figs. 4-11).

(*b*) Perineural Injection. In order to anæsthetise portions of the body where the nerves have not yet become superficial, an operator must be thoroughly acquainted with the course of the nerve trunks. Braun has made careful experi-

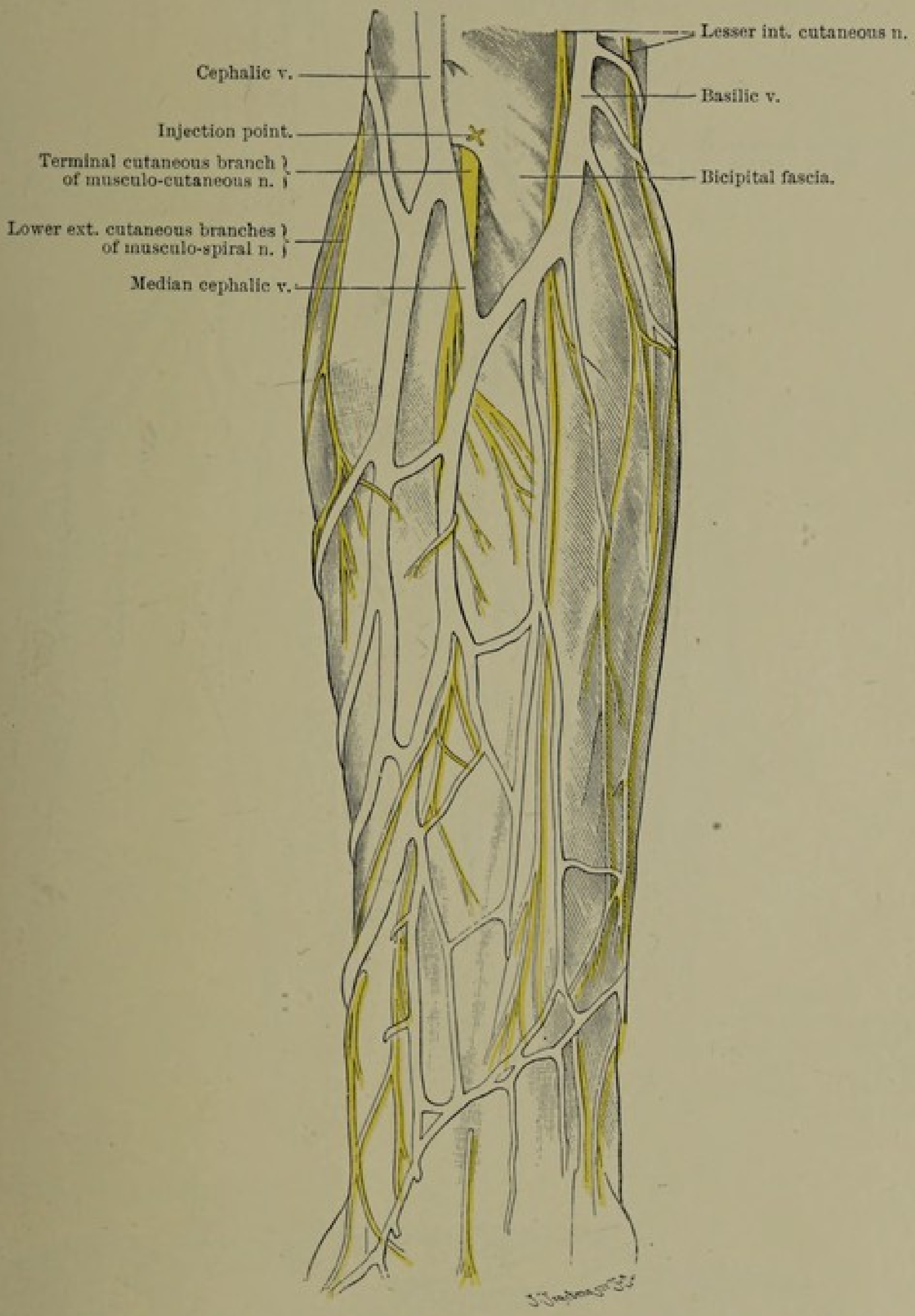

FIG. 6.—Conduction anæsthesia (Braun) for part of fore-arm (after Spalteholz).

ments to show what nerve trunks can be reached with accuracy through the skin for the purpose of perineural injection.

The median nerve above the wrist is reached by introducing the needle from the ulnar side under the palmaris longus tendon; the ulnar nerve at the wrist by passing the needle from the ulnar side under the tendon of the flexor carpi ulnaris.

FIG. 7.—Conduction anæsthesia (Braun) of back of hand (after Spalteholz). Cutaneous branches of ulnar and radial nerves.

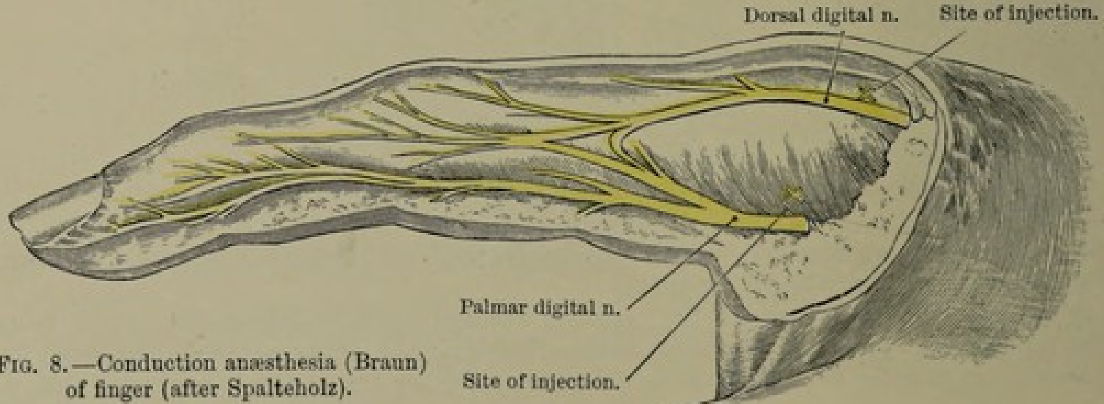

FIG. 8.—Conduction anæsthesia (Braun) of finger (after Spalteholz).

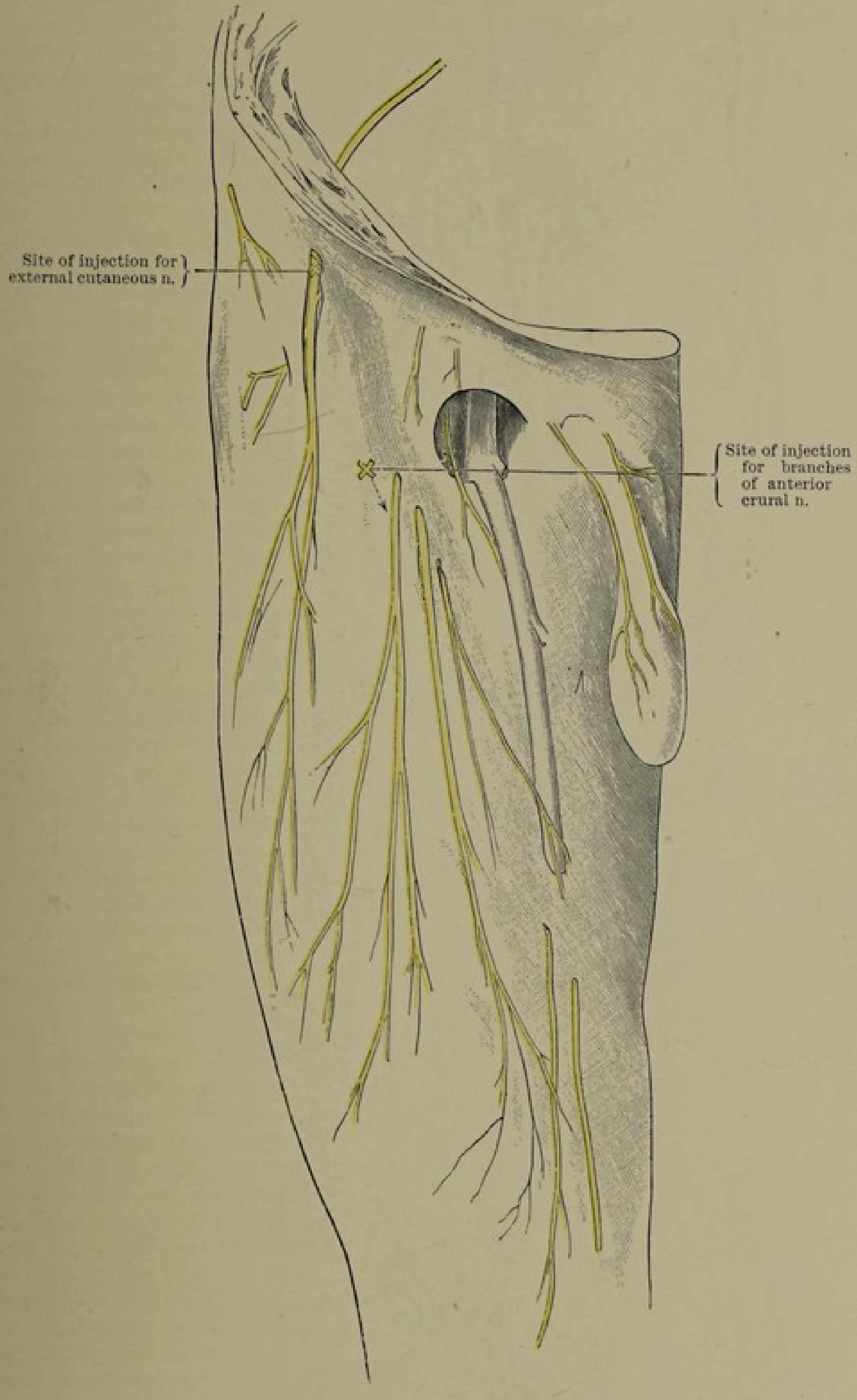

FIG. 9.—Conduction anæsthesia (Braun) of anterior surface of thigh (after Spalteholz).

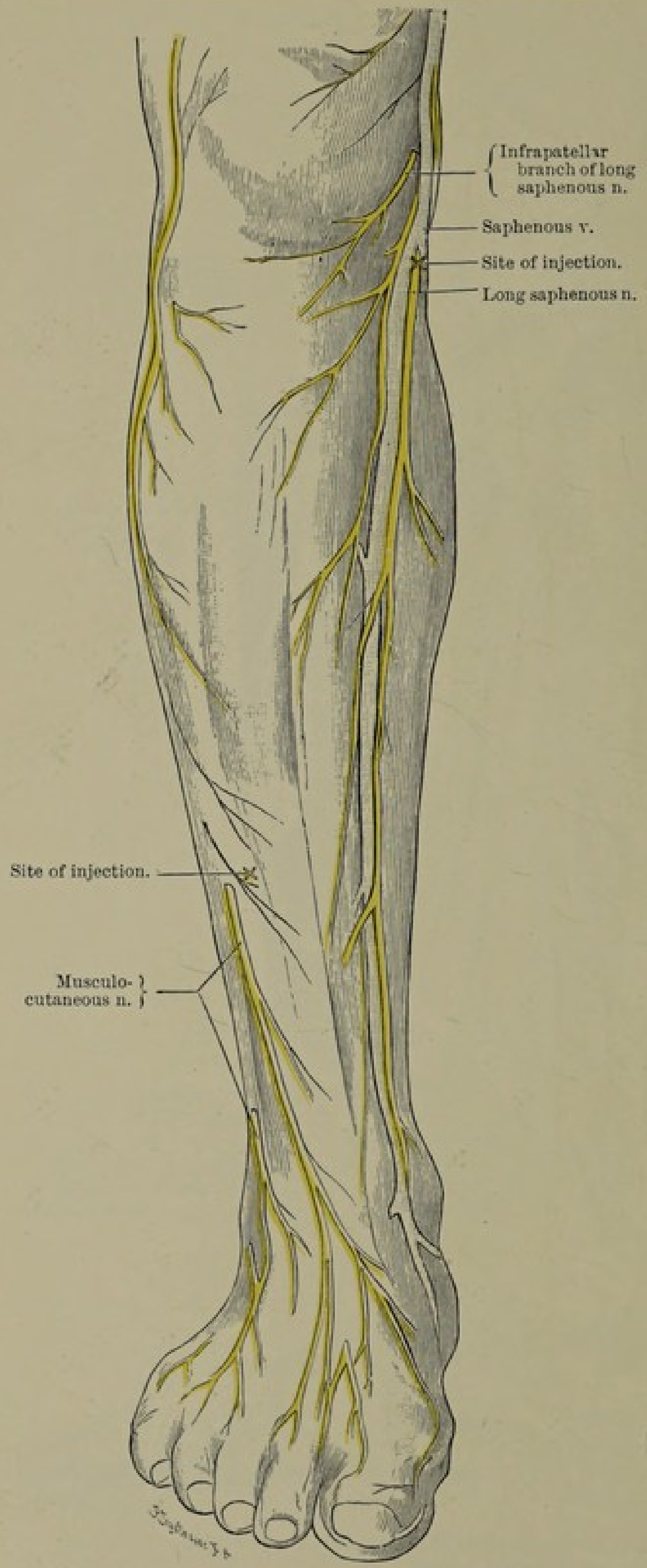

FIG. 10.—Conduction anæsthesia (Braun) of front of leg (after Spalteholz).

The latter nerve can also be reached by puncturing the deep fascia immediately behind the internal condyle of the humerus (Fig. 12).

The posterior tibial nerve can be encountered behind the internal malleolus by inserting the needle close to the tendo-Achillis and directing it forwards towards the bone so that the vessels occupy the inner side. The external popliteal nerve is found at the inner side of the biceps in the popliteal space, a puncture being made under the fascia from behind; while it can also be encountered behind the head of the fibula. The long saphenous nerve is reached by injecting directly backwards immediately below the internal tuberosity of the tibia. The musculo-cutaneous and short saphenous nerves are reached by injecting transversely half round the leg along a line a handbreadth above the external malleolus.

Nyström and Lennander inject the external cutaneous nerve just below the anterior superior spine of the ilium for the purpose of obtaining skin in Thiersch grafting.

A transverse injection above the eyebrow renders insensitive that part of the scalp which is supplied by the frontal branches of the trigeminal. Similarly the branches of the auriculo-temporal, which pass in front of the ear close to the neck of the jaw, are encountered by a transverse injection on the temple, while a similar injection on the occiput will strike the great and small occipital nerves. The great occipital can be reached with accuracy immediately after it has pierced the trapezius.

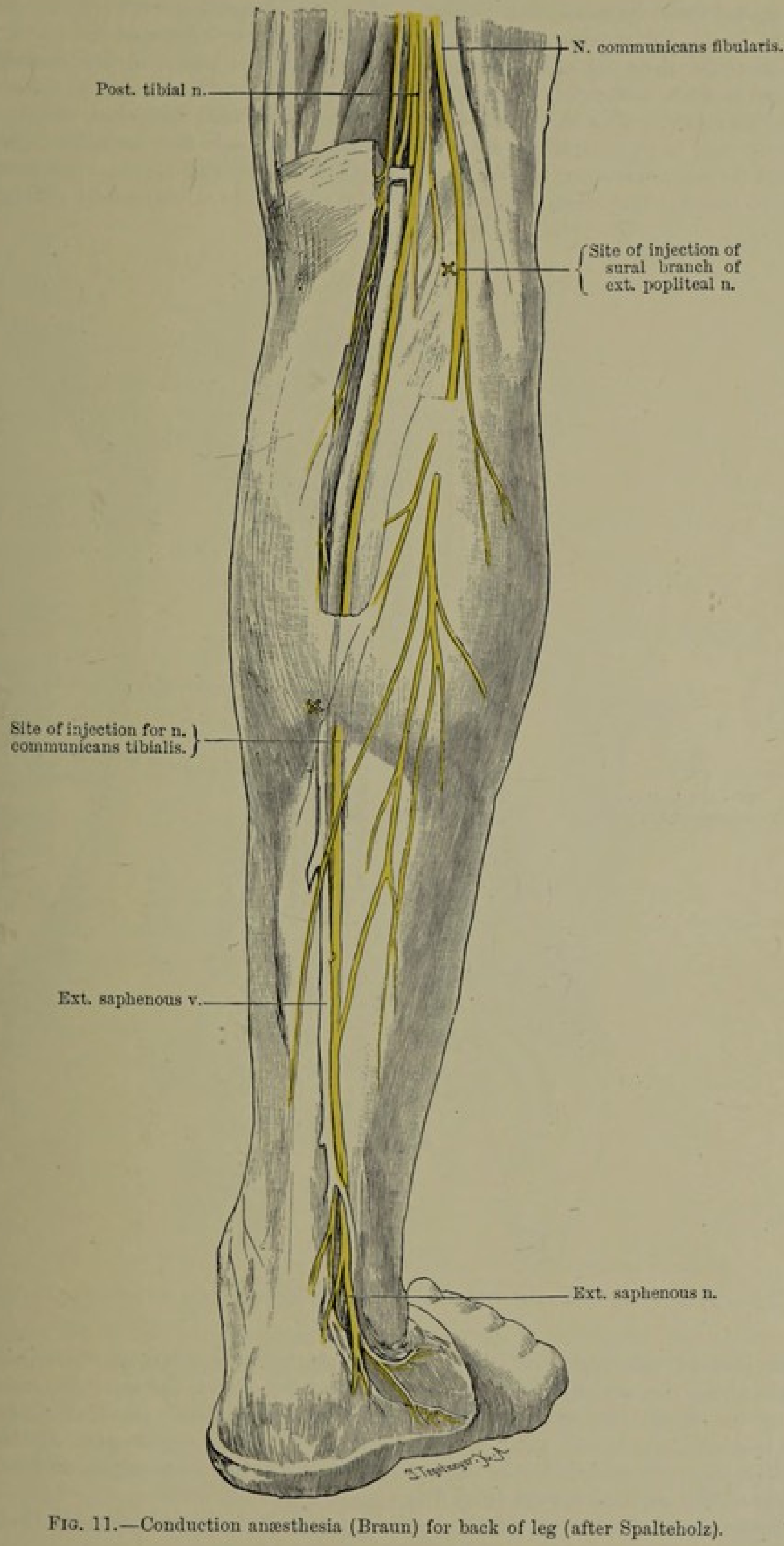

FIG. 11.—Conduction anæsthesia (Braun) for back of leg (after Spalteholz).

We agree with Halsted and Schleich that the lingual nerve can be rendered insensitive by a submucous injection at the point where the anterior pillar of the fauces joins the floor of the mouth. The point where the inferior dental nerve enters the bone is accurately indicated by the lingula on the inner surface of the ramus of the jaw. For the extraction of teeth, the small branches of the nerves to the pulp can be saturated by simple infiltration through the bone by injecting a 1 per cent cocain solution into the gum on either side of the tooth. An interval of from six to ten minutes should elapse before the extraction is performed (Braun).

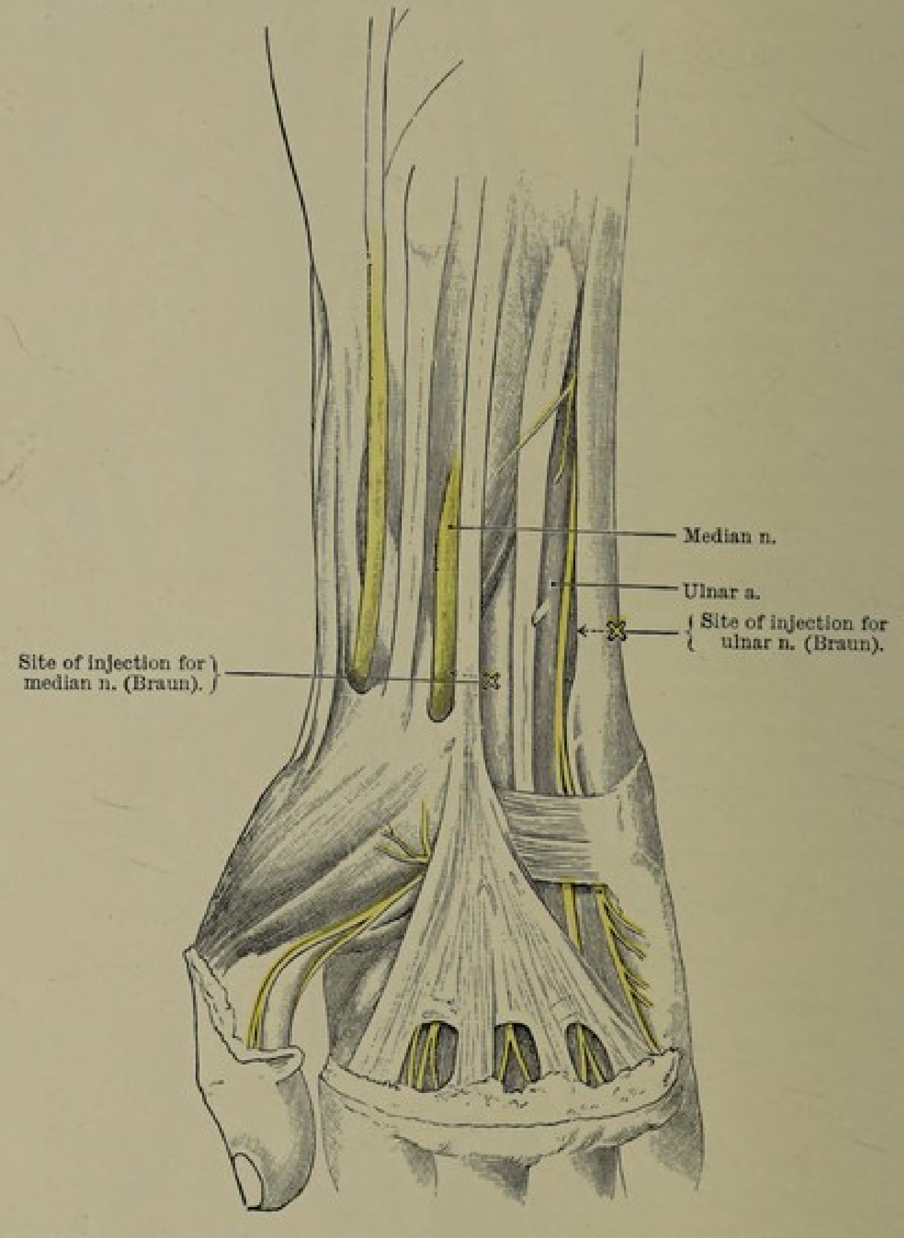

FIG. 12.—To illustrate conduction anæsthesia of the median and ulnar nerves (after Spalteholz).

One side of the neck and the region of the ear can be made insensitive by an injection along the middle third of the posterior border of the sternomastoid. This involves the small occipital, great auricular, and superficial cervical nerves. The region immediately below this, in continuation with the upper part of the thorax anteriorly, can be rendered insensitive by injecting the descending supraclavicular branches of the cervical nerves (Fig. 13).

Anæsthesia of the larynx is obtained by perineural cocainisation of the superior

laryngeal nerve, the injection being made immediately below the posterior end of the cornu of the hyoid bone down to the thyrohyoid membrane.

According to Lennander, the penis is made insensitive by injecting both dorsal nerves close to the symphysis, by a transverse injection into the subcutaneous tissue on the under surface 2 cm. behind the frenum, and by a similar injection into the corpus spongiosum at the posterior border of the frenulum.

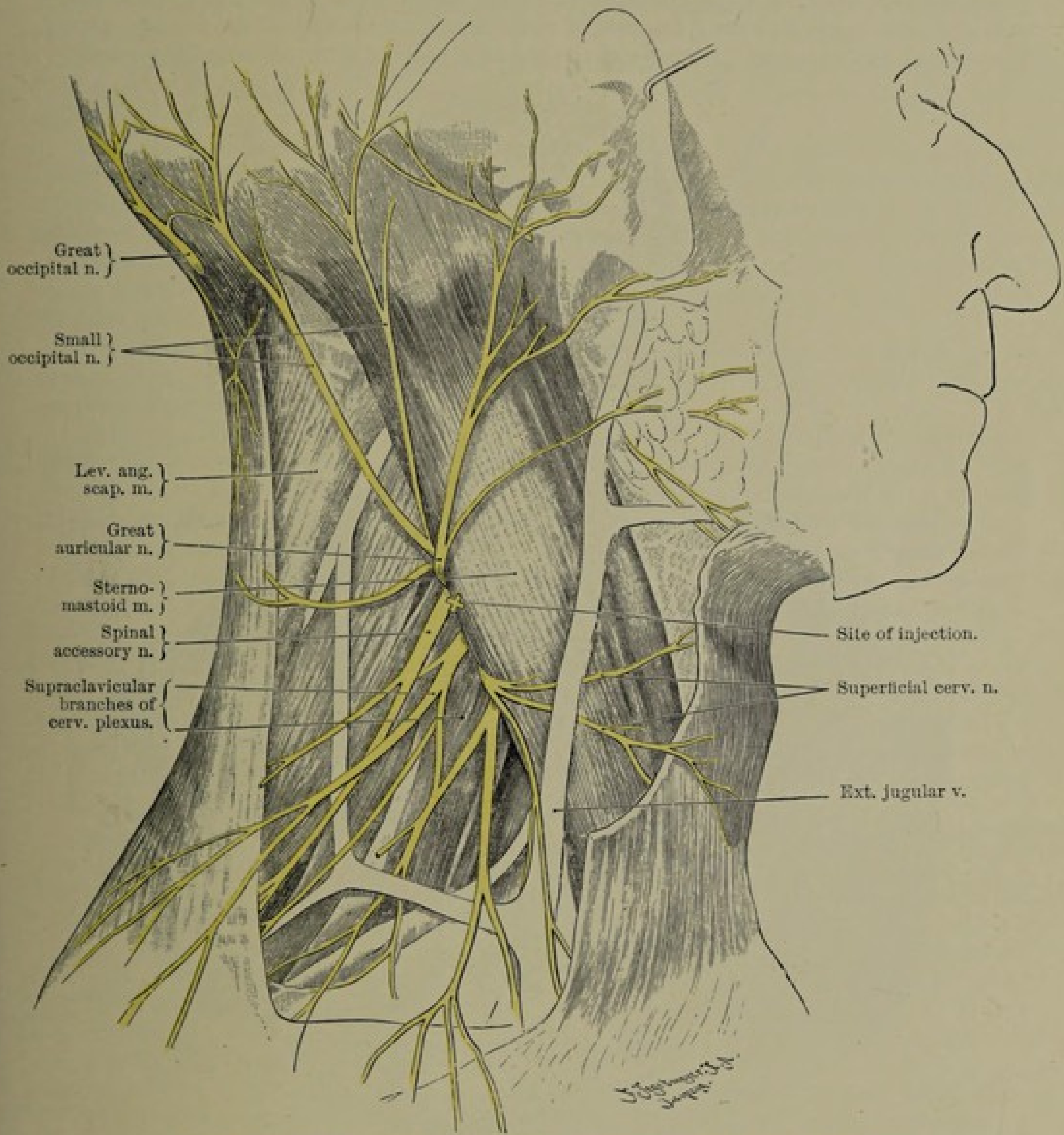

Fig. 13.—Dissection of the right side of the neck (Spalteholz) to illustrate conduction anæsthesia (Braun).

The testicle is rendered insensitive by perineural injection of the nerves in the spermatic cord, and also by infiltration of the connective tissue behind the epididymis.

The rectum may be incised or cauterised by infiltrating the surrounding connective tissue and muscles. This, of course, applies only to the part in the area of the "conduction" anæsthesia in the narrower sense (Fig. 14).

Braun always prepares the cocain solution fresh from a 10 per cent solution of the hydrochloride in absolute alcohol ($\frac{1}{2}$ c.c. $= \frac{3}{4}$ gr. cocain). He obtains a $\frac{1}{2}$ per cent solution by placing $\frac{1}{2}$ c.c. of the above in a watch glass and setting it on fire, the

residue being dissolved in 10 c.c. of physiological saline. Immediately before use 1 to 3 drops of a 1 to 1000 solution of adrenalin are added. The injection should, as a rule, be given fully half an hour before operation.

(*c*) "Conduction" anæsthesia by endoneural injection is an important substitute for general anæsthesia when the latter is contraindicated in an extensive operation. A knowledge of the exposure of the nerve is assumed. We have on three recent occasions performed a high amputation of the thigh by this method. One was a case of severe sepsis following fracture of the femur with tearing of the femoral artery. The second was a case of gangrene of the leg in a patient with advanced myocarditis;

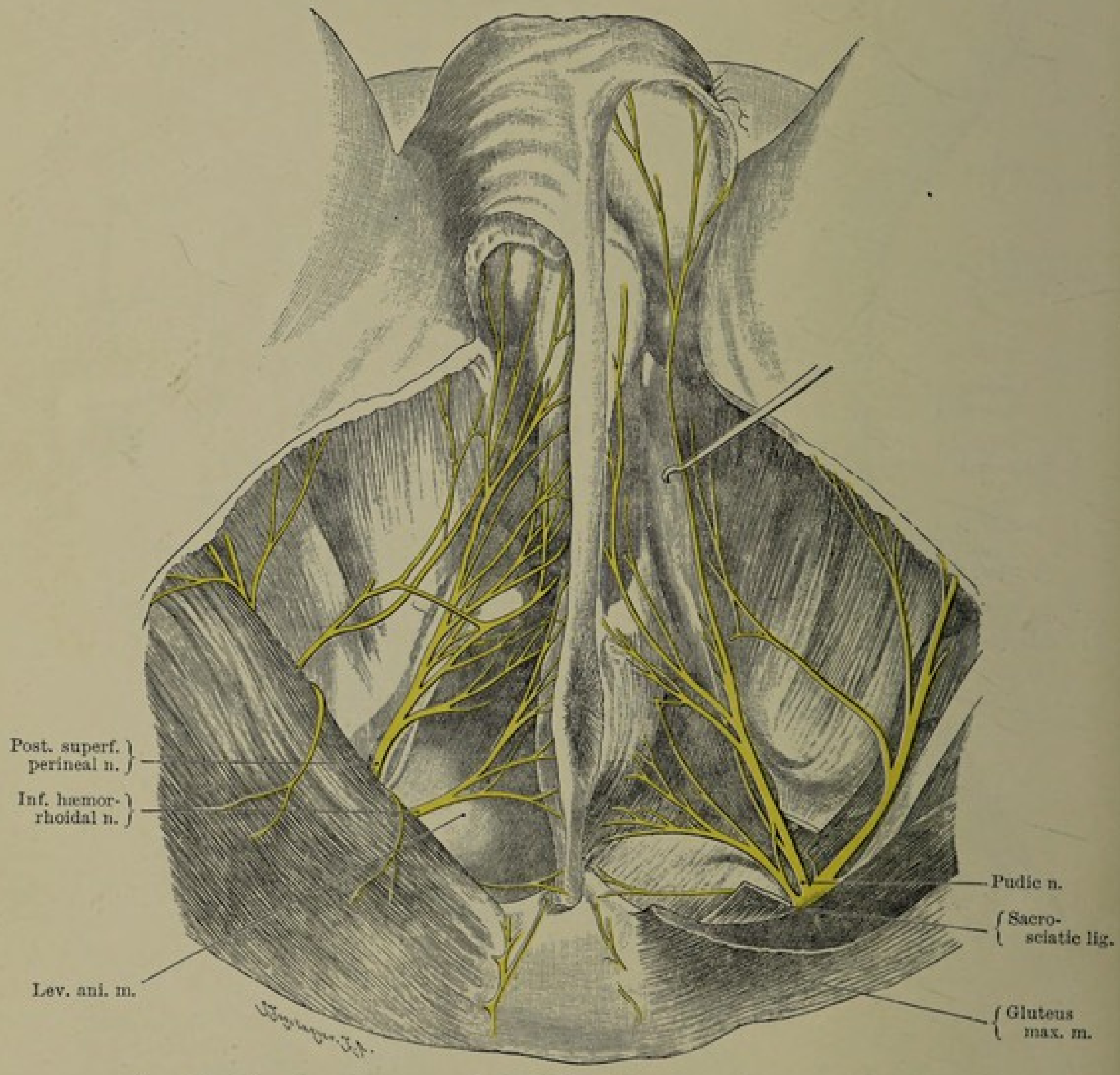

FIG. 14.—Dissection of perineum (Spalteholz) to illustrate conduction anæsthesia (Braun).

while the third was for suppuration in the knee-joint in a patient with advanced pulmonary tuberculosis. The anterior crural nerve was exposed without difficulty in the groin, as was also the great sciatic nerve in the buttock, and a 1 per cent cocain solution (without adrenalin) was injected into the nerve trunks. In the first two cases anæsthesia was immediate and complete. In the last case (where perhaps the cocain had been over-boiled) severe burning pain was complained of during the operation. In a similar manner the brachial plexus can be exposed above the clavicle and injected.

Crile and Matas were the first to adopt "conduction" anæsthesia for the amputation of a limb (arm and leg). Crile has shown that a 1 per cent cocain solution is required, the action of which is almost immediate in distinction to the perineural injection. Its effects last, at most, half an hour, but it may be prolonged by the addition of adrenalin.

Crile and Cushing have demonstrated that the injection prevents shock, which otherwise manifests itself by a sudden fall in the blood-pressure whenever the nerves are divided.

(*d*) There is still another method of employing "conduction" anæsthesia, viz. that used by Cushing where endoneural injections are made during the course of an operation performed under local anæsthesia.

Cushing has shown that during an operation for hernia, the exposed trunks of the ilio-hypogastric and ilio-inguinal nerves can be anæsthetised by endoneural injection, a complete absence of pain resulting. We agree with Braun that this method is of great practical importance, as it suggests the advisability of an operator being prepared to anæsthetise, by perineural or endoneural injection, every exposed nerve, which will subject the patient to some amount of pain if cut transversely, or which supplies part of the area of operation.

4. *Spinal Anæsthesia* (*Rachicocainisation*). Since Bier, who introduced spinal cocainisation, has warned us of the dangers to which it is liable, there are few surgeons who practise this method to any great extent.

Tuffier performs practically all his operations on the pelvis and the lower extremities (including cases of hernia) with stovain anæsthesia, and assures us that after several years' experience he would rather leave the performance of a stovain injection to his assistants than he would the administration of a general anæsthetic.

Cernezzi also speaks in eulogistic terms of the value of stovain in "conduction" anæsthesia. It is poisonous to animals in doses of (approximately 1 gr. per pound) 18 cg. per kilo, proving that it possesses only one-third of the toxic power of cocain. Cernezzi uses it along with adrenalin, as otherwise it has the effect of causing dilatation of the vessels. He injects up to 2 c.cm. (30 drops) of a $\frac{1}{2}$ per cent solution in saline, to which one drop of a 1 to 1000 solution of adrenalin has been added (Parke Davis). Stovain can be boiled without harm. The limit of a dose is 50 cg. ($7\frac{3}{4}$ gr.) of stovain and 1 mg. ($\frac{1}{64}$ gr.) of adrenalin, thus up to 100 c.cm. ($3\frac{1}{2}$ oz.) of his solution with 16 drops of adrenalin could be used. Cernezzi has also performed laparotomy under this anæsthetic.

So-called "spinal" anæsthesia comes practically under the classification of "conduction" anæsthesia. Braun points out that Eden's experiments on cats show that the nerve-roots in the spinal canal (which have no medullary sheath) are peculiarly sensitive to infiltration. An injection of water and of 0·2 per cent salt solution produced anæsthesia which continued for a considerable time. A solution of cocain would therefore prove more efficient were it not that there is the same risk here as in local anæsthesia, namely, of reabsorption in the blood, a risk which we attempted to abolish in the latter form of anæsthesia by means of constriction and the addition of adrenalin.

The injection of a fluid into the subarachnoid space acts almost as powerfully as if it had been made directly into the blood. That stovain can be more readily borne by a patient, as Tuffier seems inclined to assume, because it produces local coagulation is a point that remains undecided.

Cernezzi states that stovain is precipitated in the presence of alkaline solutions, for which reason no alkali must be used when boiling or cleaning the syringe. Klapp has shown experimentally that intradural injections of milk sugar are absorbed much more rapidly than when the injection is administered subcutaneously. He also produced complete anæsthesia of the entire body in dogs without any symptoms of poisoning, by injections of oily or concentrated solutions of gelatine. Donitz, under Bier's directions, has shown that in man the addition of adrenalin to a large extent retards the process of absorption. Notwithstanding this, the danger of uncontrollable absorption remains a great drawback in spinal injection,

a method of producing anæsthesia otherwise so convenient, for its technique is very simple, and all the nerves below the conus medullaris which have not yet left the canal are reached at a point where they are close together.

M. Mori has maintained in a very interesting work that the injection of cocain into the spinal canal presents another serious danger, namely, that it produces a fall of blood-pressure. According to Crile, who was the first to establish convincing proof of this fact, a considerable fall in the blood-pressure takes place after injections in the region of the medulla, but even after injections have been made lower down, a vasomotor paralysis of the abdominal vessels is produced through the nerves traversing the arachnoid space (Tuffier and Hallion).

In connection with "conduction" anæsthesia, Braun has observed that an impairment of the vasomotor nerves corresponds with a rise of temperature in the part affected, but in the extremities this has no serious consequences such as severe bleeding.

At the present time, spinal cocainisation as a method of producing anæsthesia cannot stand reasonable comparison with proper ether anæsthesia or with local and "conduction" anæsthesia.

C. OPERATIVE TECHNIQUE

(g) The Direction of the Skin Incisions

As we pointed out in our previous editions, the appearance of operation scars is greatly improved if the incision is made in the direction of Langer's lines of cleavage of the skin. This is especially applicable to all incisions about the face or neck. The tension of the surrounding tissues does not draw apart the edges of the skin, and the scar, after cicatrisation is complete, often becomes invisible even to a critical eye. We have abundant opportunity of observing the differences in the appearance of the scar in connection with operations on the thyroid as some of our own colleagues employ very different methods.

Since the adoption of aseptic principles, one can afford to make free skin incisions, as the resulting scar, even in exposed parts, is always of the slightest description. Certain operators, more especially younger men, in their anxiety to avoid disfigurement, employ incisions which are much too small. This is a great mistake, for malignant tumours of the face, nose, jaw, and mouth have often recurred from this cause, while in the removal of glands in the neck and other regions the use of a small incision often adds considerably to the difficulty of the operation.

All incisions should therefore be made of sufficient length and should follow the lines of cleavage of the skin. We regard these as normal incisions.

It is further possible to avoid making an incision directly over a diseased focus or organ when the skin covering the latter does not lend itself to aseptic treatment. This applies particularly to the scrotum, where, owing to the wrinkled character of the skin, disinfection is not only a difficult but often a painful process. Our inguinal incision is specially adapted for the majority of these cases, and enables the displacement of the testicle upwards. It has incidentally the further advantage that it allows one to inject the nerves to the testicle at Cushing's point.

In the earlier editions we illustrated by means of figures the results of small incisions in the body such as are employed as special openings for drainage tubes. While these are of value in showing how proper incisions come together naturally and improper ones tend to gape, we think it will be simpler to indicate merely on Langer's figures the normal incisions for a few operations, and consider the other incisions in the chapter dealing with the special part (Figs. 15 and 16). Although the median incision is not depicted, its use should always be preferred on account of the small amount of damage it involves.

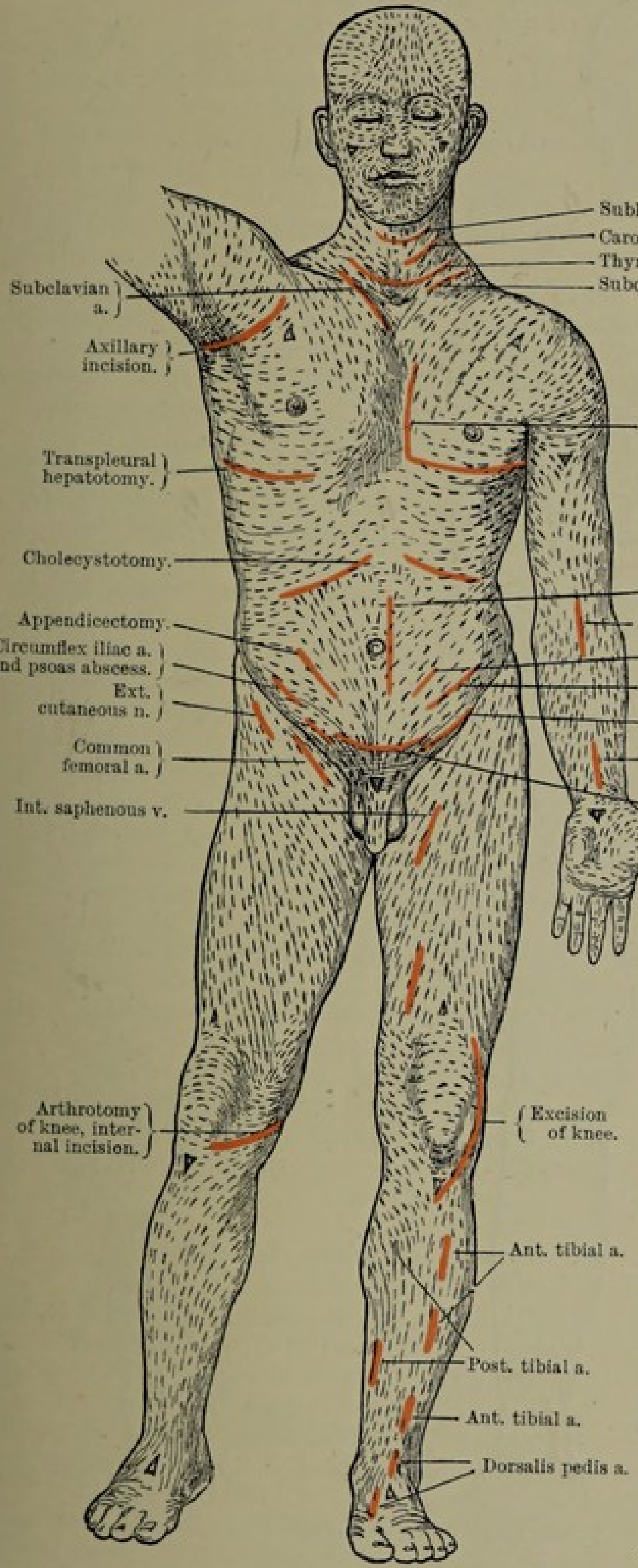

Fig. 15.

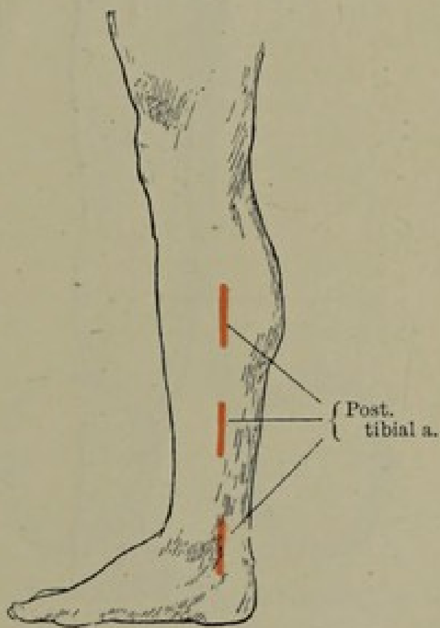

Fig. 15*a*.

Figs. 15 and 15*a*.—A few normal incisions illustrated on Langer's figures.

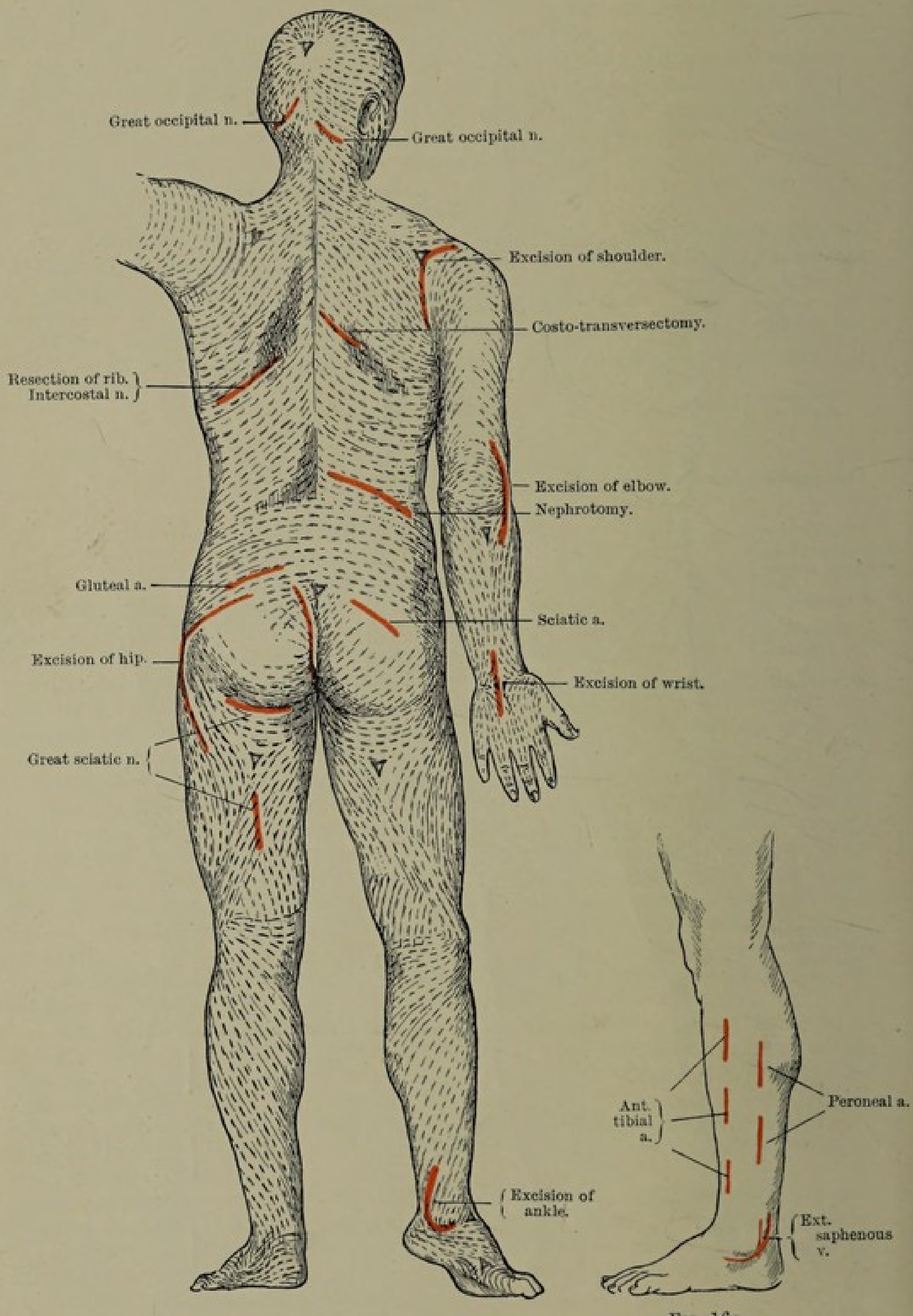

Fig. 16. Fig. 16a.

Figs. 16 and 16a.—A few normal incisions illustrated on Langer's figures.

(h) Division of Deep Tissues

It is not enough to divide the skin only in the proper line : the deeper tissues must also be divided in such a way that no unnecessary injury is inflicted. In our earlier editions we considered this matter under the head of segmental incisions.

It is obvious that an incision which divides large arteries and veins unnecessarily is to be avoided. In most cases, however, the preservation of nerves is of greater importance, for the results of nerve division (paralysis) are, as a rule, much more serious than those following ligature of a vessel : yet these are the simple points which are so often neglected.

Consider, for instance, the unsightly appearance of the neck after an operation on the thyroid which has resulted in paralysis of the sterno-laryngeal muscles. The deep hollows that are produced are very repulsive to people of refinement. It is far more important to avoid injuring the nerve supplying a muscle than the muscle itself, for with proper care the latter can be divided and subsequently sutured without any damage to its function being sustained. At the most, a tendinous inscription is formed such as normally exists in muscles which have a segmental nerve-supply (rectus abdominis). In operations connected with the thyroid, we therefore divide the muscles high up and subsequently unite them with sutures. There is no resulting harm, because there is no interference with their nerve-supply.

As a general rule, however, even the segmental division of muscles is not necessary. A muscle may be simply separated in the direction of its fibres by blunt dissection. Its sheath alone is divided, and is afterwards sutured. This procedure may be designated interfibrillar muscular division. The same principle is also adopted in the operation which was recommended by Roux and called by us the permuscular method, an operation usually performed for perityphlitis. By separating the muscle fibres, preferably with a blunt dissector, and holding the edges apart with blunt hooks, a wide interval is gradually obtained, without any harmful results. When the edges of the muscles are released, they come together again naturally (*vide* Fig. 382 under perityphlitis).

Once the skin, fascia, and muscles have been divided, the edges of the wound must be protected while the deeper tissues are being dissected. This can be attained either by covering them with sterilised towels, or by pulling out and fixing to the skin with our artery forceps a layer of deep fascia or serous membrane (especially peritoneum).

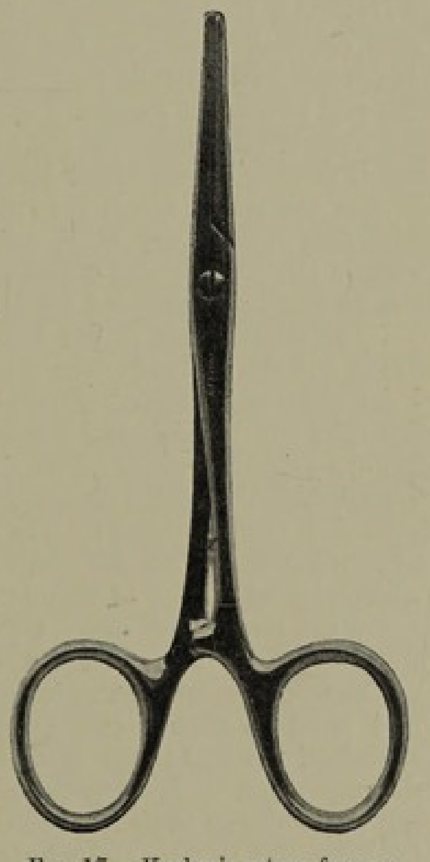

Fig. 17.—Kocher's artery forceps.

(i) Arrest of Hæmorrhage

Every bleeding point, no matter how small, should be secured in the line of the incision so that the wound may not become infiltrated with blood. This is an important consideration and one which is often disregarded. A wound that is infiltrated with blood is more difficult to heal.

The bleeding points, however, should not be immediately ligatured, for it is dangerous to expose ligature material to the risk of contamination during the whole course of an operation. The newer pattern of artery forceps has the advantage that even when a large number are necessary they are conveniently hung out of the way and do not interfere with the surgeon's movements. The variety

we use (Fig. 17) is very light, is easily applied, and takes a firm grip even in the case of dense tissues.

The ligatures should only be applied at the end of an operation—if they are then found to be necessary. Small vessels should merely be twisted. In simple operations like the radical cure of a hernia we do not employ ligatures. In the neck, however, every vessel should be tied, for in the act of coughing or vomiting even the smaller veins suffer considerable distension. Antiseptic silk should be used as the ligature material. A substitute for silk is only necessary in the absence of asepsis.

(k) Closure of the Wound

Before a wound is closed all bleeding should have ceased. A collection of blood in a wound predisposes to infection and, next to tissue necrosis, is the most important factor in retarding healing. It is mainly due to the care we bestow on the arrest of hæmorrhage that our operation wounds, *e.g.* hernia, goitre, or perityphlitis, are healed in the course of a week, when the patients are, as a rule, able to leave their beds and return home. The avoidance of excessive tissue necrosis is equally important. It was on account of the cervical portion of the uterus being ligatured *en masse* that the results of supravaginal hysterectomy were for many years unsatisfactory. In this case, as in certain others, ligature *en masse* is to be avoided.

In modern practice, an aseptic wound is no longer regarded as strictly sterile, for there is no wound entirely free from the presence of bacteria at the end of an operation. Staphylococci grow in the fluids pressed from a glove after it has been worn. All that micro-organisms require for their development is a nidus of blood-clot or dead tissue at the body temperature. So-called dead spaces are of no importance so long as they are empty. Tissue necrosis and effusions of blood are the real sources of danger.

Primary union by complete closure of the wound must therefore only be expected when neither effused blood nor necrotic tissue has been left in the wound. If there is any chance of blood collecting in the wound, free escape must be provided by inserting a drainage tube, which we invariably use when we are not absolutely certain that subsequent hæmorrhage will not occur. If one is satisfied that sufficient escape has been provided for blood and serum, the rest of the wound may be closed.

For many years it has been our practice to suture our wounds completely and bring out the drainage tube through a special opening in the skin. In this way the least observable scars are obtained. The drainage tube may, however, be simply brought out between the stitches. Burkhardt[1] has observed that tissue necrosis is always associated with an exudation of leucocytes, which sometimes amounts to suppuration. Absorption of the necrotic tissue can only occur in spite of the exudation provided that no bacteria are admitted. According to Burkhardt the process of absorption begins on the sixth day, while a couple of months are required for the absorption of a piece of tissue the size of a bean.

When one cannot prevent the necrosis of a large piece of tissue, no closing sutures must be used. For in such a case it is not sufficient merely to provide for drainage of the wound secretions as in the case of a blood-clot. Bacteria grow in dead tissue, and must be sucked out, as it were, and immediately rendered harmless. When, therefore, necrotic tissue is left in a wound, it must be prevented from undergoing decomposition by keeping the wound open by antiseptic packing. Surgeons who are not particular in their method of arresting hæmorrhage, who are not careful to avoid bruising the tissues, and who employ ligature *en masse*, do well to make it a rule to pack their wounds tightly with iodoform gauze, a practice which is still observed in certain clinics. Irrigation is only required for washing blood from a wound or when a wound has been soiled with some discharge. Normal saline solution at the

[1] Langenbeck's *Archiv*, Bd. 74.

body temperature should be used for irrigation. Tavel's solution causes a superficial cauterisation and produces a whitish discoloration of the wound. This, of course, may have an antiseptic action similar to that of bismuth or zincoxide paste. In clean wounds (*i.e.* those which are not directly soiled by bile, fæces, saliva, etc.) this is rather a disadvantage than otherwise.

When there is nothing to contraindicate closure of a wound, each layer of tissue should be sutured separately. A continuous suture of antiseptic silk is the best and simplest, and will secure the certainty of asepsis.

A layer of collodion is all that need be placed over the wound to protect it from contact with the clothes. If it does not hold well, bismuth paste may be smeared over the wound from time to time (*e.g.* in the region of the nose, mouth, vagina, or rectum). The bismuth keeps the line of suture and the ends of the stitches dry.

When drainage or packing is adopted, the exposed end of the tube or gauze must be thoroughly covered over with antiseptic gauze (iodoform, xeroform, or vioform gauze), and the dressings renewed every time the discharge makes its way through.

It is only by carefully distinguishing between wounds which may safely be closed at once, wounds in which an accumulation of blood may occur, and wounds in which a large amount of dead tissue has to be absorbed, and by adopting treatment suitable to each, that dangerous disturbances in the course of healing can be avoided.

D. AFTER-TREATMENT OF THE PATIENT

When a patient has undergone the nervous strain of an operation, and in addition has had no food for some hours previously; when he has been kept under an anæsthetic for some time, and when he has become chilled, partly from the effect of the anæsthetic, and partly from exposure of the skin; when he has lain on the table with his hands and feet tied, and when in addition there has been much loss of blood, which, of course, can and should be prevented, his condition is one calling for immediate steps being taken to restore the functions of the vital organs, especially by improving the action of the heart.

Many years ago, as a result of observations we made with pulse tracings, we advised, as a prophylactic measure, the administration before operation of tea and sugar, with an admixture of alcohol in the form of brandy or warm wine. As already mentioned, Witzel's plan of giving strong enemata is also to be recommended.

Similar treatment is also advisable after operation, when the circulation is weak. The blood-pressure can be raised by the use of stimulants, *e.g.* tea or coffee with sugar, with or without the addition of alcohol. If vomiting is present, the stimulant should be given in the form of an enema. The administration of warm fluids by the mouth, rectum, or subcutaneously, has a beneficial action. The use of subcutaneous saline infusions should never be omitted after a prolonged or serious operation.

It is very important to maintain the body heat by means of hot bottles and blankets, measures which must be persisted in till the patient is warm, or is noticed to be in a state of gentle perspiration.

Witzel is a strenuous advocate of respiratory gymnastics, *i.e.* deep inspiration and forced expiration, methods to be recommended for all patients who are confined to bed. After an operation they are even more effective, as they accelerate the elimination of the ethyl bromide and ether from the lungs. Further, forcible expiration is of value in expelling mucus from the upper air passages.

Vomiting is best arrested by washing out the stomach, for in this way the anæsthetic which has been swallowed with the saliva is removed, and acute paralytic distension of the stomach, which is occasionally observed after abdominal operations, is prevented. It is of advantage also to rinse out the mouth and nose after as well as before operation. So far as it is due to the action of the anæsthetic on the nervous system, vomiting is benefited by saline infusions and enemata, the latter treatment effectively flushing out the system (Sahli).

Every patient does not require all these remedies. Robust subjects, especially those whose pulse after operation is found to be strong and who sleep quietly, need only be placed in a well-ventilated room and covered up warmly in bed.

The position in which the patient lies after operation is a matter of great importance. Quincke[1] gives general directions in regard to the position patients should be made to adopt in bed for rest and sleep. But in the case of a patient who has just been operated on it is well to be more precise. If there is marked anæmia, shock, or collapse, and the pulse is weak, the head must be maintained at a low level in a position which is not necessarily uncomfortable, and is most conveniently obtained by raising the foot of the bed.

The same position should also be adopted when it is desired to prevent the gravitation of saliva and mucus into the trachea, either when the patient remains unconscious, or when there is impairment of deglutition or loss of the laryngeal reflex.

When, on the other hand, it is important to avoid congestion of the vessels of the head and neck, especially of the veins, the patient must be placed with his pelvis low. This is most conveniently secured by elevating the head by means of pillows. It is curious to observe the frequency with which pillows are simply placed behind the head and shoulders of a patient, with the result that within a quarter of an hour he has slipped off the inclined plane. In addition to the pillows being placed under the head, the patient should also have the additional support of a flat bolster pushed transversely under the mattress below the upper part of the thighs.

As Lennander has pointed out, a dependent position of the legs may give rise to thrombosis of the veins, especially if varix is present. In these cases, therefore, the pelvis alone must be kept low, while the legs should be raised and maintained at a higher level than the buttocks.

Witzel has emphasised the importance to be attached to the position in which the patient is carried after operation, for if attention to this is neglected when the patient is still unconscious, aspiration may take place of the fluids in the mouth and result in post-operative pneumonia, a by no means infrequent complication after laparotomy.

Apart from the danger of thrombosis, there are two conditions which must be carefully watched for shortly after operation, namely, the onset of pneumonia and paresis of the bowel.

According to Kionka, the rapidity with which the anæsthetic vapour is removed by the lungs once its administration has ceased depends on its insolubility in water. Its local effect on the air passages continues for a somewhat longer time; and even if the alleged powerful action of ether in increasing secretion does not prove so real, still the diminished resistance of the epithelial cells to the attack of bacteria is to be taken into consideration. Existing bronchitis aggravates this. We have already referred to the prophylactic treatment with large doses of creosotal in the enema.

The activity of the intestines after abdominal operations may be greatly impaired even to the extent of producing paralytic ileus. The passage of a rectal tube and the introduction of glycerine suppositories to stimulate contractions, and also the administration of saline purges (magnesium sulphate, and Karlsbad salts), may be urgently indicated, and must be resorted to without delay. In an intestine which is securely stitched, the sutures hold so securely that even in the first day or two movements of the bowel have no prejudicial effect.

The most important consideration to attend to, however, is to see that the stomach and intestine are empty before operation, and, if necessary, to have them emptied during the operation, *e.g.* in obstruction of the bowels. Further, intestinal decomposition should be restricted by giving beforehand frequent small doses of bismuth, which prevent putrefaction and the formation of gas (*vide* Preparation of the Patient). Physostigmin is a very powerful remedy, but it must be used with caution. Even 1 mg. ($\frac{1}{60}$ gr.) is very active, so that it is advisable to begin with $\frac{1}{600}$ gr. (a decimilligram).

With regard to the treatment of a patient whose stomach will retain nothing in

[1] *Die Krankenpflege*, Bd. 1, 1901.

the shape of nourishment, or in whom feeding by the mouth is not permissible, the introduction of fluid is of the greatest importance. Patients may be kept for days on subcutaneous injections of saline lotion.

When rectal feeding is employed, an enema of warm milk will be found to produce the least amount of decomposition and to be retained longest. The addition of an egg aids decomposition, while nutritive powders such as tropon and somatose do so still more.

When rectal feeding cannot be resorted to, sugar and fats, or albumin in some non-coagulating and non-poisonous form, may be administered subcutaneously. As an alternative for subcutaneous injections of sterilised olive oil (20 to 100 gr. with 3·58 per cent grape sugar in solution), Friedrich recommends the injection of Siegfried's pepsin-fibrin-peptone (up to 20 g. (300 gr.) at a time), the caloric value of which is reckoned as about 100, the daily requirement of man being 4200 calories.

E. DETAILS WITH REGARD TO ANÆSTHESIA

The preceding chapters A to D have been made as short and practical as possible, and everything tending to cause confusion has been omitted. Argument has been abridged, and points that did not seem to us to have a practical bearing on the subject have been avoided. The directions we have given are identical with those summarised for the benefit of our assistants and staff, in order that the best results may be obtained by a combined system of administration.

For this reason anæsthesia has been briefly considered merely as an adjunct to ether narcosis. There are, however, numerous topics of interest connected with anæsthesia and wound-treatment which require further elucidation. In the next two chapters additional questions will be discussed which are of more theoretical importance.

(1) Further Remarks on Local Anæsthesia

As we observed in our former editions, the majority of the deep tissues possess no great degree of sensitiveness. This has been clearly proved by the fact that our thyroid operations are conducted without either a general anæsthetic or tissue infiltration, in this way testifying to a noteworthy advancement in the practice of local anæsthesia.

Only a few tissues are sensitive, and if they are carelessly torn, pulled, or crushed, instead of being cut, any operative procedure has a painful result. With careful methods of operation, even children have admitted that they felt absolutely no pain during an operation for goitre.

To Lennander is due the credit of having systematically investigated the sensibility of the organs and tissues in the human body. A brief summary of his results is of great interest.

1. Lennander's Investigations.[1] Lennander in his work acknowledges the value of the experiments of Bloch, Byron Robinson, and Max Buch, and calls attention to the diversity of opinions on the sensibility of the organs and tissues, at the same time giving a full account of the literature on the subject. The first facts he established were in connection with the abdomen.[2]

Lennander's investigations are singularly brilliant owing to the simplicity of their results. He finds that in the abdomen the only sensitive tissues are the peritoneum covering the diaphragm and the peritoneum of the abdominal walls. The peritoneum included between the sympathetic cords in front of the 4th and 5th lumbar vertebræ, and probably also in front of the sacrum, where sensory nerves are not found anatomically, is non-sensitive.

The parietal peritoneum is sensitive only to pain, not to touch, heat, or cold. Further, according to Lennander, normal or inflamed peritoneum is

[1] *Deutsche Zeitschr. f. Chir.* Bd. 73. [2] *Grenzgebiete d. Med. u. Chir.* Bd. 10, 1902.

equally sensitive, but earlier investigators have considered the latter condition more keenly alive to sensation, of which all the abdominal viscera which he examined were shown to be entirely devoid.

The conclusion can therefore be drawn that only the intercostal lumbar and sacral nerves (possibly also the phrenic nerve), which are distributed in the subserous tissues, are concerned in the conduction of pain, as all the organs supplied by the vagus and sympathetic are entirely non-sensitive.

According to Lennander, inflammation of an abdominal organ entails severe pain when the parietal peritoneum becomes involved by the spread of the toxins and the inflammatory process along the subserous lymphatics into the lymphatic glands in the posterior abdominal wall. Pains of a colicky nature in hollow muscular viscera such as the stomach, intestines, gall-bladder, bile duct, and ureter, are the result of muscular contractions exerting traction on the cerebro-spinal nerves of the abdominal wall.

Unless the parietal peritoneum is involved, there is no pain. The visceral peritoneum, mesentery, and omentum are devoid of sensation even when they are hyperæmic and inflamed. A peritonitis limited to the appendix is not necessarily provocative of pain.

Adhesions between the viscera and the parietal peritoneum produce pain by tension, but adhesions between viscera alone are free from this result.

The reason why pain is frequently felt at a distance from the seat of the actual disease is that in this situation the chemical, bacterial, or mechanical irritation first affects the abdominal wall. Thus, in appendicitis the pain may be referred to the umbilicus or the region of the stomach, while in a strangulated hernia it is referred to the urethra or other organ. According to Kronecker, Weber has proved that the common sensation is fully developed in the abdominal organs, and that internal organs, though they have no sense of touch, are sensitive to pain. Nerves, muscles, and the brain are insensitive to touch but are sensitive to pain. Nothnagel explains colic, for instance, by the action of "adequal" stimuli.

The nausea and vomiting that are so frequently produced when traction is made on an abdominal organ, *e.g.* the omentum, are simply due to irritation of the cerebro-spinal nerves in the adominal wall.

The mucous membrane even of the rectum is insensitive as far down as its junction with the skin. Distension of the rectum merely creates a desire to go to stool and only becomes painful when the rectal contractions, which are really the underlying cause of the pain, stimulate the sensory nerves of the periproctal connective tissue by traction. The vagina and uterus are insensitive to pain as long as traction is not made on the abdominal wall.

The testicle and epididymis, which are supplied by the sympathetic nerves in the spermatic cord, are insensitive to pain: they only give rise to a sensation as if pressure was being put upon the abdomen. The only pain-conducting nerves are derived from branches of the lumbar plexus which enter the spermatic cord and are distributed in the coverings and the parietal layer of the tunica vaginalis, in the same way as the scrotal branches of the internal pudic nerve give sensation to the connective tissue on the posterior surface of the epididymis. The penis is supplied with sensation through its two dorsal nerves as well as by the deeper terminal branches of the internal pudic nerve.

Like the thyroid gland, the trachea, lungs, and visceral layer of the pleura are all insensitive. The parietal pleura, on the contrary, is particularly sensitive.

Lennander regards bone and bone-marrow as insensitive, the periosteum alone proving sensitive to pain, while he also considers granulation tissue devoid of sensation.

It is clear, therefore, that the observations of Lennander and his associates must have an important effect on the technique of local anæsthesia. There is no occasion for infiltrating tissues with cocain, according to Schleich's method, when they are already insensitive. Further, as cerebro-spinal nerves alone transmit painful sensations, it follows that the conduction method is the one which really goes to the root of the matter. We know the course of the cerebro-spinal nerves, and only require

more accurate anatomical detail to be able to obtain the effects of conduction anæsthesia in any part of the body.

Lennander, and more especially Braun, have led the way in this direction, but there is much still to be learned about the subject. The conduction method has the great advantage that the injection can be made sometime before and at a distance from the site of operation, whereas in Schleich's method the actual tissues to be cut have to be rendered œdematous by forcible infiltration.

Until we can accurately locate for the majority of operations all the points at which peri- or endo-neural injections can be made, Cushing's modification of Schleich's infiltration method may still be adopted with advantage for the deeper tissues. Schleich, who was the first to demonstrate the practical value of dilute solutions of cocain, deserves the credit for raising local anæsthesia to the position it now holds. It will be no disadvantage, however, were the method he adopts, in which "the tissues when incised appear glazed and jelly-like and drip like an over-ripe melon," to be discarded. The directions Schleich gives for the removal of a rib, which consist in forcing the injection through the periosteum into the bony canals and marrow so as to produce saturation of the posterior periosteal surface round the edge of the ribs, and many similar injunctions are, from Lennander's observations, entirely unnecessary.

If the nerve which supplies the area of the operation is known and is accessible, the injection should be made previous to operating. But when this is impossible, the skin in the line of incision may be rendered insensitive by the injection of a 1 per cent solution of cocain (with adrenalin).

When injecting the cocain we always keep the point of the needle in contact with the deep surface of the skin, and endeavour to avoid raising wheals in the skin itself, which, apart from the pain they entail, interfere with the vitality of the skin after suturing. We have never found "endermatic" injection a necessary measure. Braun states that a subcutaneous injection of cocain, combined with the simultaneous application of the ethyl chloride spray for one to two minutes, produces satisfactory anæsthesia, as the action of the ethyl chloride on the sensory nerves intensifies the effect of the cocain. Once an incision is made in the skin (or fascia), the nerve twigs supplying the area of operation can frequently be observed; if not, their approximate position can easily be ascertained. Direct perineural or endoneural injections (Cushing) can then be administered. Cushing described his method as specially effective in herniotomy, but it is also well adapted for the intercostal and other nerves. If these nerves fail to be exposed in the incision, sensitive areas may be infiltrated with a 1 to 1000 isotonic solution of cocain (Braun). Infiltration is, however, specially indicated before incising the sheath of a muscle preparatory to dividing it, as, for example, in operations on the thyroid, where no harm results, as it is followed by incision into the infiltrated layers.

Previous to division of the muscles the injections should be made. Here, again, infiltration is not harmful, as the fibres are simply separated (as described in the operative technique) and no subsequent suturing is necessary.

Finally, organs like the thyroid or kidney, which have a fibrous capsule, may be decorticated without pain by injecting the cocain underneath the capsule. The same process is applicable to the periosteum.

It may often be possible to render a large surface of mucous membrane completely anæsthetic by simply sprinkling it with a rubber spray containing either a cocain, B. eucain, or tropococain solution. As Schleich observes, the latter substance in the solid state acts effectively and is harmless, while B. eucain has the advantage of being less poisonous, is more stable, and is not affected by boiling, an injection of 1 part in 1000 normal saline solution producing anæsthesia which lasts from ten minutes to an hour (Braun). Anæsthesin (Ritsert) (3-1000 solution) is equally serviceable. Spindler strongly recommends akoin (Trolldenier) 1-1000 solution in physiological saline. It can be depended upon to produce an anæsthesia which is maintained for three-quarters of an hour. Braun's method of using cocain in the form of a spray affords excellent results when employed in combination with ethyl chloride, the effect of which is increased by freezing.

When the capsule has been separated, the insensitive substance of the organ or the bone, as the case may be, is encountered. Lennander has shown that in the case of organs which have a pedicle, *e.g.* the testicle (we would include the thyroid), a more effective anæsthesia is obtained by a simple injection into the pedicle rather than by the production of a diffuse œdema. During excision of the thyroid gland, the resulting pain is more severe when the superior thyroid vessels are ligatured or pulled upon. It is at this stage that the excruciating "radiating" pains occur, *e.g.* the earache and toothache referred to elsewhere.

Our observations have hitherto been almost entirely restricted to the consideration of cocain and its administration, as we agree with Braun that it is more advantageous to possess a thorough knowledge of the use of so well known a local anæsthetic as cocain hydrochloride, than to be continually testing the anæsthetic properties of substances which are new.

The anæsthetic effects of cocain can easily be increased, and at the same time may be more readily obtained, by combining it with other substances in the same way as chloroform is used to augment the narcotic effects of ether. As we have already mentioned, Schleich occasionally adopts solid tropococain for this purpose, especially with regard to the surface of the peritoneum. To scrape or cauterise a large ulcer of skin, Braun employs extensive infiltration with a $\frac{1}{2}$ per cent solution of tropococain (up to more than 50 c.cm.) accompanied by freezing. Schleich also frequently combines the ethyl chloride spray with infiltration in opening certain collections of pus, Lennander making use of anestil for the same purpose. In hypersensitive patients the insertion of the needle may be rendered painless by previously freezing the skin. Braun has shown that local cooling increases in a marked degree the action of cocain by delaying the process of absorption and by lowering the vitality of the tissues (*vide infra*). The combination of a local anæsthetic with freezing has been found very satisfactory in operations on inflamed tissues, which cannot be easily cocainised, *e.g.* in cases of furuncle, whitlow, and dental abscess.

A preliminary injection of morphia ($\frac{1}{6}$ to $\frac{1}{3}$ gr.) half an hour before the operation—although the necessity is seldom indicated—is also an aid to local as well as general anæsthesia. More importance is attached to the necessity of increasing the local action by diminishing the circulation or by reducing the vitality of the tissues (Braun).[1] Cocain is, to a certain extent, a vaso-constrictor, but its anæsthetic qualities are not dependent on this property to the extent that Eversbusch, Laborde, and Maurel declared them to be. Kionka agrees with Schleich in attributing the production of anæsthesia to the fact that the tissues are infiltrated under high pressure, *i.e.* the infiltration produces ischæmia by mechanical compression of the nerve elements.

Ether, ethylchloride, or methylchloride in the form of a spray, act directly on the vitality of the skin by causing a considerable local removal of heat and in this way assist the action of the local anæsthetic. (Ethylchloride, which has a low boiling-point (12·5 C.), is particularly effective.)

Cocain, on the other hand, is a protoplasm poison and acts in virtue of its combination with the protoplasm of nerve tissue. According to Kionka, Hans Meyer maintains that certain anæsthetics act chiefly on the lecithin bodies and cholesterin fats contained in red blood corpuscles and in the cells of nerve ganglia, acting locally as well as when they are taken up in the blood corpuscles and conveyed to the brain. The property of dissolving fat is, for example, an important factor in the explanation of the narcotic action of chloroform.

To explain the specific and elective actions of narcotics, a special affinity for the albumins of the cells must be assumed. This assumption also applies to the adminstration of cocain, as in cases of cocain poisoning only a small quantity of the drug is excreted. The combination is certainly a loose one, and the nerve protoplasm recovers with great rapidity.

By reducing the vitality of the tissues, the local action of an anæsthetic can be strengthened. Further, a similar effect is produced if the tissues are rendered

[1] *Arch. f. Klin. Chir.* Bd. 69.

anæmic, for by this process absorption is retarded. This is the explanation why such artifices as local constriction, cooling (per ethylchloride spray), and the addition of adrenalin, materially increase and prolong the action of a local anæsthetic. Corning[1] was the first to demonstrate the importance of constriction. Similarly Custer's experiments have proved that dilute solutions of cocain diminish the risk of toxæmia due to the delayed absorption on account of the large quantity of the solutions made use of. By intensifying the local effects, the general effects, and in particular the symptoms of poisoning, are obviated not only for the time during which the circulation is interrupted (*e.g.* by constriction), but subsequently when they either fail to appear in any form, or appear only in a slight degree, as the cocain has then entered into harmless combinations which can be readily eliminated from the system.

Adrenalin, which is a local vaso-constrictor (Biedl), is now regarded as the best adjuvant to local anæsthesia. It was first adopted in ophthalmic surgery by Dor and Darus,[2] and in naso-laryngeal surgery by Swain, Bode, and Bukofzer, Braun initiating its use in general surgery. The intensity of its action must, however, be remembered, for even $\frac{1}{10000}$ mg. per kilo is sufficient to raise the blood-pressure in animals.

A 1-2000 to 1-5000 solution of adrenalin produces anæmia of mucous surfaces. Braun found that the injection of a 1-1000 solution into the skin of the forearm produced in five minutes complete blanching for an area with a diameter of 1 to 2 ins., the effect of which lasted for an hour, and was not followed by hyperæmia. According to Braun, $\frac{1}{2}$ mg. of adrenalin in very weak solution produces no general symptoms, while he has never observed any local tissue disturbance caused by adding 3 drops of a 1-1000 solution of adrenalin to 1 c.c. of a 1 per cent or 10 c.c. of a 1-1000 solution of cocain. The addition of adrenalin undoubtedly prolongs anæsthesia for hours, and therefore the injection may be given half an hour before the operation, so as to avoid unnecessary delay in its commencement.

Braun noticed that $\frac{1}{2}$ mg. adrenalin, administered on himself, produced both circulatory and respiratory disturbances; while Schäfer observed that intravenous injections were followed by increasing respiration and muscular efficiency, stimulation of the vagus, with slowing of the pulse and more powerful contractions of the auricles and ventricles, with a rise of the blood-pressure due to contraction of the peripheral vessels. The vessels of the brain also contract under the action of adrenalin.[3]

(m) Appendix to Medullary Anæsthesia

Corning's ingenious suggestion of anæsthetising nerve roots or even the spinal cord itself, by injection into the lumbar region of the subarachnoid space, was first put into practice by Bier. Unfortunately, even though it had been taken up with enthusiasm on all sides, Bier himself had very shortly afterwards to publish a warning against the use of this procedure.

The technique is comparatively easy. With the patient sitting[4] (or lying on the side, if the former position is not possible), a line is drawn joining the highest points of the iliac crests. This crosses the fifth lumbar spine (Tuffier). At a point on this line, 1 cm. from the middle line, a fine hollow needle is thrust directly forwards for a distance of 5, 6, or 7 cm. between the fourth and fifth lumbar spines,

[1] *New York Med. Jour.*, 1885.

[2] Braun recommends Parke Davis' adrenalin solution, which contains adrenalin chloride with salt, some free hydrochloric acid, and aceton chloroform. The suprarenin of the Hochster factory has proved equally good: suprarenin 1 g. to 9 g. common salt in 2 c.cm. of a 10 per cent solution of hydrochloric acid and water to 1000 g.

[3] On one occasion we observed the sudden onset of œdema of the lungs with severe dyspnœa and cyanosis, which lasted half an hour, occur from the inadvertent mixture of 6 per cent adrenalin (Parke) with a 1 per cent cocain solution. 5 c.cm. of the solution were injected.

[4] Fig. 18 (Tuffier) gives an excellent idea of the point where the needle enters between the fourth and fifth lumbar vertebræ.

through the soft tissues and the tough ligamentum subflavum between the laminæ down to the dura and arachnoid. The escape of a few drops of clear cerebro-spinal fluid shows that the point of the needle has reached the right place. Fifteen minims of a $\frac{1}{2}$ to 2 per cent solution of cocaine are then injected. If no fluid escapes it is useless to inject, for there is no proof that the subarachnoid space has been reached. The same may be said if blood escapes, a result due to the wounding of the extradural plexus of veins.

Klien (Grenzgebiete, Jena, 1903) utilised the X-rays in order to determine through

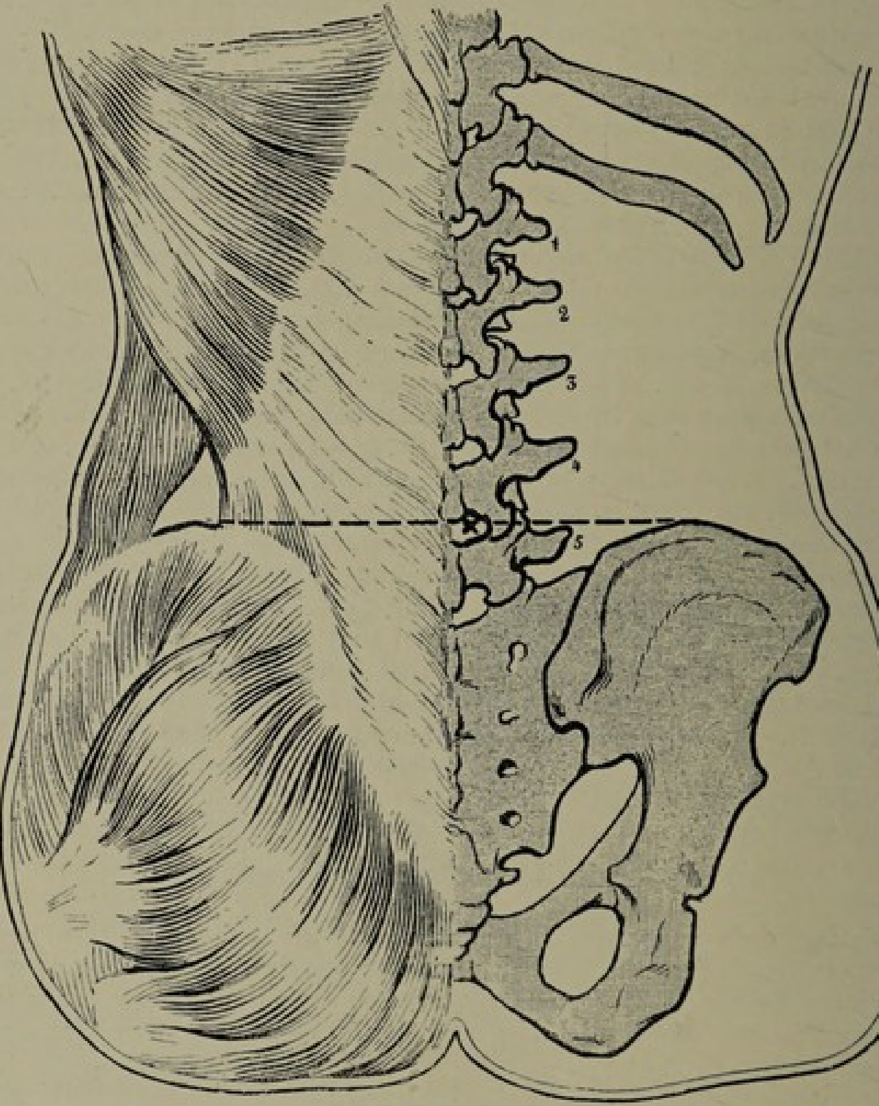

FIG. 18.

which intervertebral space the spinal canal can be most easily reached by puncture. He found, however, that there were very great individual differences. As a rule, the puncture is most easily made in the interval between the third and fourth lumbar vertebræ.

Klien's skiagrams demonstrate the importance of forcibly flexing the trunk so that the intervertebral spaces may be made wider. He recommends the insertion of the needle immediately below the spinous process in a slightly upward direction. If there is any difficulty the puncture may be made some millimetres to one side, the operator at the same time directing the needle towards the middle line.

When the injection has been accomplished, complete anæsthesia of the parts of the

body below the level of the injection is obtained in the space of ten to fifteen minutes, the anæsthetic proving effective on the parts supplied from the lumbar and sacral regions, and in exceptional cases on the areas supplied by the dorsal and lower cervical spinal nerves. This anæsthesia lasts from one to three hours, so that even extensive operations can be performed without sensation on the part of the patient.

There is no doubt something very attractive about this procedure. In the first case in which we employed this method we did not let our students into the secret of the injection, and performed an excision of the ankle, which was very much inflamed,

Fig. 19.

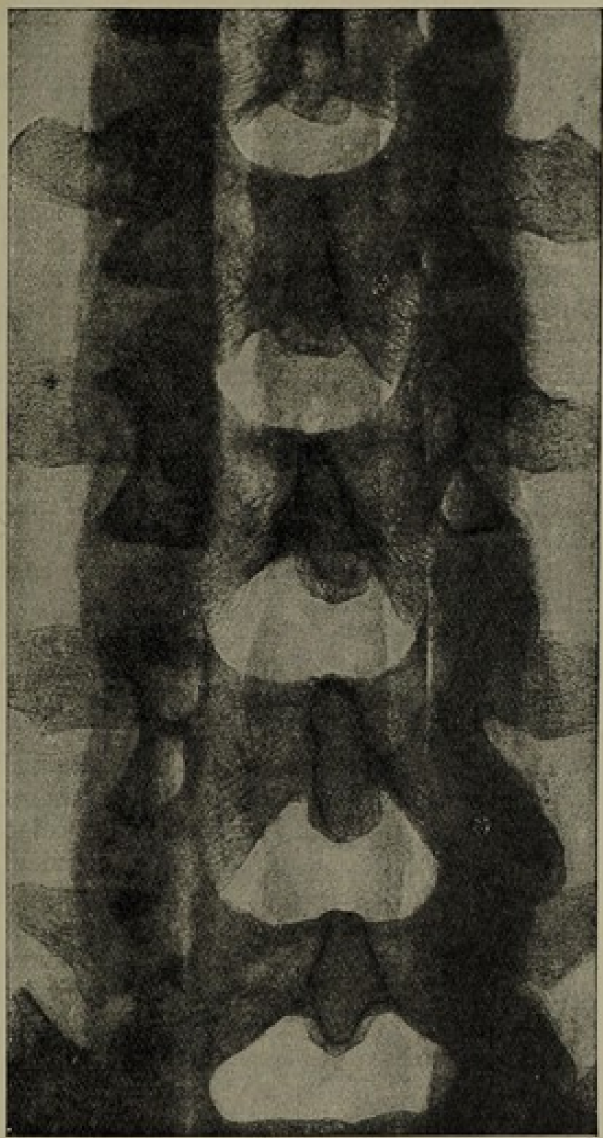

Fig. 20.

Figs. 19 and 20.—Skiagraphs of the lumbar vertebræ (with Prof. Klien's kind permission).

in a child much addicted to screaming. During the operation the patient was engaged in eating and in talking unconcernedly with an assistant behind a curtain which hid from him his diseased foot.

Unfortunately, the anæsthesia is not always so complete, as symptoms appear in a few hours which far exceed in unpleasantness the sequelæ of general anæsthesia. The principal resultant is severe headache, often lasting for several days, frequently accompanied by vomiting, with almost invariably a rise of temperature (to 104° F.), which is particularly liable to cause an erroneous impression of the state of the wound. The temperature generally falls the next day.

Stumme[1] has reported the results of medullary anæsthesia in Mikulicz's clinic. In 21 out of 40 cases anæsthesia was incomplete or absent, while nausea, vomiting, sweating, oppression, tremor, headache, and collapse (2 cases) were noted. As a rule these symptoms were of short duration, but the vomiting occasionally continued for days, while headache was the subject of complaint for as long a period as two months. In addition, pain in the back, exhaustion, and fever were also observed.

In isolated cases more severe after-effects have been noted, which take the form of delirium, with violent excitement, extreme anxiety, breathlessness (respirations 42), very rapid pulse, dilated pupils, and cramps or exaggerated sensibility of the lower extremities. Fever and rapid respiration and pulse continued in one case till the third day, while in a few cases transitory motor paralysis was observed.

Two serious results of this form of anæsthesia still require to be taken notice of. The first may seem questionable to many, but we have observed in cases where the anæsthetic worked particularly well that the wound ran a markedly unfavourable course. This observation was confirmed by Dr. Cushing, to whom the subject had been mentioned. A still more serious result is death following the injection. We have seen one such case, in which the fever and headache failed to subside, and tuberculous meningitis developed. Dr. Dumont has also published a case where death occurred. We cannot with certainty exclude the possibility of deleterious effects produced by cocain on the central nervous system, and especially on its coverings, and which show themselves in headache and other irritative phenomena, giving the necessary impulse to the production of peculiar inflammation in predisposed persons. In consideration of the above facts there can be no question, at least until further research has been carried out, of the general disadvantages of medullary anæsthesia as compared with the much less dangerous and more pleasant form of general anæsthesia.

Every practitioner is not so fortunate as Bier to be able, in his first experiments with a new procedure, to draw attention to its disadvantages. The possibility of preventing the serious after-effects of medullary anæsthesia by choice of suitable media has not been worked out. Bier himself entertains hope of improvement in this direction, and K. Schwarz had no evil results from the use of tropa-cocain ($\frac{3}{4}$ gr.) instead of cocain.

Neugebauer[2] also recommends tropa-cocain in $\frac{3}{4}$ gr. doses. It should be freshly prepared and boiled. He states that anæsthesia appeared in the perineum in the course of a minute, and gradually spread to the genitals, posterior surface of the thighs, the feet, legs, groin, and abdomen. Following Bier's suggestion, Dönitz injected adrenalin along with the cocain. He first injected half a c.cm. of a 1 to 1000 solution of adrenalin diluted with an equal amount of water, followed by an injection of $\frac{1}{8}$ to $\frac{1}{4}$ gr. ($\frac{3}{4}$-$1\frac{1}{2}$ cg.) of cocain. Entirely satisfactory anæsthesia was obtained in this way in animals, and prejudicial after-effects were absent.

As we have already indicated, spinal anæsthesia received a new impulse after the introduction of stovain by Fourneau in 1904. Reclus, who is a staunch supporter of local anæsthesia, declares that stovain is as powerful an analgesic as cocain, and has the advantage of proving less dangerous. Poenaru Caplescu of Jonnesco's clinic regards it as a valuable local anæsthetic in doses of from $\frac{1}{2}$ to 1 gr. (3-7 cg.). Gemuseus, working under Dumont, uses $\frac{1}{2}$ to 1 drachm of a 4 per cent solution for tooth extraction. Foisy considers that stovain is less active than cocain, and that in combination with adrenalin it is apt to cause tissue necroses.

It is chiefly employed in the production of spinal anæsthesia, and we have called attention to the extensive use made of it by Tuffier, while it is highly recommended by Jonnesco. Czerny finds it serviceable in doses of 1-$1\frac{1}{2}$ gr. (6-10 cg.) and Sonnenburg has reported 57 operations under stovain. In eleven of these it failed, but in the other 46 cases the anæsthesia lasted from one-half to three-quarters of an hour, and was attended by no bad after-effects.

Sonnenburg uses the preparation that is sold in sterile tubes. He dilutes it in the syringe with spinal fluid and injects 1 to $1\frac{1}{2}$ gr. (5-7 cg.). After an average

[1] *Beitr. z. klin. Chirurgie*, Bd. 35. [2] Wien, *Klin. Wochenschr.*, 1901.

interval of five and a half minutes the anæsthesia reaches the upper part of the abdomen, including the abdominal organs.

Lastly, at the Berlin Surgical Congress in 1905, Bier and Dönitz communicated their experiences of stovain in combination with paranephrin. They employed a 4 per cent solution instead of the 10 per cent solution that is sold ready for use. It is easily sterilised. They consider that the injection should be made at a higher level than is customary, namely, between the first and second lumbar vertebræ. We should refrain from injection above the interval between the second and third on account of the close proximity of the conus medullaris. The needle is introduced in the middle line. On several occasions Bier and Dönitz found that only unilateral anæsthesia was produced — a satisfactory proof of localised infiltration of the nerve-roots. Bier specially recommends spinal anæsthesia by stovain, combined with paranephrin in elderly feeble people with disease of the pelvic organs.

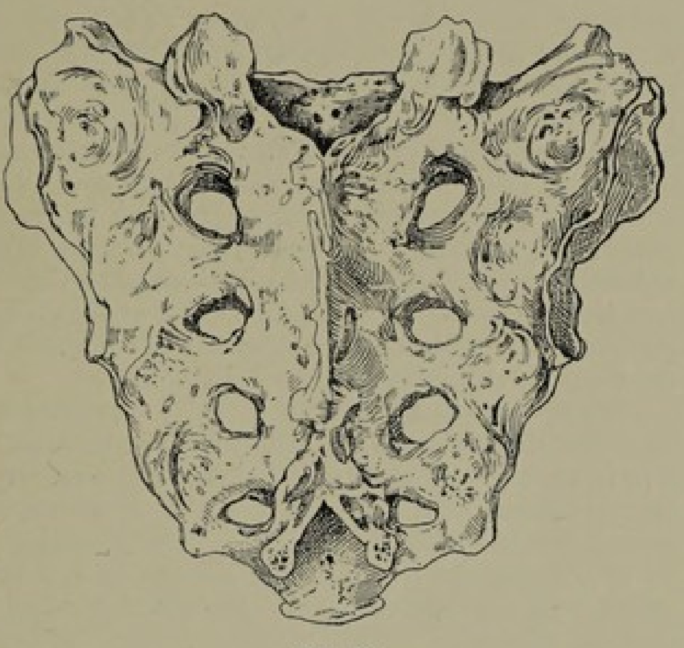

FIG. 21.

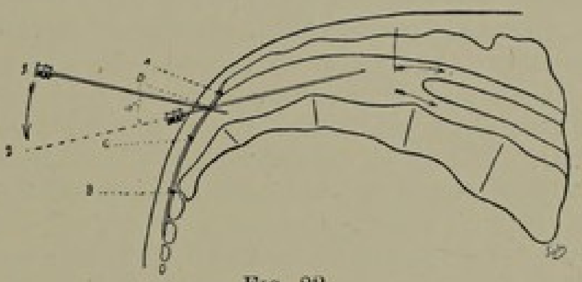

FIG. 22.

FIGS. 21 and 22.—To illustrate Cathelin's method of injecting into sacral canal. Note the alteration in the direction of the needle.

(n) Epidural Injection into the Spinal Canal

Before leaving the subject of spinal anæsthesia we must make allusion to epidural injection. After Tuffier and Hallion's observations had shown that medullary injection acts only on the nerve-roots, Cathelin [1] attempted infiltration of the nerve-roots outside the dura, *i.e.* between the dura and the bony wall of the spinal canal, by puncture of the sacral canal. The veins in the dorsal plexus carry the injection as high as the dorsal region of the cord, owing to their free intercommunication and the narrow outlet from the spinal canal.

The puncture is not easily accomplished, and we have performed it with the patient in the lateral position. A needle, $2\frac{1}{2}$ inches long, is inserted below the last sacral spine between the two prominent posterior sacral tubercles. It is then pushed forwards in the triangular space between these tubercles till it has sufficiently penetrated the thick membrane which closes the space. The needle is then directed upwards towards the sacral canal for a depth of 1 to 2 inches, exactly in the middle line, when the injection is given.

Cathelin explains that the injection acts by the entrance of the anæsthetic into the rich venous plexus between the dura and the wall of the spinal canal. It has also, however, a local action, as he has found the injection produce very satisfactory results in neuralgia of the lower extremities, lumbago, in the radiating pain of tabes and also in cases of enuresis. Cathelin injects 1 drachm (4 g.) of a $\frac{1}{2}$ per cent

[1] *Bull. de la Soc. de Chir.*, 1901, *et Soc. Biol.*

solution of cocain. In dogs he was able to produce complete anæsthesia of the whole body. The two conditions in which Cathelin's method are chiefly indicated are incontinence of urine and pain in the lower half of the body.

(o) Further Details on General Anæsthesia

Rose has stated that no one can avoid an occasional fatality under anæsthesia, as a patient may die suddenly from the nature of his disease, quite apart from the use of the anæsthetic. The truth of this cannot be denied. Death may occur very suddenly from the status thymicus and status lymphaticus, and also from certain circulatory disturbances, *e.g.* atheroma of the coronary arteries. Patients who have a high blood-pressure are liable to apoplexy, and in this connection death has taken place suddenly from an increased blood-pressure in the vessels of the brain. In diseased conditions of nutrition, such as diabetes and Addison's and Basedow's disease, death may occur rapidly under anæsthesia if the disease is far advanced.

All this, however, is no excuse for the frequency with which deaths occur under anæsthesia, because, as we have already observed, general anæsthesia is clearly contra-indicated in these diseases, and if these conditions are not observed, no anæsthetic is free from danger. If a careful examination of the patient is invariably undertaken previous to the operation, one can make practically sure of preventing a fatality as the result of administering the anæsthetic.

We agree with Mikulicz that till the present time ether and chloroform are the only anæsthetics which are sufficiently understood, and which can be safely used for a prolonged severe operation. Among the anæsthetics for minor operations, ethyl-bromide comes first. As we have already stated, it is more advantageous to make oneself familiar with the method of administering a well-known anæsthetic than ever to be striving after new agents for the sake of novelty. The use of laughing gas, which was first discovered by Horace Wells in 1844 (according to Rose), has now been abandoned.

According to Gurlt's statistics (*Deutsch. Gesellschaft f. Chir.*), the mortality from chloroform is 1 in 2075, and from ether 1 in 5112, although countless deaths from chloroform are never published. These figures, as well as personal experience, have induced a large number of surgeons to adopt ether. Certain schools, notably those of Lyons and Boston, have always held firm by ether, and surgeons, who, like Juillard, have used ether exclusively for many years, are most enthusiastic in its favour. Witzel, in recent years, has become one of its staunchest advocates.

Ether was first administered by inhalation by Collins Warren in 1805. Long utilised it for small operations in 1842, but it was not till 1846 that it was regularly adopted by Morton.[1] In 1847 came Simpson's discovery of chloroform. Why is it that in spite of the enthusiasm with which ether has been adopted from the time Morton first made use of it (*vide* earlier editions, and Kappeler's great text-book on Anæsthetics) there are still so many hospital surgeons and practitioners who give their adherence to the use of chloroform? The reason is simply this, that with chloroform one can be certain of producing complete anæsthesia in a brief space of time, whereas with ether this result is impossible. It is, moreover, significant that George W. Gray,[2] a surgeon educated in the Harvard School at Boston, even now finds it necessary to draw particular attention to the cases in which chloroform is preferable to ether, *i.e.* cases in which there is any respiratory impairment.

Further, San Martin[3] makes the assertion that only one fatality from chloroform occurred in Spain during last century, and that in twenty-four years he has only had one death—a result which he attributes to the rarity of alcoholism in Spain, and also to the fact that the anæsthetic is always administered by a specialist. Apart from the latter consideration, we consider that the use of bellows apparatus for giving the

[1] According to Tinker (*Johns Hopkins Hosp. Reports*, Sept. 1902), the credit for introducing ether is really due to Dr. Morton.

[2] *Boston Med. and Surg. Journal*, Oct. 1895. [3] *Revista de med. de Madrid*, 1905, No. 865.

anæsthetic is important, while Martin lays stress on the use of a small nozzle through which the chloroform vapour is blown into the nose.

Chloroform is a much more intense poison than ether. All experiments [1] (Hyderabad Commission) intended to prove that chloroform always causes first an arrest of respiration, and through this an arrest of the action of the heart, are contrary to the experience of surgeons, even in the case of persons in whom after examination no defect of the heart or respiratory system has been demonstrable. This fact is now supported by Embley's experiments (*vide infra*). It may happen that suddenly during chloroform narcosis the face turns pale, the pupils become dilated and immobile, the pulse disappears and the heart stops, while respiration continues regularly or irregularly for a time. Certain observers would refer the early as well as the late syncope to trigeminal reflex with irritation of the cardio-inhibitory centre in the medulla, since often a few drops will determine death (Zoege Manteuffel), but the experiments of Gaskell and Shore on cross circulation in dogs prove with certainty that constant lowering of the blood-pressure and consequent danger of collapse may ensue even if the influence of the brain be excluded, and Winogradoff and Schmidt, under Kronecker, have referred this result to disease of the heart ganglia. Numerous other experiments (English Chloroform Committee, Wood and Hare, Schmey, Kronecker, and others) have proved that chloroform can cause death as a pure cardiac poison. Kronecker and his fellow-workers have shown that the co-ordination centre of the heart is paralysed, and that in dogs it fails to make recovery.

Embley [2] has recently undertaken a large number of experiments with chloroform anæsthesia. Sudden arrest of the heart is due to stimulation of the vagus. Inhalation of air containing more than 2 per cent of chloroform causes weakening of the heart's action and a fall of the blood-pressure; a still higher percentage produces paralysis of the heart. Cardiac paralysis does not occur if the vagi are previously divided, and can be prevented by section of the vagi. On the other hand, stimulation of the vagi, if the heart is already weakened by more than 2 per cent of chloroform, causes cardiac arrest. The fall in blood-pressure is the result of paralysis of the musculature of the heart and the small arteries. The cardiac paralysis comes on without stimulation or sudden alteration in the pulse rate, and the heart dilates. The arrest of respiration either occurring before or after arrest of the heart is due to the fall of blood-pressure, and does not occur without it. Respiration is restored on raising the blood-pressure.

Nevertheless, all these experiments, which appear to disprove the possibility of cardiac paralysis of medullary origin, do not preclude the contingency of cardiac failure from paralysis of the vasomotor centre in the brain, although Gaskell and Shore only observed excitement of the same.

We can, fortunately, avoid these cardiac dangers by administering to the patient *only the dose* he can sustain. The administration of chloroform not sufficiently diluted with air is the cause of the bad effects, and the latter may be referred primarily to reflex influences through trigeminal and vagus twigs in the nose, larynx, and lungs on the cardiac and respiratory centres, and also to the direct influence of the poisoned blood on the heart. Holmgren has shown that the reflex respiratory and cardiac arrest caused by the use of non-concentrated chloroform disappears spontaneously, along with the diminished sensibility which accompanies the further administration of the chloroform as long as the access of fresh air is allowed. According to Cushing, also, death from cardiac arrest is avoided by administering chloroform in proper dilution. Only then it endangers life through paralysis of the respiratory centre of the medulla when narcosis is very prolonged. The volumetric proportion of chloroform and air in which animals can live the longest and with the least damage to themselves has been definitely estimated (5 c.c. to 100 litres air, according to Kronecker). The dangers, therefore, may be avoided by inducing narcosis with a minimum dose, and not increasing the degree and duration of the anæsthesia beyond a certain point.

[1] Cf. Kappeler's excellent article on Narcosis for more exact details in *German Surgery*.
[2] *Brit. Med. Journ.*, April 1902.

The dictum of Sedillot, "pure chloroform properly administered never kills," is therefore justified, and the astonishment of some authors at our earlier method of giving first chloroform and then following up with ether, causes no surprise to those who are properly versed in the use of chloroform. Without the help of an apparatus, or such precautions as will prevent the overstepping of a certain degree of concentration, inexperienced operators should never be allowed to induce chloroform anæsthesia.

Junker's and particularly Kappeler's apparatus, constructed on the basis of Snow's experiments, give the greatest protection in this respect, as they can be regulated so as to obtain a definite percentage of air and chloroform. Dumont recommends Krohne and Sesemann's apparatus.[1] Braun's apparatus is amongst the best.

Although an apparatus by which an admixture by volume of chloroform and air can be supplied possesses undoubted advantages, yet Esmarch's simple mask is still in most common use. The mask depicted here, while preserving the shape of Esmarch's and of Gerard's, leaves a sufficiently wide gap all round to render it impossible to respire too concentrated chloroform, and it has the advantage that narcosis may be induced with minimal doses at first, if the drop method be adopted. This method, which was recommended by us a year before the publication of Zuckerkandl's paper in the *Correspondenzblatt für Schweizerärzte*, in ignorance of Léon Labbé's publication, is now, by the employment of Kappeler's apparatus, the method in general practice. It permits of such a dose being administered to any patient as will induce narcosis without risk.

In the hands, however, of inexperienced or careless anæsthetists a mask does not

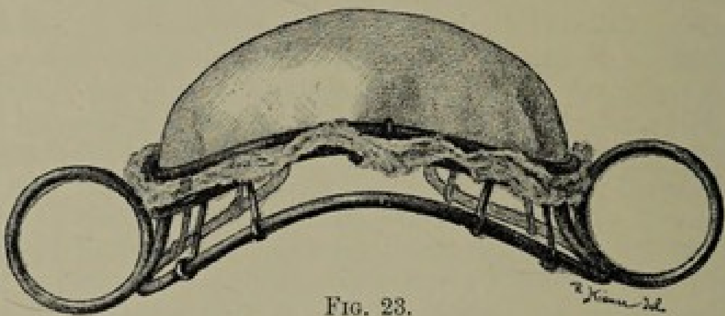

FIG. 23.

give assurance against the worst accident, viz. sudden death at the beginning of the narcosis in comparatively healthy individuals. That these deaths may surely be avoided with proper foresight, every surgeon who has seen thousands of chloroform cases without one such accident will affirm. Bardeleben, after 30,000 cases, had his first experience of such a death. But, it must be admitted that this danger is more difficult to avoid with the use of chloroform than it is with that of ether, because chloroform produces its toxic action in much smaller doses, and therefore Bert's safe interval ("zone maniable") is a much narrower one.

Even careful surgeons are still confronted with the great difficulty of maintaining the right degree of narcosis during a prolonged operation, because by it the blood-pressure becomes markedly reduced, and such complications as loss of blood add still further to the danger.

However, it is not possible to avoid the more intense toxic action which finds its expression on certain organs in the after action of the drug, when narcosis has ceased, since, when anæsthesia has been prolonged, degenerative processes are developed in the vital organs. These changes appear in certain subjects with chronic constitutional or nutritional disturbances, and generally pass off without permanent effect within

[1] Ratimoff, working under Kronecker, found that paralysis of the respiratory centre and death from cardiac paralysis occurred in one hour with 20 cm. of chloroform to 100 litres of air. With 5 c.c. a satisfactory narcosis was maintained for several hours, and for a longer period this required an increase to 7 cm. if the body temperature was kept up. Kappeler found that for satisfactory narcosis 9½ grams of chloroform to 100 litres of air were necessary as an initial dose, but that men required 50 c.cm. According to P. Bert the two extremes are 10 grams per 100 litres for rapid anæsthesia, and 20 grams for sudden death.

a few hours or days, but may in exceptional cases lead to a fatal termination. The latter cases have drawn attention to the fact that certain sequelæ, which were accepted as the more or less necessary accompaniments of the narcotic effect of the anæsthetic, such as vomiting, etc., may have a very palpable causal foundation in certain organic diseases. These special sequelæ of chloroform narcosis do not always even now receive the attention they deserve. Since Fischer and Thiem drew attention to them from their experience of an unfortunate case, a number of observers have furnished experimental proof of their causation.

Nothnagel was the first to furnish experimentally the anatomical basis for the clinical phenomena. Unger, Strassmann, Casper, Fränkel, Schellmann and Ostertag, Bandler and Bastianelli have contributed to a more definite knowledge of the changes. These consist in fatty degeneration of the muscles, especially (but not invariably) of the heart muscle, of the kidneys, stomach, and mucous membranes generally, and of a coincident fatty infiltration of the liver. Ostertag, from the presence of the pigment in the urine, deduces destruction of the red blood corpuscles. Ajello finds hyaline degeneration of the vessels, and deposits of the products of degeneration in the spleen. Fatty degeneration is associated with necrosis of the renal epithelium (Fränkel) and of the lobules of the liver. Marthen found that the changes in the kidneys were especially well-marked. Pohl showed that the largest amount of chloroform was found combined in those organs which contained the greatest proportion of constituents soluble in chloroform—that is to say, in the brain and the red blood corpuscles. Overtoun observed that the different narcotics act by combining with the lecithin and cholesterin-holding constituents of the cells, whereby they induce a change in the physical condition of these cerebral fatty matters, even the loss of the function. Kionka has certainly pointed out that the solubility of fat does not constitute the essential point, but that a specific action must be assumed.

Stiles and M'Donald[1] have sought for the explanation of the deposit of fat in the property of chloroform as a protoplasm poison. They find a similarity between delayed chloroform poisoning and other auto-intoxications, and have observed an increase of acetone in the urine as a result of the fatty degeneration. Offergeld[2] holds with Neudörffer that the deficient oxidation and fatty degeneration are due to the distinctive action of chloroform on the hæmoglobin. He finds parenchymatous nephritis with fatty degeneration the most constant danger. The latter is prevented by ligature of the renal artery, but is increased by ligature of the vein or the ureter. If there is a coexisting nephritis (bacterial or toxic) the epithelial degeneration is increased by the chloroform. Regeneration takes place as the fat disappears and is stored up in the liver. There is less fatty degeneration when chloroform-oxygen narcosis is induced.

Kast and Mester have shown that there is destruction of albumen in chloroform narcosis as proved by the increased excretion of nitrogen, and by the increased proportion of neutral sulphates in the urine. According to Battier and Soulier, chloroform diminishes the amount of glycogen in the liver, and since the latter acts as a destroyer of the poison, the proportion of poison in the urine is increased, and gives rise to vomiting, which may be counteracted by naphthol, washing out of the stomach, and by the administration of glycogen. According to Thiem and Fischer, the safety of repeated chloroform administration may be ascertained by the isonitril reaction upon chloroform in the urine. The urine should no longer reduce Fehling solution. This is important, for, as Schenk has demonstrated, the frequently repeated administration of chloroform at short intervals is followed by a well-marked degeneration.

To be able to definitely ascribe the degenerative changes in the organs to chloroform, other toxic, and especially septic, influences must be excluded. This point has not always been carefully enough noted, as wound infection and its more severe results are especially apt to assert themselves after general anæsthesia. The greater risk of poisoning with other toxic agents, whether they be antiseptic or bacterial, is indeed one of the unfavourable results of general anæsthesia. Galeazzi and Grillo found

[1] *Scot. Med. and Surg. Journal*, 1904. [2] Langenbeck's *Archiv*, Bd. 75.

that after chloroform narcosis rabbits were killed by a dose of diphtheria toxin, which was not fatal to a non-narcotised rabbit, because its elimination suffered in consequence of damaged kidneys, just as, according to Battier's views, the destruction of the poison in the liver was diminished.

As previously mentioned, the direct action of the anæsthetic on the epithelium of the lung is to be regarded as diminishing the bactericidal power of the lungs. According to Snels'[1] experiments it predisposes to severe infections of the lungs after prolonged anæsthesia.

That individuals with fatty liver, kidney disorders, digestive disturbances, chronic poisonings, such as Basedow's disease, etc., should be specially liable to the dangerous sequelæ of general anæsthesia can be readily understood.

Bandler and Leppmann have shown that, in animals, degenerative changes are far less frequent and extensive with ether than with chloroform narcosis. In fatal cases the symptoms from the after-effects of chloroform are mainly those of impaired function of the kidneys and liver, giving rise to vomiting, icterus, diminution in the quantity of urine, and the presence of albumen and casts, and, as Heintz describes, marked acceleration of pulse, and collapse. In Bandler's case (Wölfler's clinic), which ran its course like an acute yellow atrophy, there occurred, in addition to the above symptoms, pains over the liver, headache, delirium, blood in the motions, unconsciousness, and petechial hæmorrhages, while, towards the end, leucin and tyrosin appeared in the urine. Bandler asserts that it is the fat in fatty liver which combines with chloroform, and so induces a complete degeneration resembling that of acute yellow atrophy. These pathological changes are the results of an overdose of chloroform, since they are found only after operations of long duration. And as it is of great importance, in the administration of chloroform, to guard against the occurrence of syncope, it is equally important not to expose the patient's life to the risks of these after-effects when the operation to be performed is likely to be prolonged. It should also be noted that in anæmic and cachectic individuals, and in operations in which a serious loss of blood is entailed, all the above conditions will be exaggerated.

The contraindications to the use of chloroform are numerous—as already described. It is suitable for persons of strong constitution, for children and adolescents. Hagenbach, a very careful observer, has used it almost exclusively for twenty-five years in the Sick Children's Hospital at Basle without a single mishap, using an apparatus devised by himself, which allows of the administration of air along with the chloroform. In time of war, chloroform is the anæsthetic most commonly adopted, because one has to deal with young and healthy subjects, in operations undertaken for recent injuries to soldiers. In unhealthy individuals, *e.g.* in septic cases, the contraindications hold good.

In the author's private clinic, where for twenty years chloroform has been used almost exclusively, only one death has occurred. The case was one in which, during a long operation, begun under ether, chloroform had afterwards to be administered. This is a method we consider objectionable, but one to which we were driven on this occasion, because the patient's struggles rendered it impossible to complete the operation. In our private clinic we have always had the services of the same anæsthetist—a very careful and conscientious man, and a layman.

The dangers of chloroform can therefore be avoided, but experience, and a thorough examination of each individual case before its administration, are imperative. For this reason it is far more convenient to have at our disposal an anæsthetic whose range of safety is less limited, and where want of foresight in its use is not forthwith punished by death of the patient. Such an anæsthetic we have in ether.

That ether narcosis may prove fatal is shown by statistics, but it has this advantage over chloroform, that its action on the heart is insignificant as compared with its action on respiration, and also that the poisonous after-effects involve the other organs to a far less extent. The contraindications to the use of ether can be more precisely formulated, and are in practice more easily determined than are those

[1] *Nederl. Tijdschr. voor Geneeskunde*, 1902.

of chloroform. Respiratory disturbances and pathological changes in the respiratory organs with dyspnœa are the contraindications of prime importance, as ether causes more severe and more lasting damage to the respiratory organs than can be attributed to chloroform.[1]

But we here repeat that these contraindications really apply when the ether is incorrectly administered, not when administered according to the methods described in the earlier section on anæsthesia. Chapman[2] found in rats that the repeated administration of ether produced ecchymoses on the surface of the lung, with alveolar and peribronchial exudation. Pneumonia was readily produced in animals which were made to inhale cultures of the diplococcus after repeated administrations of ether, while it did not occur when they were not etherised.

A deleterious action on the kidneys has also been attributed to ether, but experiments and clinical observation by Roux and Wunderlich, as well as by Fueter and Lerber (under Dumont's direction), show that in this respect ether is certainly not more dangerous than chloroform. Yet Thomson, Colemann, and Kemp, by direct measurements, have shown that ether causes a greater diminution in the amount of blood contained in the kidney, and in the amount of urine secreted by it, than does chloroform. Out of ninety deaths in the Roosevelt Hospital, five were due to renal affection following ether narcosis. Brown has described a considerable decrease in the solids excreted in the urine after etherisation.

Casts and albumen are certainly met with just as frequently after the use of chloroform (Niebergall), and, according to Eisendraht, Zachrisson (Lennander), Lerber, Barbacci and Bebi, Luther and Rindskopf, even more frequently, while Stockvis and Doyer maintain, on the contrary, that kidney affections are decidedly more common after ether.

The peculiar effects of ether on pre-existing congestive, hyperæmic, and inflammatory conditions of the larynx, bronchi, and lungs are well known. Such deaths as we have observed following the administration of ether occurred after operations on cases with marked tracheal stenosis, diseases of the lungs, or empyema.

In cases dying shortly after the operation, with steadily increasing dyspnœa, it was remarkable to observe how great was the hyperæmia of the tracheal and bronchial mucous membranes of even the finest tubes. In all these cases, however, pure ether was given without morphia, and was freely poured on a mask covered with waterproof sheeting.

It is worth while inquiring into the causation of the damage to the respiratory organs, which may end in œdema of the lung, severe bronchitis, hepatisation, and pneumonia. For the elucidation of this point the interesting work of Gottstein is deserving of notice.

If ether, even more than chloroform, be credited with producing a tendency to pneumonia, then, as Gottstein argues, these pneumonias should cease to occur when local anæsthesia is employed. But Gottstein (Mikulicz's clinic) has observed that of 74 non-abdominal operations under cocain, only 1 was followed by pneumonia, whereas in 114 abdominal cases pneumonia occurred in 27—*i.e.* after deducting the cases of pneumonia caused by lymphatic infection following peritonitis, and the cases succeeding vomiting, he still found 14·8 per cent as against only 5·8 per cent in chloroform anæsthesia.

Gottstein accounts for these figures by the fact that the abdominal operations under cocain were performed on old people, and were of a serious nature. Mikulicz considers that there is a danger of pneumonia in all abdominal operations, and for this reason he does not perform the radical cure of hernia unless there are symptoms of incarceration.

He accepts the Gussenbauer-Pietrozowski theory, viz. that pneumonia in these cases results from emboli, which reach the lungs either through the liver, or through direct

[1] Bruns has called attention to the fact that the after-effects of ether result from its impurity. Professor Drechsel informs us that even with the purest ether oxone is generated if it be exposed to the light.

[2] *Annals of Surgery*, 1904.

communication between the portal vein and twigs of the inferior vena cava, and he considers that the infarcts so formed in the lungs may, without being primarily infected, become secondarily infected from the air passages.

These deductions of Gottstein's prove, therefore, that pneumonia following ether narcosis is not to be considered an ether pneumonia as a matter of course. According to some statistics, those of Schultz, for example, pneumonia is more common after chloroform—a fact in accordance with many clinical observations. What is chiefly of importance, however, is the fact that the bad effects of ether on the lungs are in large part avoidable since they are caused by faulty administration of the anæsthetic.

Hölscher[1] (Esmarch's clinic) states that most authors refer bronchitis and pneumonia following ether narcosis to direct irritation of the ether, or to some impurity in the ether (Bruns) acting on the mucous membranes. Nauwerck deserves the credit of having called attention to a new and important source of infection, viz. that owing to the paralysis of the soft palate, the root of the tongue, and the epiglottis, the saliva and mucus, which are both greatly increased, are apt to be drawn back during inspiration, carrying with them organisms from the buccal cavity.

Grossmann considers that the "rattle" consequent on the back-flow of mucus and saliva is the result of bad technique, which he blames as the true cause of the lung affections.[2]

Hölscher, prior to inducing anæsthesia, coloured the fluid of the mouth with a watery solution of gentian violet, according to Lehrwald's procedure. He has ascertained that with the patient in a horizontal position, and with a plentiful accumulation of fluid at the back of the throat, the act of respiration is sufficient to carry the colouring agent to the finest bronchi, and even to immediately under the pleura. Where respiration is obstructed this is proportionately increased in one or other lung, according to the position of the patient, and if the head be propped up this overflow into the lung is much more marked.

But with the head dependent no aspiration occurs, except in cases of tracheal stenosis, and then only as far as the trachea itself. So long as the head is horizontal and is inclined to one side, the mucus and saliva, which are copiously secreted in ether narcosis, are prevented from accumulating at the orifice of the larynx, and are allowed to flow out at the corner of the mouth.

In the surgical clinic at Kiel the headpiece of the operation table is lowered so that the head is dependent, while Witzel operates with the head forcibly thrown backwards.

Hölscher does not believe that a hypersecretion of mucus is demonstrable. At an autopsy performed shortly after death he found no collection of mucus and no hyperæmia. He has also observed, that however marked salivation may be, no mucus is secreted.

In cats, however, which, like human beings, and unlike dogs, are supplied with a great number of mucous glands in the trachea, he found distinct increase in the secretion, as well as mucus in the chalice cells, and also constantly on the general surface of the membrane, but considered that the amount was so small as to be easily removed by the ciliary movements, which, contrary to Bernard and Engelmann's statements, are not paralysed by ether and chloroform.

Hölscher could never satisfy himself of the presence of hyperæmia or inflammation of the trachea or bronchi. For this reason he considers that the tracheal and bronchial mucous membranes are less affected than are those of the mouth, nose, and pharynx, but he thinks that this may be explained on teleological grounds, since the trachea and bronchi cannot exercise this faculty, as they are protected by the mouth and nose.

He finds that salivation occurs with pure ether, even although administered through the trachea; but he admits that a part of the action may be a local irritative one on the termination of the lingual nerve, a view held by Claude Bernard.

He attributes bronchitis and pneumonia partly to the cooling effect of chloroform

[1] Hölscher, "Experiment. Untersuchungen," etc., *Langenb. Arch.* Bd. lvii. 1898, S. 175.

[2] Grossmann, on this account, entirely rejects the mask introduced by Juillard, and recommends his own modification of Wanscher's mask.

and ether (does he make an exception in the case of cocain ?), but for the most part he considers them the result of aspiration of infected material, and of this he adduces ample proofs. Before the Surgical Congress in Berlin, 1901, Henle communicated some very interesting contributions on the subject of the influence of cooling in the causation of pneumonia, and we agree with him that, for protracted operations, a heated operating table, such as we have used for the last twenty-five years, should be universally employed.

Another important cause of cerebral anæmia is marked cooling of the body. This is all the more important from the fact that, in every prolonged anæsthesia, whether from chloroform or ether, not only does the body temperature fall but the blood-pressure is considerably lowered.

One must conclude from Hölscher's experiments that, with healthy respiratory organs, the bad effects of ether may be guarded against, but at the same time there is no proof that the same holds good when the organs are diseased. Just as we consider it certain that heart disease and weakness are the contraindications to the use of chloroform, so are diseases of the respiratory organs and extensive narrowing of the respiratory passages contraindications to the use of ether.

At the German Surgical Congress held at Berlin in 1905, Kelling and Lenhartz, who had made a special study of post-operative pneumonia, regarded aspiration as the chief factor in its prevention. Embolism and extension from the lymphatics were considered as merely secondary considerations. According to Henke, infarcts are not found *post mortem* sufficiently often to attach much importance to an embolic origin.

Lenhartz laid special emphasis on the fact that in abdominal operations the interference with diaphragmatic breathing causes deficient æration in the lower parts of the lung. That interference with respiration plays an important part in the production of pneumonia has been proved by Schloffer (Wölfler's clinic), who recorded 29 cases of pneumonia out of 107 cases of excision of the thyroid under anæsthesia. But since the introduction of scopolamin and morphia narcosis, Kümmel has observed a significant decrease in the frequency of pneumonia. Still in these cases the severity of the injury is not without its influence on the results. Schloffer observed more cases of pneumonia after Bassini's operation for the radical cure of hernia than after any of the other methods. When using ether, therefore, our chief care should be to reduce this tendency to cause damage to the respiratory passages to a minimum by following the rules laid down by Nauwerck, Grossmann, and Hölscher, viz. to adopt a suitable position of the patient, with the head dependent and turned to one side, to allow the saliva to flow away as it is secreted according to the statements of Hofmann, Witzel, and others. But still more important than position is the dilution of the ether vapour with air.

Schmidt (Kronecker) has observed how well animals, which otherwise suffer from severe catarrhal affections of the air passages, bear ether administered by Kronecker's apparatus, the ether mixed with moist air being blown down the nostrils. But there is still another factor which must be kept carefully in mind. When ether (on account of its weakness as compared with chloroform, and of the larger dose required) is administered by the "asphyxiation method," which is effected by pouring a large quantity of ether into a mask and excluding the air, hyperæmia of the lungs and marked salivary secretion always result, evils which may be prevented by diluting the ether with air.

Dreser has formulated the same rule for ether as for chloroform, viz. that a definite proportion of air should be used with it. He starts with 2 c.c. and rises to 4 c.c. of ether in 10 litres. In this way he guards against the sensation of choking, and against irritation of the bronchi. Cushny (Kronecker) has experimented with carefully measured mixtures of chloroform and of ether, which he introduced through tubes into the nose by means of water pressure, and he proved that narcosis could be induced by means of 15 to 20 per cent of chloroform vapour, and that it could be maintained with 5 to 7½ per cent, while a 20 to 30 per cent ether mixture did not always cause anæsthesia, and, to maintain narcosis, ether required a higher percentage than chloroform (20 to 25 per cent). As will be shown later, Braun, of

Leipzig, has arrived at the conclusion that, in proper dilution (6 to 7 per cent by volume), ether has no bad effects on the respiratory organs, but that in this form it is not always powerful enough to induce complete anæsthesia. Hofmann and Witzel dilute the ether with air by dropping the ether from some height on to an open mask. In cases where the diluted mixture is not strong enough to produce complete narcosis, we endeavour to avoid the evils of more concentrated ether vapour by inducing anæsthesia with a small dose of a rapidly acting anæsthetic, such as bromethyl, which for healthy adults is harmless in small doses. Bromethyl has now quite superseded chloroform for this purpose, though Lennander, following Zachrisson, obtained very good results with the latter.

Recommended by Nunneley in 1849, bromethyl has found a strong advocate in Haffter of Frauenfeld. We have made use of it in accordance with Haffter's methods and writings, and can fully confirm his experiences.

Narcosis may be induced in adults by 20 to 30 g. of bromethyl, the whole dose being put into a mask, covered with impermeable tissue, and inhaled for 30 to 60 seconds. There is then no need for the large doses of ether with exclusion of air, and satisfactory anæsthesia can be maintained for a long time without the cyanosis from impediment to the breathing, and without the rattle consequent on the backward flow of the saliva. Bromethyl is quite unnecessary for children or weakly and delicate individuals. We have never seen anything to cause us anxiety when using Haffter's doses; but we use only one small dose, and never repeat it, as it is only by prolonging the bromethyl narcosis that we feel any danger is incurred. It should not be administered for any prolonged operation.

Regli has described a deleterious action on the kidneys and lungs after the use of bromethyl alone, and, in the case of alcoholics, he has entirely failed to induce narcosis sufficiently deep as to ensure muscular relaxation. Abonig and Baracz give similar experiences. The latter author rightly points out that induction of chloroform narcosis with bromethyl is dangerous, although, since introduced by Ebermann, this method (the Poitou-Düplessy method) has attained great popularity in France (Dumont), and although, according to Dastre, the toxic properties of the two substances are antagonistic, both, however, act deleteriously on the heart (Löhrs) and blood-pressure, and whereas ether at once counteracts the passing depression caused by bromethyl, chloroform rather accentuates it.

The results of bromethyl-chloroform narcosis recorded by Rein in Diakonow's clinic are not in favour of this combined procedure. In 167 cases asphyxia resulted 12 times, the pulse stopped in 8, and no fewer than 7 deaths occurred in 2260 cases anæsthetised.

Whether the drop-method of administering bromethyl or the administration by Braun's apparatus prior to ether should remove the last objection to this procedure, if the maximum dose is never exceeded has still to be proved. We do not consider it adapted to all cases. Partsch's experiences (Larisch) are very much in favour of the drop-method. The method above described of administering bromethyl prior to ether so facilitates the induction of anæsthesia (both for the doctor and the patient, on account of the rapidity and ease with which it is induced in strong individuals) that we should no longer neglect such an excellent expedient. For all cases where there are no definite contraindications to a general anæsthetic, it is immeasurably superior to medullary anæsthesia.

A period of excitement with screaming, struggling, and clonic and tonic contractions of the muscles, accompanied by difficulty in respiration and cyanosis, reflex action on the heart and respiration, spasmodic respiration, or arrest of both heart and respiration, we have never seen occur in bromethyl anæsthesia. How these untoward accidents can be avoided with pure ether anæsthesia we have already fully discussed in an earlier chapter on Anæsthesia.

In a certain number of diseases there are absolute contraindications to the use of ether as well as chloroform, as one or other could only be administered at a risk to the patient's life.

Amongst those contraindications are included all those conditions with which are

associated advanced degeneration of the cardiac muscle, of the liver, of the kidneys, or of the lymphatic system—that is to say, in a number of conditions implying disturbances of general nutrition, such as Addison's and Basedow's diseases, "cachexia thyreopriva," severe forms of anæmia, marked degrees of fatty degeneration and alcoholism, conditions of inanition, sepsis, severe poisoning, diabetes (Becker has collected twelve cases of death from diabetic coma following anæsthesia), and particularly the status thymicus and status lymphaticus.

According to Mikulicz and Stein, chronic inflammation of the cervical glands increases the risk of anæsthesia. Death may occur after operation in patients who are of a "lymphatic diathesis" (Doyer),[1] even without enlargement of the thymus.

The number of deaths under an anæsthetic (ether as well as chloroform) in subjects with enlarged thymus and enlargement of the lymphatic apparatus is proportionately high, and is all the more striking from the fact that the victim is usually in the early decades of life, when, as a rule, the administration of a general anæsthetic presents the fewest dangers. Friedjung, in his review of the literature relating to the status lymphaticus, has found only one death under ether, as opposed to numerous deaths under chloroform. Dr. Hedinger reported to us a case of death following the administration of ethylbromide. Here also the status lymphaticus was present. In our own practice, one death under ether (in a boy aged sixteen years), which occurred, in 1896, during an operation on a fistulous empyema, depended on the status lymphaticus. In these cases death occurs from cardiac paralysis *during* the administration of the anæsthetic, but it occasionally occurs *after* the administration of the anæsthetic. In goitre, and especially in cases of Basedow's disease,[2] fatalities are particularly frequent.

Dr. Hedinger has stated that the *post mortem* examinations held in the Pathological Institute at Berne (Langhans) showed that the status lymphaticus or a persistence of the thymus was present in all the cases of death under chloroform. This is in accordance with Kundrat's statements. The same conditions were also found in a case of Basedow's disease, where the patient died suddenly after "struma extirpation." The explanation may be found either in mechanical influence on the heart or its nerves, a hyperthymisation or an autointoxication, from inefficiency of the lymph glands in removing the products of assimilation, or in a hypoplasia of the chromafin apparatus.

Friedjung attributes the fatal issue in part to mechanical causes resulting from the position of the trachea between the thymus and the innominate artery. But Paltauf and Kundrat very properly do not consider it as positively proved that the cause is mechanical. Schlömischer points out that, in subjects affected with the status lymphaticus, death does not depend on the nature of the anæsthetic, but occurs as frequently with ether as with chloroform. It is, therefore, desirable to percuss out the sternal region, to palpate the supra-sternal fossa, to examine the throat for tonsillar hypertrophy, and to investigate the spleen, since by neglect of these precautions the patient's life may be exposed to extreme danger. If it should then be deemed necessary, a preparatory course of thymus extract may be adopted, as suggested by Escherich.

The opinion we hold and the procedure we favour in regard to anæsthesia have been already stated in the chapter dealing with the regulations for the beginning of the operation.

In the absence of the conditions mentioned previously as contraindications, ether administered in the way already described is the best anæsthetic.

(1) If the state of ether-intoxication (Sudeck) is desired, the ether is administered on Czerny's mask, which is firmly applied to the face, a form equally useful for either short or interrupted anæsthesia (*e.g.* combined with local anæsthesia).

(2) It may be administered by means of the drop-method (Hofmann and Witzel)

[1] *Annals of Surgery*, 1904.

[2] In these subjects a combination with the status lymphaticus is, according to Mobius, Spencer, and Schnitzler, of frequent occurrence.

where the pelvis is lowered and, if necessary, the head is thrown back, or as an equivalent, Braun's bellows may be brought into operation.

(3) It may be administered in combination with other drugs if the operator finds the individual resistant to the action of the anæsthetic. Morphia may be previously injected (Riedel, Kümmel, Witzel, and others) or the anæsthetic may be induced with a single dose of ethylbromide. Stimulants should always be given half an hour before operation.

In all cases where there is no hindrance to the breathing and no affection of the respiratory organs, ether must be regarded as the most suitable anæsthetic. The best method of procedure is to induce narcosis with a single dose of bromethyl, and to maintain it with ether in measured doses. The drop-method is not sufficient, but success is generally ensured by pouring on measured quantities of ether, according to the effect produced on the patient.

In this way, as proved by statistics collected from our clinic by Dr. Oppikofer, quiet anæsthesia is obtained, on an average, in 6·41 minutes, the patient's sensation and respiration requiring careful observation.

The condition of the pupil is a valuable indication of the degree of anæsthesia. According to Kappeler, as sensibility disappears the pupil becomes small, whereas in the excitable stage it may be dilated. The behaviour of the pupil is, however, much less constant with ether than with chloroform. In prolonged ether narcosis the pupils should be watched, and this is still more important when there is a special necessity for inducing anæsthesia with chloroform. In a patient under the influence of chloroform, whenever slowing of the pulse is apparent enough has been given. Further administration is to court danger, while slowing of the breathing is also a sign to be cautious in continuing the chloroform.

Stertorous breathing, athetosis of the finger (Koblank), complete muscular relaxation, and irregular pulse indicate that the full permissible dose has been exceeded. It is frequently difficult to obtain quiet and complete narcosis in alcoholic subjects. The difficulty is best overcome by a previous injection of $\frac{1}{4}$ grain morphia. We restrict the use of morphia, fearing, like Kümmel, the production of respiratory disturbances. Moreover, by giving alcohol in large doses, we can much more efficiently facilitate the induction of anæsthesia. Franck also protests against the use of morphia on account of its depressing action on respiration. The addition of $\frac{1}{60}$ grain atropin, as suggested by Dastre, would appear to guard against dangerous reflexes (*e.g.* cardiac arrest) acting through the vagus. It certainly acts effectively by preventing the secretion of saliva, but Franck asserts that it cannot be given in sufficiently large doses to be of any service.

Chloroform should supplant ether in all cases where, in the absence of a definite contraindication, disease of the respiratory organs is found to be present. It should invariably be given by an apparatus which allows of an admixture of air, at first in minimum doses, and its administration should be regulated by the condition of the pulse and the state of the pupils.

Prolonged anæsthesia with chloroform should always be avoided, and in any case it is only to be employed with an apparatus which ensures accurate measurement of the dose. According to Wohlgemuth[1] Neudörffer was the first to conduct investigations with chloroform and oxygen. Kreutzmann improved the method of using it, while Hillischer recommends gas and oxygen anæsthesia, and Krönig still commences his oxygen-ether-chloroform anæsthesia with laughing gas.

In 1901 Wohlgemuth adopted a practical method of administering chloroform and oxygen, in which oxygen from a steel cylinder was passed through a U-shaped tube over a wad soaked with chloroform. The Roth-Dräger drop-apparatus for chloroform, ether, and ethyl bromide is an improved and simplified form of Wohlgemuth's apparatus. By its means the quantity of chloroform mixed with the oxygen can be accurately measured, and any alteration can at once be made by simply moving an indicator.

Wohlgemuth states as the advantages of oxygen-chloroform anæsthesia :—The

[1] *Arch. f. klin. Chir.* Bd. 64.

face retains a good colour, the pulse is slower, the breathing regular and quiet, and the pupils are contracted and do not react, while the stage of excitement is absent or short, and there is no salivation.

The Roth-Dräger apparatus admits of the administration of 3 litres of oxygen per minute. If the indicator points to 25 drops, the mixture contains $\frac{1}{3}$ gr. (5 min.) of chloroform; and as a rule it is sufficient to have the indicator at 35 drops, while in alcoholics it has to be placed at 65 drops. Wohlgemuth found 0·1 of chloroform in 1 litre of oxygen was necessary for satisfactory anæsthesia.

Oxygen-chloroform anæsthesia should replace ether, when the latter is contra-indicated by dyspnœa or disease of the lungs.

The best forms of apparatus are built on Braun's principle, *i.e.* it is possible to administer different anæsthetics simultaneously, or alternately, by simply turning a stopcock. According to calculations made by Kionka for Krönig, the Roth-Dräger apparatus is unsatisfactory when the anæsthetic is begun with ether, for only 5·7 per cent of ether vapour by volume is produced instead of 7 volumes.

Krönig begins by placing 45 drops of chloroform and 180 drops of ether in the apparatus, and continues the anæsthesia with 5 drops of chloroform and 120 of ether per minute. As a rule, however, he induces the anæsthesia with laughing gas (Bennet's inhaler) just as we use ethylbromide.

By following the instructions we have already given, the risk of suffocation and fainting with which we had formerly to contend need no longer be faced. Suffocation may follow incautious administration and depends on closure of the glottis owing to the so-called "swallowing of the tongue" (really falling back of the epiglottis), or on spasm, or on blood, mucus, or food getting into the glottis. Syncope is dependent on cerebral anæmia.

Suffocation by too intense stimulation of the terminations of the fifth nerve (also of the laryngeal nerves, and of the vagus terminations in the upper air passages) is due to the sudden contact of concentrated vapours. This is the cause of the reflex spasm of the glottis and of the involuntary muscles of respiration, and also of cardiac arrest. Rosenberg prevents these reflex effects by spraying the mucous membrane of the nose with a 10 per cent solution of cocain, and François Frank also recommends this method.

"Swallowing the tongue" is a consequence of the paralysis of the muscles of the tongue and pharynx, the flaccid epiglottis falling back and occluding the entrance to the larynx during inspiration. In a patient in whom we had to resect the lower lip along with the chin and the central part of the jaw, we were easily able to convince ourselves that such is really the mechanism.

This complication is avoided by the Heiberg-Esmarch grip, by placing the four fingers behind the angle of the jaw and pushing it forwards. The effect of this, as we were able to demonstrate in the above case, depends not merely on the pushing forward of the tongue—how frequently we see that pulling out the tongue with forceps has no effect—but on its being lifted up, thus putting the glosso-epiglottidean ligaments and the epiglottis on the stretch. Our mask is constructed with two rings (Fig. 23) for the thumbs, the fingers being kept in such a position that they are ready to grip the jaw. Witzel prevents its occurrence by having the head bent backwards so that the muscles from the jaw to the tongue and larynx are put on the stretch.

Obstruction from blood, saliva, or mucus is avoided by inclining the body with the head downwards.

Food may be prevented from entering the larynx by keeping the stomach empty, either by a fast for three to five hours previous to the operation, or, where this is impossible, owing either to the exhausted condition of the patient or to the pressing necessity for immediate operation, by emptying the stomach by means of the syphon. This should never be forgotten. Vomiting of itself is of no consequence, except in so far as it brings up food-stuffs. It seldom occurs, however, if the stomach be empty. A special precaution to be taken to heart by young anæsthetists is not to keep the jaw forward when vomiting sets in, as by lifting up the epiglottis stomach contents

gain access to the larynx.[1] Attacks of syncope are far graver than the danger of suffocation. The best means of preventing the cerebral anæmia, which is responsible for sudden syncope, is by placing the patient on an incline, with the head more dependent than the trunk and legs. The introduction of the Trendelenburg position has made it very easy to carry this out, and experience goes to prove that syncope need not be feared with the patient in this position. This gives the Trendelenburg position the advantage over that of Rose, in which the operation is performed with the head hanging over the end of the table.

Further, cerebral anæmia is to be expected when there is extreme loss of blood, and, when this is unavoidable, the anæsthesia should be immediately stopped. The best means of avoiding the danger consequent upon the loss of blood is immediate intravenous transfusion of a ·75 per cent salt solution at 38° to 41° C. The administration of the anæsthetic should be stopped also in cases where anæmia of the brain is produced, *e.g.* in ligature of the carotid.

Another important cause of cerebal anæmia is marked cooling of the body. This is all the more important from the fact that, in every prolonged anæsthesia, whether from chloroform or ether, not only does the body temperature fall but the blood-pressure is considerably lowered. It is to be avoided by keeping the patient warm.[2]

Fear and anxiety perceptibly increase the tendency to syncope. In such circumstances a dose of morphia may be ungrudgingly given before operation, but an appropriate dose of alcohol, or, better still, of tea with some brandy in it, is perhaps more effective. According to Feilchenfeld, the addition of five or six drops of tincture of strophanthus is sufficient to ensure complete composure if given on the morning of, and for two nights before, the operation. The subcutaneous injection of morphia before beginning the operation would seem to be a very doubtful proceeding, because in certain persons morphia rapidly produces a sensation of uneasiness with accompanying attacks of syncope.

In one of our last cases of death under chloroform, in which all precautions had been taken, we are inclined to ascribe death, which took place at the very commencement of the operation, to this idiosyncrasy. The patient had had an injection of $\frac{1}{6}$ grain of morphia immediately before the operation, instead of half an hour beforehand, as had been ordered. The patient, a woman of eighty years of age, suffering from trigeminal neuralgia, collapsed at the first incision, the pulse disappeared, respiration stopped, and the face assumed a bluish tint.

Finally, cerebral anæmia from shock consequent upon too early commencement of the operation must be guarded against. If the sensibility is not entirely suspended, a sudden intense pain in certain sensitive nerve areas may result in severe shock, as Crile has quite recently shown. Cushing has also noticed similar shock during anæsthesia when large nerve trunks are severed. This can be avoided by making the skin incision under cocain or by injecting the nerve trunks with cocain.

Stein,[3] who has a wide experience in anæsthesia, draws special attention to the sudden onset of the following symptoms, viz. dilated pupils, intermittent breathing, rapid pulse and pallor, when very sensitive tissues (parietal peritoneum) are handled. Probably the greatest benefit derived from morphia is that it alleviates these unfavourable conditions, which are reflexly produced and occasioned by pain. It also prevents the stage of great excitement during which impatient administration of the anæsthetic is particularly dangerous.

If cardiac and respiratory arrest (which are usually associated with pallor or slight cyanosis and dilatation of the pupils) should occur during anæsthesia, in spite of careful attention to the above prescribed rules, there remain but three reliable procedures, viz. artificial respiration, transfusion, and cardiac massage. Artificial

[1] A short time ago we saw a fatality occur during ether anæsthesia because the stomach had not been emptied. As the anæsthetist did not immediately pay attention to this, asphyxia resulted from vomiting.

[2] According to Allan a higher temperature of the surrounding air is dangerous. In animals anæsthetised in a heated room the temperature rises while the blood-pressure falls in a marked degree.

[3] *Prager med. Wochenschr.*, 1903.

respiration is the expedient to which one naturally turns in every case. As long as respiration continues there is hope of resuscitating the cardiac and cerebral action. Many experimenters have been much astonished by the fact that animals, if artificial respiration be kept up, are not killed even by a very considerable pressure on the brain, and it is unfortunate that in man we have not got a convenient means of inducing and maintaining respiration. With Kronecker's apparatus a deep and regular respiration can be kept up for hours, by firmly tying a tube into the trachea and pumping in air periodically. There appears to us no doubt but that the inefficiency of artificial respiration in man, in a certain proportion of cases, depends upon imperfect methods of carrying it out. Larborde reflexly stimulates the voluntary muscles of respiration by rhythmical traction on the tongue, with irritation of the naso-larygneal nerves. Knapp and others extol this method, which is supposed to act by exciting the respiratory centre through irritation of the glosso-pharyngeal and superior laryngeal nerves. Strong faradic stimulation of the phrenic nerves, as already described, is very useful under certain circumstances, and we are not convinced of the general applicability of Braatz's objections to the procedure.

Of the methods in vogue for inducing passive respiratory movements, that of Schüller is, according to Djelitzin, the most effective. The same method was introduced in our own clinic quite independently by Roux. It consists in raising and forcibly depressing the lower costal arches by seizing them from above with four fingers close to the sternum (Djelitzin). How deep an inspiration and expiration are thus obtained can easily be demonstrated. Djelitzin at the same time raises the thorax and relaxes the abdomen by flexing the thighs.

Sylvester's method, also very successful, consists in stretching the thoracic muscles by raising the arms till the elbows touch behind the head, and then forcibly depressing them against the ribs and towards the sternum. The tongue must be simultaneously pulled out or tracheotomy performed. Brosch cordially agrees with Djelitzin's observations and writings on the technique of Schüller's method. He has established the fact that the greatest increase in the capacity of the thorax is obtained by increasing and decreasing the sagittal diameter. He therefore places a high cushion between the shoulders, moves the arms upwards past the head, and then forces them backwards towards the ground, thus causing inspiration. For expiration he presses the approximated elbows with increasing force against the chest wall.

Of the methods of pumping air into the lungs Kronecker's apparatus seems to us the most efficient. The mouth is kept open for expiration.

Transfusion may take the form of auto-transfusion by placing the body in a sloping position.

The supreme importance of the position of the body during anæsthesia has been recently demonstrated by the interesting experiments of Leonard Hill on the influence of gravity on the circulation. In dogs rapidly anæsthetised with chloroform, or chloroform and ether, the pressure in the carotids rapidly sinks to zero, rising immediately the body is raised into an inclined position with the head low, if the abdomen is compressed or firmly bandaged. These phenomena are not influenced by artificial respiration. With ether the blood-pressure falls much less rapidly, and the action of both anæsthetics continues for some time after their administration has been discontinued.

Opening the abdomen when the feet are lower than the head causes a serious fall in the blood-pressure. The risk run by persons in whom the blood-pressure is *a priori* low and whose heart action is feeble (changes in the heart muscle, or exhaustion from tachycardia) is particularly great if the effect of the influence of gravity on the circulation be not carefully considered. Further, the normal compensation for the influence of gravity brought about by the vaso-constrictors of the splanchnic system is upset in all persons who have been in the horizontal position, a condition occurring in a large number of our operation cases. Although cessation of respiration always occurs first, yet, according to Hill, it is the vaso-motor paralysis which induces the most urgent symptoms. But the final and most dangerous arrest of respiration (with shallow Cheyne-Stokes breathing) is the result of a failing blood-supply to the

respiratory centre and to the brain in general, and is consequent upon vaso-motor paralysis, which can only be removed by rapidly raising the blood-pressure.

That the heart can still continue to beat after the brain is paralysed is accounted for by the fact that the circulation may persist longer in the coronary arteries.

It should also be kept in mind that firm bandaging of the abdomen, which Leonard Hill has practised in animals, is an aid to the vaso-motor nerves in producing compensation for lowered blood-pressure. This procedure is, however, only permissible when it does not seriously interfere with respiration—that is to say, where respiration is almost completely thoracic, and therefore chiefly applicable to women. For this reason chloroform is very safe in parturient women (Hill). It is more advisable in every case where vaso-motor paralysis is apprehended—that is, according to Hill, in every case of narcosis, and especially chloroform narcosis—to place the patient in an inclined position.

According to Hill it is of greater importance to raise the pelvis than to raise the legs, but this must not be carried so far as to slowly engorge the heart, for chloroform itself may directly paralyse the heart muscle. This was proved by Gaskell and Shore in their experiments with crossed circulation, the brain being excluded and respiration being maintained. Hill recommends the alternate compression of the abdomen and the thorax: by the former the heart is filled and by the latter emptied. This is, in short, the procedure usually followed in performing artificial respiration.

Next to transfusion, therefore, correct position of the body is our most valued safeguard, but more as a prophylactic measure — a precaution to be taken at the commencement of the operation. Every operation under chloroform and even when the patient's blood-pressure is naturally low, should be performed with the body in a slightly sloped position, the pelvis and lower extremities being slightly raised, and attempts at resuscitation, in all cases in which the blood-pressure has fallen, should be conducted with the body inclined at a moderate angle.

Heart massage has recently proved one of the most effective measures against syncope when the latter is produced by the action of the anæsthetic on the heart.

Krönig recommends a rapid succession of blows over the præcordia, while Hill compresses the abdomen and thorax alternately. A still more effective method of carrying out this principle is by massage of the exposed heart, as recommended first by Schiff, then by Batelli [1] and Prus, and carried out by Tuffier, Hallion, Maag, and others on the living subject.

By this heroic treatment Prus succeeded in resuscitating sixteen out of twenty-one animals killed by chloroform, and thirty-one of forty-four artificially suffocated, although respiration had been suspended for an hour.

Kemp and Gardiner [2] were able to resuscitate by cardiac massage eleven of twenty-three dogs killed by chloroform. They recommend elevation of the pelvis, artificial respiration with intubation and an air pump, incision of the chest wall, and even resection of parts of fifth and sixth ribs. Two fingers are then passed behind the heart, and the latter is rhythmically compressed against the chest wall or against the thumb. Schiff, and also Batelli, performed artificial respiration at the same time. Care should be taken that the temperature be sustained.

Bomcard [3] has successfully performed cardiac massage in animals through an incision in the diaphragm. A mesial incision was made downwards from the xiphisternum through which the heart was pulled down and massaged till it beat again with regularity.

Prevost and Batelli have restored the heart contractions by means of alternating currents of 240 volts, one electrode being inserted in the rectum and the other over the heart. Kronecker places one electrode in the œsophagus instead of over the heart.

Prus, however, employed another aid to resuscitation, viz. transfusion, which was merely another means of attaining Hill's object of supplying blood to the heart and brain. The extraordinary effects of this in hæmorrhage, where the blood-pressure has fallen to a minimum, are well recognised. In such cases auto-transfusion is no

[1] *Journal de physiol.*, 1900. [2] *Revue méd. de la Suisse romande*, Oct. 1903.
[3] *New York and Philadelphia Med. Jour.*, 1904.

longer sufficient. Moreover, as it is so often required in those cases where, combined with severe hæmorrhage, the blood-pressure is being lowered by some toxic absorption, it would appear quite justifiable as a means of resuscitation in those cases where the blood-pressure has fallen.

Borrow has seen such success follow the subcutaneous injection of relatively small quantities of normal saline solution that he is quite enthusiastic about this method. Long before Borrow's paper was published, we were in the habit, in our lectures, of recommending intravenous transfusion as a valuable remedy in cases of chloroform collapse, and we instructed one of our students, Miss Gomberg, to study the action of transfusion experimentally under Kronecker's direction.

Some of our clinical experiences are thoroughly convincing. A boy of eleven, who was being operated on for a retro-maxillary tumour, suddenly became pulseless at the end of the operation, respiration ceased, and the pupils no longer reacted. Stimulating injections and subcutaneous infusions were administered without success. Lowering the head had no effect. Tracheotomy was performed and artificial respiration begun; at the end of twenty minutes no reaction could be made out beyond an occasional spasmodic contraction of the face; the median basilic vein was opened (no blood escaped from it), and one litre of salt solution at 41° C. was slowly injected. Spontaneous respiration then appeared, the cardiac impulse became palpable, and, lastly, the pulse returned at the wrist.

After removal of a fibro-sarcoma from the base of the skull in a boy, paralysis of respiration supervened, and lasted for one hour, with a just perceptible, very rapid pulse (150), and complete unconsciousness. Chloroform had been given through a tracheotomy tube. Præcordial massage and artificial respiration produced no result, although the application of a strong faradic current to the phrenic nerves (the disc on the abdomen and the small rounded electrode on the anterior border of the scalenus anticus) caused satisfactory respiratory movements. Immediately on stopping the faradic current the pulse became weak. After an hour two litres of salt solution were transfused into the median basilic vein. One litre had been previously given subcutaneously with no effect. Almost immediately spontaneous respiration commenced, and the patient began to respond when shouted to. In cases of death from ether, such as those of Kaarsberg, where respiratory arrest occurred while the heart continued to beat, transfusion might have been equally successful.

By filling the heart with fluid, therefore, the activity of the cardiac and respiratory centres may be stimulated, even after prolonged arrest. Kemp and Gardener recommend that the saline solution used for intravenous injection (up to $2\frac{1}{2}$ litres) be heated to a temperature of 40° C., at which degree it is sufficiently warm to exert a stimulating action of the heart. According to Gottlieb's experiments, the blood-pressure may be permanently improved by repeated injection of $\frac{1}{10}$ milligram of adrenalin (*i.e.* approximately two minims of a 1-1000 solution), which effects a direct action on the cardiac ganglion (Münch). He obtained this reaction after complete arrest of the heart for five minutes, especially when he combined it with massage and compression of the præcordia.

Mankowsky even considers that, in apparent death from chloroform, injection of suprarenal extract is more efficacious than any other means of resuscitation.

Our experience in such cases points very definitely to intravenous transfusion. Subcutaneous infusion, when the blood-pressure is reduced to a minimum, is not rapid enough, although it is sufficient in cases of respiratory arrest when the pulse is good; but when syncope has supervened, and subcutaneous injection has no effect, intravenous injection may still be of use. It must be continued to such an extent that the circulatory system is so filled as to ensure that a sufficient quantity of blood goes to the heart, and is thence sent to the brain. We have used up to two litres to attain this object.

It is obvious that artificial respiration and alternate abdominal and præcordial massage must not be relied upon in cases of cessation of respiration. In so far as the fall of blood-pressure and consequent collapse depend on vasomotor paresis (Hill), transfusion is more strongly indicated than any other treatment. If, as Winogradoff,

Schmidt, and Kronecker maintain, this depends on paralysis of the cardiac ganglia, then it, like any other method, will have no influence on a fluttering heart.

It is still an open question whether any benefit is derived from direct stimulation of the cardiac muscles by the König-Mass method, which consists in rhythmical compression of the heart by repeated firm compression of the præcordia. Körte brought a patient round after forty minutes' continued cardiac arrest by this method, combined with intravenous transfusion of salt solution. Kraske was the first to point out that the success attributed to expansion and compression of the thorax in artificial respiration was, in part, due to the artificially-established circulation.

Lockhart Mummery[1] avoids giving stimulants in cases of shock. He advises placing the head low and giving an intravenous injection 1 : 20,000 solution of adrenalin in saline (in case of laparotomy it may be injected into the abdomen) compressing the abdomen, and—as has been already done in America—raising the blood-pressure by pneumatic compression of the extremities.

The improved methods of administering ether have rendered the use of methyl chloride superfluous, although no less an authority than Spencer Wells employed it as his chief anæsthetic. Similarly ethylchloride (Kélène) has no claim to be recommended as a general anæsthetic, as it is not free from danger and offers no obvious advantage over ether or bromethyl.

Ethylchloride was introduced as a general narcotic by Billeter and Carlson. It is much praised by Lotheussen for short operations, as a result of his experience with it in v. Hacker's clinic at Innsbruck. Five grammes are sprayed from fine tubes on to wool, so that it freezes, and this is then inhaled from a Breuer's mask. It is said to cause rapid narcosis, followed by rapid awakening, generally without vomiting. Dumont also praises it. He pours 5 to 10 c.c. into a large Juillard-Dumont ether mask, and when the patient is anæsthetised he continues with ether. He recommends it more especially for the induction of ether narcosis, as its own effect is very transitory, but König's experiments do not say much for it. Seitz published a fatal case not long ago in the *Correspondenzbl. für schweiz. Ärtze.*

In 1896 Soulier discussed the subject and recommended ethylchloride. Several years ago we gave it a trial for general narcosis, with unsatisfactory results, which we cannot, unfortunately, report, as the clinical records of the cases have been lost, and we are therefore not in a position to give definite information as to the preparation employed. Ethylchloride, which boils at 12·5° C., is of chief value as a local anæsthetic, acting by the withdrawal of heat.

Mixtures of different anæsthetics render it more difficult to pronounce a judgment on the individual effects of each.

Kemp points out, if the mixture containing chloroform be considered from the point of view of its volatility, ether remains ether and chloroform chloroform, and, when it is administered by the open inhalation method, the effect is that of pure chloroform. The popularity enjoyed by Harley's A.C.E. mixture, and Billroth's chloroform and ether mixture given in a special way, depends partly upon the fact that they are comparatively safe anæsthetics. If they were used separately, a much more reliable opinion of their value would be formed.

The researches of Honigmann and Kochmann (Kionka) have shown that when two narcotics are used in combination, their anæsthetic properties are considerably increased.

In our opinion it is best to be able to control the mixture by an apparatus, so that one anæsthetic can be given after or in conjunction with the other, as in Braun's apparatus already described.

By means of it the dose can be varied, and either pure chloroform, pure ether, or a mixture of both given according to requirements. If the patient be not sufficiently under the influence of the diluted ether, the chloroform cock can be further opened without exceeding a safe quantity. If, on the other hand, the full dose of chloroform has been given, it may be shut off, and ether, with the correct proportion of air, administered alone.

[1] *Lancet*, March 1904.

A double bottle is used (150 c.c. of ether and 40 c.c. of chloroform) with a bellows which, when squeezed at each inspiration, admits 90 c.c. of air. At first the air contains 6 vols. per cent of ether vapour and 1·7 of chloroform, but later, as the result of cooling, it contains only half this quantity.

Braun, like Witzel, ourselves, and others, only considers ether reliable when it is inspired in a diluted form. In 6 to 7 vols. per cent it produces an ideal narcosis without cyanosis, and without increasing salivary secretion. Where this proportion is not powerful enough, it should be strengthened with chloroform, or chloroform should be substituted. This is the principle on which his apparatus is constructed.

Willy Meyer has also shown that when ether and chloroform are mixed, a new substance, anestol, is formed, the use of which he does not consider entirely safe.

Korff has made efforts to reinforce the action of the anæsthetic by administering scopolamin and morphia, and Kionka (Kochmann) has shown that in the case of dogs the action of each element is greatly increased by the combination of the two drugs. In the case of man, however, several deaths have been recorded as the result of scopolamin-morphia narcosis. According to a more recent communication, Korff injects $\frac{1}{6}$ gr. (0·01) of morphia and $\frac{1}{60}$ gr. (0·0012 gr.) of scopolamin four hours before operation, the injection being repeated two hours later and again half an hour previous to its performance, from which procedure he has not observed any evil effects. Kümmel injects only $\frac{1}{100}$ gr. (0·0005) of scopolamin and $\frac{1}{6}$ gr. (1 cg.) of morphia 1-1$\frac{1}{2}$ hours before operation with a subsequent administration of ether. Death has been noted, however, by Lasek, Rys, and Zahradnicky, after a repetition of this dose. Israel has recorded one death during the operation and two fatalities after operation, while Dick has notified three deaths occurring in the course of operating.

Quite recently Matthæi has recommended alcohol narcosis, the alcohol being administered at a temperature of 50° to 60° C. by means of Kappeler's apparatus, with an enema of $\frac{1}{3}$ alcohol in water previously introduced, an alcoholic subject requiring to take beforehand a bottle of strong wine. This method may be brought into use when there are positive contraindications to the use of chloroform or ether. Death might have been prevented, for example, by the employment of alcohol narcosis, in a case we had of excision of the thyroid in a cretin with marked tracheal stenosis, where the operation was commenced without an anæsthetic, but where, on account of the patient's unruly conduct, it had to be continued under a general anæsthetic.

TREATMENT OF WOUNDS

(p) Sterilisation of Dressings, Instruments, and Lotions

All the skill brought into play by the surgeon is of no avail if steps are not taken to prevent infection of the wound. Apart from the immediate risks of the anæsthetic, which are reduced to a minimum if it is administered with sufficient care and in accordance with the directions we have laid down, the only dangers associated with an operation are wound infection and bleeding in the case of a serious operation. The exclusion of micro-organisms from the wound, according to Lister's principles, is of vital importance to the patient, though fortunately the time is long past for wounds to be poisoned by antiseptic agents.

After Fr. Schültze, Schwann and Helmholtz, Schröder and Dusch had prepared the way for the demonstration of the fact that air, after being heated, treated with sulphuric acid, or filtered through cotton wool, does not cause putrefaction if organic material be excluded, Pasteur enunciated the broad principles of the observation that no decomposition of organic material occurs without the presence of living germs. Innumerable workers, for example Tyndall in the case of the air, and Rindfleisch in the case of water, have demonstrated whence these living germs originate. Lister has, since 1867, on the foundation laid by Pasteur, built up the present method of

treating wounds by proving that decomposition in wounds only occurs after the admittance of organic particles from without. Jules Lemaire had previously formulated the axiom, "Pas de suppuration, si l'on tue les germes," while Lister, with his usual caution, stated that these organic particles are really germs capable of development.

Koch has enabled us to discover in individual cases the germs which are responsible for wound infection, and to study their action with closer attention, after Billroth had worked on the same lines, but with insufficient methods. Billroth and Thiersch assumed the presence of germs in the interior of the tissues, but the adoption of improved methods has served to prove that, in healthy individuals, germs only exist on the surface—skin and mucous membranes—and that they are always carried into the deeper tissues from the exterior.

Our knowledge of wound infection and its prevention rests on this basis. Schültze, Lesser, and Schede transplanted Lister's principles into German soil, where they at once took root and bore fruit plentifully, a result mainly owing to Volkmann's enthusiastic initiative. But in spite of the enormous amount of work contributed in the last decade to advance the procedure in the treatment of wounds, a complete understanding of the best means and methods has only been reached in a few directions. So much has, however, been ascertained that we can with absolute certainty prevent infection of wounds as far as this is dependent on the materials necessary for the treatment, and especially of everything which is comprised under the heading of dressings, instruments, and lotions destined to come into contact with the wound surface. The greatest advance in this direction is, that in the preparation of these materials we have abandoned the old highly-complicated methods in favour of those of modern simplicity, which enable us to observe the requirements we have advocated, not only in the elaborately-furnished clinics and operating theatres, but also in the simplest and most humble conditions now introduced into practice.[1]

As regards the instruments, dressings, and lotions, they can be sterilised by means of boiling, or by subjecting them to the action of circulating and compressed steam for a sufficient length of time. Infection by direct contact, generally designated as contact infection, which threatened the life of every person operated on prior to Lister's antiseptic treatment, is thus entirely prevented. Although the bacteriological therapeutics, especially in wound treatment, are not at present making remarkable progress, the acquisitions already made to our knowledge will not readily be abandoned.

The first essential in the treatment of wounds may therefore be stated as follows: all solid and fluid substances which come into contact with a wound, either directly or indirectly, must be sterilised. This is accomplished by boiling them for twenty minutes in ordinary water, or in solutions less injurious to the materials boiled, such as a 1 per cent solution of soda for instruments. Sterilisation of dressings and instruments is materially shortened by using circulating and compressed steam, a method by which, if allowed to act for fifteen minutes at 120° to 125° C., perfect sterilisation is obtained, as Tavel and his pupils have amply demonstrated.[2]

Superheated steam, however, is to be avoided. Scot Skirving[3] has made careful investigation into this matter, and finds that, so long as the steam is in contact with the water which produces it, it is saturated. When it is separated from the water its temperature may be raised by heat without its pressure being altered: the steam is then superheated, although it fails to obtain any greater amount of latent heat. If a steriliser is subjected to further heat when all the water has been converted into steam, the steam becomes superheated; and Esmarch and Rubner have shown that superheated

[1] We are not, like Walcher, inclined to limit the aseptic field in operations as much as possible. It requires an unduly greater amount of watchfulness to keep at a distance dangers which surround the body than it does to exclude them altogether. It is, of course, correct that the theoretical standard should be that nothing infective should approach the wound, and the determination to prevent menstruating nurses from attending operations was thoroughly justified.

[2] Braatz has directed attention to an important point in sterilising by steam,—that dressings should not be warmed beforehand as is customary, as if this is attempted the steam becomes superheated, and is thus no longer saturated, but rendered useless, a direction which also applies to steam not subjected to pressure.

[3] *Scot. Med. and Surg. Journal*, Dec. 1904.

steam proves less effective than saturated steam, since it has only the action of hot air, requiring the space of an hour at a temperature of 170° C. to kill the spores of organisms. For the same reason sterilisation will prove imperfect if all the air has not been previously expelled from the steriliser, which often results from failure to open the valve at the bottom of the steriliser, where the air is found to collect. The expulsion of air is also interfered with by packing too closely the dressings in the steriliser.

The prevention of infection of the dressings after sterilisation and before use was for many years overlooked and neglected. Only those materials can be regarded as completely sterilised which have been taken directly from the boiling or steaming apparatus by means of sterilised instruments or gloves, and applied to the wound, while the dressings should not be stored for any length of time. The same rule must be adopted for instruments and lotions, and the latter especially must be taken direct from the boiling apparatus and placed on the wound without being poured from one vessel into another for storage.

Cases in which sterilisation of the materials to be used immediately before the performance of an operation is impracticable seldom occur, and in such circumstances only those methods of storage are permissible which preserve the materials, dust-proof, in the vessels in which they were sterilised. This process can be carried out with an apparatus which, at the end of the disinfection procedure, can be completely shut up and easily carried without disturbance of the contents, the apparatus of Schimmelbusch proving singularly effective for this purpose on account of its simplicity.

According to Skirving, the dressings remain damp only if they are not at once removed from the steriliser while they are still hot, in which case they dry readily. He objects also to the Schimmelbusch drums on the ground that they do not close satisfactorily, and he quotes instances for his contention. He has, therefore, constructed a drum of his own devising, which is hermetically sealed by simply pushing home the lid. It is fitted with an inner wire cage, the holes being arranged round the sides of the instrument and close to the top. During sterilisation the apparatus must be placed upside down, *i.e.* with the holes downwards, as it is only in this position that the steam uniformly penetrates the dressings. Braatz employs a drum which is of somewhat similar construction, but one which has two sets of lateral openings, one above and one below.

(q) Disinfection of the Skin

It is, unfortunately, impracticable to extend sterilisation to every object coming into contact with a wound, as the human body will endure neither boiling water nor steam, owing to which circumstances the patient's skin, as well as the surgeon's hands, brought, during the operation, into intimate contact with the surface of the wound, are incapable of being sterilised, and it comes to be a question of how far the action of circulating steam or boiling water can be replaced by other means. These considerations are generally grouped under the heading of purification of the hands, and the subject of a possibly-perfect disinfection of the hands has given rise to lively discussions at the meetings of various learned bodies. The grouping under this title does not seem to be of a very happy nature, since the question involves not only the cleansing of the surgeon's hands and those of his assistants, but that of the skin of the patient. The last-named requirement has been long neglected, and even nowadays it is no uncommon sight to see the surgeon and his assistants scrupulously careful about the cleansing and scrubbing of their own hands, while the patient's skin is washed with a little soap and lotion immediately before the operation, receiving subsequently a few douches of corrosive lotion, proceedings which imply a contradiction. This procedure can only be partially excused on the grounds that infection conveyed by the surgeon's hands is calculated to have much more serious results than infection originating in the patient's skin. We shall afterwards return to the

consideration of this point. In the meantime we shall only observe that it is not very unusual for a severe form of infection to be carried from the patient's skin when this is the seat of a sore, however small it may be and difficult to recognise.

The present opinion of the majority of surgeons on the question of disinfection of the skin is, that sterilisation is not attainable by any means at present at our disposal.[1] Those who maintain that no process of disinfection can render the hands absolutely sterile insist on the use of gloves made of an impermeable material, which can be sterilised by means of boiling, and thus afford perfect protection against contact-infection from the bare hands of an operator.

The introduction of the systematic use of rubber gloves[2] is due to Halsted of Baltimore, and it affords a precaution which no surgeon can afford to neglect, the improvement in their manufacture, their cheapness, and their durability recommending their general use, while the thin rubber of which they are composed proves an additional advantage as not interfering with the sense of touch which formerly militated against their serviceability.

The chief use of rubber gloves is to protect the surgeon's hands from contamination when he is operating in the presence of pus or infected tissues, for which purpose they are indispensable in the daily routine of a practitioner's work. No careful surgeon at the present time makes an examination of the mouth, pharynx, rectum, vagina, etc., without protecting his hands with rubber gloves, while it is equally necessary to take similar precautions to prevent contact with any form of wound secretions.

Why then do we not systematically wear gloves for all operations? Because, strictly speaking, all the assistants and operation sisters should wear them as well as the operator, and this would entail great expense, as the gloves are continually liable to be torn by instruments or against edges of bone, when they have immediately to be replaced. In addition to this disadvantage, Heile has shown that the organisms on the surface of the skin may increase from 88 to 30,000 in the moist interior of a rubber glove.

As the sense of touch is necessarily somewhat impaired by the use of gloves, it is more difficult in abdominal cases to make an accurate diagnosis from palpation, or to handle smooth organs like the intestines. Their use is thus necessarily restricted. Finally, we cannot protect the skin of the patient in a similar manner, for, even although a thin sheet of guttapercha can be satisfactorily affixed to the skin by means of hot water, it does not adhere with sufficient firmness and is readily detached when handled.

What is therefore required is a method of purifying the skin, which, if it does not amount to absolute sterilisation, yet affords efficient disinfection. As we shall see, this implies the exclusion from the wound of pathogenic organisms capable of development, a point which is easily capable of demonstration. The question further arises whether, after having procured a thorough disinfection of the skin, an operator can secure any advantage by wearing cotton gloves, which are not only cheaper but more comfortable to wear. Originally introduced by Mikulicz, cotton gloves were for some time in general use, until it was proved that they failed to prevent the invasion of germs.

We can confirm the statement that after thorough systematic washing of the hands, it is beyond doubt gloves sodden with fluid and blood abound with germs, especially the staphylococcus albus, the most common organism in the human skin. This power of acquiring organisms possesses a certain advantage, as although the germs are present they remain entangled in the glove and have thus less opportunity of gaining admission to the wound. Since it has been definitely proved that the number of germs cannot increase during the time occupied by an ordinary operation, the absorptive power of gloves might be regarded as of considerable value, although we fail to attach much importance to this point. Heile has shown that 4·8 per cent of

[1] Sarwey, who, with Krönig, has already made such valuable contributions to the subject of disinfection, has recently confirmed this statement.

[2] Manteuffel first recommended their use in Germany, while Döderlein, Blumberg, Perthes, and specially Friedrich, by introducing seamless gloves, have brought them into general use.

the germs on the surface of the skin pass through stockinet gloves, while 28 per cent remain enveloped in the gloves. Thread gloves, and more notably the close-meshed yarn gloves recommended by Heile, are really only of service from their efficacy in the absorption of germs. It is also with the object of soaking up the secretions and possible germs that we cover up our wounds and the edges of the incision with gauze during the course of an operation, the gauze being frequently changed.

It is worthy of notice that germs have been shown to exist in gloves only when they are sodden with fluid and blood. If the gloves are changed frequently during the operation a definite quantity of infective material is removed from the hands at every change. The experimental investigations of Haegler and others have proved that the majority of the germs do not come from the air, but that they are derived from the surface of the skin.

Further, Mohaupt's researches demonstrate that, even after thorough purification of the skin, germs are left in the sweat glands, and that they reach the surface in the secretion in half an hour if the person sweats, otherwise within twenty-four hours. It follows, therefore, that gloves, to be really useful, must be periodically changed whenever saturated with blood or fluid.[1]

There are no micro-organisms on the surface of gloves when they are removed from the steriliser. For this reason gloves are of great value, and in our opinion their chief use depends on the fact that they prevent contact between the skin surface and ligatures and swabs, and therefore prevent the most serious of all forms of infection, namely, that which we have designated implantation infection.

Swabs can be very effectively manipulated with sterilised sponge-holders. Contact with the fingers is thus avoided. Ligatures, on the contrary, have to be taken in the fingers, even when they are kept in the glass tubes which Lanz introduced. Haegler[2] has proved that even when the hands have been most carefully cleansed, a ligature cannot be firmly drawn through the fingers without receiving germs from the skin surface. For this reason we are of opinion that it is of great importance that the nurse in charge of the ligatures, as well as the surgeon and his assistants, should put on gloves (even though they should be permeable ones) just before the ligatures are tied. This is also the reason why we always defer the tying of ligatures, however many there may be, till the end of the operation. At an operation for goitre, for example, it occasionally happens that as many as fifty to one hundred artery forceps are applied before any ligatures are tied.

Infection of ligatures from contact with the hands can be absolutely prevented if we follow Goepel's advice by wearing thread gloves over those manufactured of rubber. Goepel sterilises his gloves in a current of steam and applies them to his hands in a dry condition, while we prefer to remove them direct from the sterilised lotion and slip them on while they are wet.

Before putting on either rubber or cotton gloves, we must see that the hands have been as carefully disinfected as if the operation had to be conducted without the use of gloves, as the rubber may be readily torn and cotton may absorb germs from the skin. With or without the use of gloves, thorough cleansing of the hands and skin is therefore absolutely necessary.

Can the skin be cleansed so effectively that we can regard the process as disinfection? If the distinction between *sterilisation* (freedom from all germs) and *disinfection* (freedom from pathogenic germs capable of development) be maintained, it is possible that we can achieve disinfection of the skin even though we may have to give up the idea of absolute sterilisation. This is, in truth, the case, if the results of disinfection be measured by the success of our operations.

In 1899, in a communication dealing with the glove question read before the American Surgical Association, we gave, along with a chronological table, the results

[1] Heile has lately shown by experiments on animals that with frequent change of gloves even operations with infected hands can be carried out with impunity, that is to say, without any resultant infection of the wound.

[2] We would draw special attention to Haegler's excellent book on the cleansing of the hands, etc.

which we had obtained in all our operations (numbering 325 aseptic cases) performed during the winter session 1898-99. From these we demonstrated that with our routine and purely aseptic method of treating wounds we had not a single case of suppuration of a wound, let alone a more serious form of infection.

We are able to show also that, in an operation in which infection is apt to prove very serious, for example in excision of goitre, some hundreds of these operations could be performed with uninterrupted and faultless primary union (*i.e.* true adhesion and complete union in eight days). For all practical purposes, therefore, satisfactory disinfection of the skin and hands can be effected so that the severest operation may be undertaken without fear or danger, and with every prospect of uninterrupted repair in the wound.

Dührssen has expressed the opinion that surgical operations are in these modern times devoid of danger, basing the proof of his assertion on the results he obtained in 267 vaginal operations necessitating opening of the peritoneum, in 68 total excisions of the uterus, in 60 operations for uterine myomata (without a death) and in 500 other gynæcological operations, in all of which contact-infection was absolutely prevented.

We are completely in accord with Ahlfeld (although in other matters we seldom agree) when he says that the degree of freedom of the hands from germs may be judged by the results of operations. We should not, however, care to assert positively that in every case in which primary union occurred disinfection of the skin had been absolute. Lanz and Flach, in our clinic, have found that in wounds healing by first intention no intensely pathogenic organism, such as staphylococcus aureus, could be demonstrated, but only the staphylococcus albus and some others which, from our experience, we are not inclined to regard as actually pathogenic in the human subject. The fact of their constant occurrence in gloves used at operations where repair was faultless supports this view.

Brunner and also Budinger, however, have found staphylococcus aureus, an organism whose virulence is unquestioned, in wounds healing by first intention. But this appears to be rare, even according to their own statistics.

To what methods of procedure are the faultless results which can be obtained in an uninterrupted series of severe operations to be referred? On the so-called abstinence. But we use the word in a much wider sense than the gynæcologists, not in the sense of entire abstinence from operative interference, but abstinence from risk of infection with pathogenic and virulent germs. A surgeon who has to perform aseptic operations should most scrupulously guard his hands from possible contact with virulent pathogenic organisms. This indication cannot be too carefully remembered when it becomes necessary to touch an infected wound, or where examinations have to be made in which the surface of the skin comes into intimate contact with abundant infective material, as in the examination of the mouth, fauces, vagina, or rectum. In such cases, without exception, the hand should be protected by rubber gloves. Therein lies the true usefulness of gloves, namely in wearing them, not at the operation, but in the intervals between operations. Much laughter was caused when, at a meeting of doctors, while discussing the question of "operation gloves," we enunciated the paradox "gloves should be worn between the operations and taken off at the commencement of an operation." The true secret of freedom of the hands from germs lies in the use of gloves whenever there is a possibility of a large number of germs being pressed or rubbed into the skin. As Zweifel points out, on the grounds of Krönig and Reinecke's researches, the hands become spontaneously germ free in a short time if not constantly re-infected; and Haegler has shown that the dread that the deeper parts of the skin are always crowded with germs is exaggerated. He finds that, as a rule, there are no germs in the sweat glands, and in the hair follicles they are only found close to the surface. They may gain access to the hair follicles merely by friction, but are at once forced out again by the current of secretion. On the other hand, in every injury to the skin, however small, microbes at once begin to grow and multiply.

Neglect of the skin is therefore unpardonable. We do not consider it any excuse to

say that it is not possible for a doctor in practice to avoid contact with infective material in handling patients. If a doctor finds it impossible to avoid loading his hands with pathogenic organisms, then he must leave operative surgery to others. But we do not see any reason why a doctor who wishes to operate should not put on gutta-percha gloves when he has to make a digital examination of the mouth, throat, vagina, or rectum, or when he has to touch unclean skin, an eczema, a furuncle, or a fistulous wound. There still remains contamination by those germs which are present on our own bodies, or which fall by accident on our hands without our being able to avoid it. But against these we have a very sure defence in immediate and thorough purification before they have time to dry. This, too, is the sole occasion on which it is necessary to momentarily douche the skin with a strong antiseptic, especially with 1-1000 perchloride of mercury solution—a precaution which acquires a double significance when a mechanical cleansing of the skin is impracticable from want of water.

The methods which we employ to secure a satisfactory purification of the hands apply only to hands which are not highly infected with virulent organisms. Even for highly-infected hands we hold that a sufficient degree of disinfection is possible if, besides the mechanical cleansing, the skin is saturated with antiseptics, *i.e.* bathed and scrubbed in a 1-1000, or better, a 1-2000 sublimate solution for ten minutes. It can be proved that virulent organisms are in that way rendered sufficiently innocuous. Krönig and Blumberg have made extensive trial of sublamin. But in practice we ought not to require such strong disinfectants. It is certain that he who cannot conform to "abstinence," as above defined, can never know the ideal meaning of a purely aseptic treatment of wounds. He remains condemned to the use of antiseptics.

What are the methods of disinfection which yield at the present time the most satisfactory results? Furbringer's treatment with alcohol is the most reliable, and it has been extensively exploited by Reinecke of Zweifel's clinic; while Ahlfeld, who is an enthusiastic advocate of disinfection by means of hot water and alcohol, has established the benefit derived from the proper utilisation of this method, which has been adopted in numerous operations with excellent results.

We wash our hands with soap (and the much-defamed brush) under a stream *of very hot water*, so that the smallest wrinkle is thoroughly scrubbed, without regard to the time it takes to complete the process. The hands are not dried, but are thoroughly freed from soap under a stream of warm water. The hands are then scrubbed with fresh sterile brushes under warm running sterile water, after which they are treated to a second scrubbing with 85 per cent alcohol and fresh brushes that have been steeped in alcohol. Ahlfeld prefers to use 96 per cent alcohol. Every uncovered particle of skin is thus treated, with further brushing, inch by inch, especially the nails and nail-folds, without any regard for time, till the cleansing is as thorough as it can be made. At this stage scrubbing with a sterilised compress may be useful. Haegler finds that by this means the superficial epidermic scales, together with a number of germs harboured in them, are rubbed off. Two points in this method of purification are of importance. In the first place, the brushes, after having been sterilised by boiling, must never lie, or remain lying, in anything except a strong disinfecting fluid (1-1000 corrosive sublimate or 5 per cent carbolic acid). The latter should remain quite clear when the brushes, thoroughly boiled, are placed in it. With the above precautions taken we have never been able to find any necessity for the brushes recommended by Schleich. Should doubts be entertained with regard to brushes Sanger's sand soap may be substituted. Haegler found the brushes more efficient than Schleich's marble soap.

The second point, and one which is essential to success, is the removal of the projecting portion of the nails. The surgeon who keeps his nails long has no prospect of attaining complete cleanliness by mechanical means. If, on the contrary, the nails are cut as short as possible, there is no need for the mischievous nail-cleaning instruments, as a brush with soap and hot water, followed by alcohol, suffices to clean even the dangerous crevice beneath the nails. Then, once and for all, away with these nail-cleaners!

In this method we do not ascribe the chief importance to any disinfecting property peculiar to the alcohol. We intend, rather, by the use of alcohol after soap, to obtain a more radical removal from the skin surface of all the fatty constituents and the organisms harboured by them.

It has been shown by Fett and others that alcohol penetrates the cutis to a much greater depth than can be attained by water. Rielmann has demonstrated by the use of colouring matters that 96 per cent alcohol reaches further into the cutis, even as far as the subcutaneous tissue, and fills the hair follicles, but is only able to penetrate slightly the sweat glands on account of the pressure of the secretion. According to Leedham Green,[1] continued and energetic washing with soap and hot water, or even with marble dust or Schleich's soap, fails to diminish the number of germs. A prolonged system of washing and the use of a soap such as soft soap, rich in alkali, causes great damage to the epidermis and converts it to a sodden condition.[2] There is no antiseptic which can render the hands entirely free of germs. We would especially emphasise the opinion of Schäffer, an opinion supported by Leedham Green, that it is a mere superstition to think that any real benefit is obtained merely by dipping the hands in an antiseptic lotion. Even the use of alcohol for the purpose does not effect hand sterilisation, as, apart from dissolving fats, the disinfecting action of alcohol depends on its property of fixing the superficial layers of the epidermis.

A 70 per cent alcohol supplies the most effective action, as it is stronger than 1 to 1000 perchloride solution, the addition of lysol or biniodide of mercury failing to increase its action, while Mikulicz's spirit of soap is less effective than alcohol.[3] Engels further has shown that with Ahlfeld's method of hot water and alcohol the more deeply situated organisms in the skin retain their viability. Futh, as the result of his experiments, arrived at the same conclusion and recommends the use of rubber gloves as the only certain method of obtaining disinfection. After what we have said it is hardly necessary to observe that the skin of the patient requires cleansing for some distance around the field of operation, in exactly the same way as cleansing is necessary for the operator's hands.

By Klein's method, which is worthy of notice,[4] he first thoroughly scrubs the skin with soft soap, which is then washed off under a stream of warm water, the skin at the same time being scrubbed with fresh brushes, the operator immediately afterwards soaking his hands in ether and alcohol, in order to remove the fats. It will be seen that we have entirely given up the use of any of the more active substances to disinfect the patient's skin and our own hands. This was the result, in the first instance, of our own inability to withstand the action of corrosive sublimate. But as soon as we were convinced that it could be dispensed with without any evil consequences we countermanded its use for assistants, nurses, and patients, and we have not had the slightest reason to regret the step. To be absolutely candid, however, we must admit that we have come across individuals who can neither attain true "abstinence" nor even get as far as thorough mechanical purification. For uncleanly persons the use of strong antiseptics for the hands is an absolute necessity. Under certain conditions the same holds good for the patient's skin. Haegler considers that preliminary treatment with 60 to 70 per cent alcohol allows of a deeper penetration of the corrosive sublimate by the removal of fat.

According to Engel, the best method is that in which 99 per cent alcohol is used in conjunction with lysoform, sublamin (2 per cent according to Krönig and Blumberg) or even Bacillol alcohol. The alcohol dissolves the fats by displacement of the air,

[1] London and Birmingham, 1904.

[2] Paul and Sarwey reject soft soap on account of the injury it causes to the skin. They rightly consider that the wax ingredients of Schleich's "marble soap" are unsuitable. Dr. Saltikoff, at our request, has experimented on threads to determine to what extent waxing of silk, up till lately so common, prevented the access of organisms. The result was that germs were found to be able to pass easily through a layer of wax, while it was proved to materially hinder the action of chemical antiseptics, exactly as Paul and Sarwey had described.

[3] Compare Gotstein's recommendation on this point. According to Haegler soap spirit is not more valuable than alcohol.

[4] *Zeitschr. f. Chirurgie*, Bd. 75.

and enables the disinfectant to come into closer contact with the bacteria. Where, however, skin incisions have to be made in the neighbourhood of sources of infection from virulent organisms, or where the patient has a "quite impossible" skin, with cracks, wrinkles, and scales (we recently excised an elbow-joint in a subject of ichthyosis), one may then endeavour to arrest the action of the alcohol (99 per cent) by the addition of antiseptics; but, in our opinion, much stronger antiseptics than these should be brought into employment. When, as not infrequently happens, acne pustules, or small furuncles, are situated in the area to be operated on, each focus must be most carefully destroyed with the thermocautery.

When fistulæ, granulating surfaces, or necrotic tissues are present in the field of operation they must be mechanically removed by excision or by scraping, followed by disinfection of the surface by the thermocautery. Otherwise a severe infection is very liable to occur. When coarse, wrinkled, scaly skin is involved in the area of operation,[1] a mechanical removal of the organisms is impossible. An antiseptic fomentation of carbolic or formol-glycerine should be applied from one to two days previously, but the prognosis with regard to infection should be very guarded. Absolute security can only be guaranteed by the use of impermeable coverings (rubber gloves).

It is not yet absolutely demonstrated, even by Paul and Sarwey's admirable researches, that the number of germs is at all diminished by such chemical disinfection. We are inclined to accept Haegler's theory that only diminution of virulence is thus obtained. As these authors admit, destruction of all the germs cannot be accomplished even by means of reliable antiseptics;[2] the few that remain would certainly suffice to infect the wound, were it not that their virulence is diminished.

The last point well worth considering in this relationship is the prevention of importation of infective material from skin or mucous membranes situated at a distance from the field of operation. As regards the skin, it is nowadays customary to cover our bodies, with the exception of the face and hands, with a sterile material, and it is just as important to cover up the patient and the operating table with sterile sheets as it is for us to wear a sterilised coat, sleeves, and operating cap.

The transplantation of germs from the mouth and nares, not only of the operator and his assistants, but also of the patient, deserves special notice. We are indebted to Flügge for demonstrating how widely germs from the mouth and nares are disseminated during speech, coughing, or sneezing.

During speech, germs native to the mouth infect nutrient plates at a distance of several metres. According to Mendes de Leon's observations,[3] the number of organisms in the air exhaled during speech amount to about a quarter-of-a-million, consisting chiefly of streptococci, diplococci, staphylococci and sarcinæ. To avoid these germs it is not sufficient merely to rinse out the mouth and wear a gauze mask, as absolute protection can only be obtained by wearing a respirator made of cotton wool. The conditions here are exactly similar to those governing the use of rubber gloves. As every participator in an operation has to thoroughly disinfect the hands, so must he completely disinfect the mouth, nose, and especially the teeth. If the surgeon or his assistants are suffering from a cold or sore throat, or if cleansing of the mouth is not possible, a cotton-wool respirator should invariably be worn over the mouth, similar precautions being adopted by the patient. It is unnecessary to draw attention to the amount of infective material which exists in and around a carious tooth. Such a condition should always receive careful attention. In our numerous operations for goitre a sheet is secured to the front of the patient's neck, and spread over a support which arches over mouth, nose, and face in such a way as not to interfere with respiration, but yet completely to exclude any possibility of contaminating the site of operation. According to Leon's experiments, the addition of a layer of cotton wool

[1] Paul and Sarwey have endeavoured to demonstrate the great difference in the microbes contained in various parts of the skin according to its quality; and Blumberg has shown that even in the most superficial scratch there exist colonies of pathogenic organisms.

[2] Krönig and Blumberg recommend mercuricæthylendiamin in preference to sublimate because it does not irritate the skin or precipitate blood or albumen.

[3] Langenbeck's *Archiv*, Bd. 72.

lends considerably to the security of the mask. The covers for mouth, nose, and beard act for a time as filters, or microbe traps, and retain organisms which are exhaled and shaken out. Like the gloves they must be frequently changed. Thorough and repeated rinsing of mouth and nose, along with sponging of the beard and hair before and during the operation, have always sufficed for us if care be exercised. It is also to be noted that the patients, by thorough mechanical cleaning of the teeth and antiseptic gargling, materially lessen the risk of aspiration pneumonia after narcosis.

(r) The Prevention of Air Infection

Besides contact-infection there are two other modes of infection of wounds which play an important part in the treatment of wounds. The first of these, *air infection*, as it has long been called, was originally considered very important, but has been proved to be less so than contact-infection already described. The second, to which we have given the name *implantation infection*, is at the present time just as important as contact-infection, and even more to be dreaded.

Tavel has distinguished a fourth form of infection, which he calls *lesion infection*, which we shall discuss later on.

That *air infection* is of far less importance than contact-infection is certain; experiments, however, show that it has been somewhat neglected. We agree with Rydygier that air infection is not to be despised, for we observed in our own clinic that operations performed in the clinical lecture theatre for the benefit of a number of students were much more liable to go wrong than those performed in the aseptic operating room.[1] We cannot absolutely exclude air infection, but we can reduce it to such a minimum that it may be disregarded. This is effected by operating in dust-free air. The room in which the operation is to be performed and everything entering it must be absolutely freed from dust. Flügge has shown how difficult it is to detach germs from a damp surface by means of air currents, and also how easily dried microbes are carried away by draughts of air, and how they remain suspended for a long period.

The floor, walls, and especially the seats[2] in the operating theatre must be thoroughly freed from dust, either with hot water or with a steam jet, and special care must be taken to prevent dust being raised in any shape or form during an operation, as the restlessness of the spectators just makes the difference we have referred to above in the progress of wounds. We have been thoroughly convinced of these facts by exposing plates before, during, and after a clinic (Haegler).

The rooms most suitable for operation, and in which we obtain the best results, are those which are devoid of fixtures, such as wash-basins, etc., as Witzel very justly observes. Further, the walls should be smooth and free from recesses so that they can be readily washed down and be free from the accumulation of dust germs.

The reason why air infection is of less importance than contact-infection, as shown by Friedrich's experiments, is that germs which fall on to a wound without any pressure are far less frequently absorbed than are germs which are pressed into the tissues, whether by fingers, instruments, or by covering them over with skin, a proceeding which causes tension proportionate to the depth of the wound. Contact infection is nearly related to that form of infection to which we proposed to give the name of inoculation infection, in which the germs are introduced or rubbed into the deeper layers of the tissues. If such mechanical factors can be excluded, air infection can be easily combated by frequently douching the wound during the operation. The best lotion is hot normal saline solution, which washes germs from a wound just as well as any antiseptic fluid, without the disadvantages possessed by the latter of

[1] Heile has recently brought forward numerous proofs of how dried secretions, pus, etc., get into the air, and stick to the clothes, on which they are conveyed into the operating room.

[2] In many of the high and elegant operation rooms now in vogue this indication cannot be efficiently carried out. Hanging lights are for the same reason objectionable.

lowering the vitality of the tissue elements and by this means favouring infection. It is, however, simpler and more practical to protect the wound by means of moist gauze compresses, which, as we mentioned above, soak up blood and lymph and assist in the removal of the bacteria.

(s) Implantation Infection and the Question of Ligatures

The importance of *implantation infection* is, on the contrary, very great. It consists in the introduction of micro-organisms into a wound along with certain foreign bodies which have to be left in inside. Of these the most important are ligatures and sutures. The question of ligatures cannot be regarded as finally settled, as is evidenced by the great number of discussions on the subject, especially in gynæcological papers. New facts are constantly being accumulated to assist in determining the relative merits of silk and catgut, or of some new substitute, but a long time will in all probability elapse before this point is unanimously settled, for it is difficult to obtain a clear idea as to what disadvantages should or should not be ascribed to each particular ligature on account of the great number of factors involved. But we have for long taken up a very definite position with regard to this question, and experience has confirmed our opinion.

There is no possible doubt that catgut, introduced by Lister, has great advantages over other ligatures owing to its being so readily absorbed when introduced into the human body. But this property of easy absorption is nowadays being prejudicially affected by new methods of preparation regarded as specially reliable and valuable. Minervini has demonstrated this fact by elaborate experiments. In this way the principal advantage of catgut is being done away with. Besides this, catgut, even when sterilised, is liable, as Poppert has shown, to an unpleasant chemiotactic action owing to the inclusion of chemical products which remain active even after sterilisation. Abscesses containing sterile pus may then form,[1] delay healing and introduce secondary dangers, although this form of reaction does not give rise to progressive inflammation or suppuration. Still, Lauenstein and Braun have shown that in a large proportion of these cases the action supposed to be purely chemical turns out finally to be a true infection, with all its natural consequences.

According to Minervini and Jacobs, treatment with juniper oil, as we recommended, is one of the most reliable methods of preparing catgut, but the action must be very prolonged. We have paid great attention to this point, and have preserved all our catgut for months in juniper oil. Jacobs, after sterilising the catgut in juniper oil, impregnates it with iodoform, according to Körte's formula, and is thoroughly satisfied with the result.

It is necessary, however, before using the catgut to wash out the juniper oil by soaking in ether and alcohol, in order to avoid any serious chemical action on the adjacent tissues. For immediate use the catgut is best put into 1-1000 solution of sublimate in alcohol. We employ catgut where a wound is already infected, or where infection cannot be avoided, and especially in suppurating wounds. In all other cases we have remained true to our motto, "Away with catgut, and use silk sutures for all aseptic operations." So entirely satisfied are we with silk, that we have never even given a trial to the numerous other catgut preparations, amongst which are recommended Bergmann's sublimate catgut (especially Schäffer's formula, boiling in alcohol sublimate), the cumol-catgut of Krönig, and the iodised catgut of

[1] Krönig, that worthy investigator in the realm of antisepsis, considers that he is in a position to meet every requirement by bringing forward an uninterrupted series of cases of healing by first intention where catgut was used. But he takes twenty days as the limit of primary union—far too long a period, and Zweifel says that the stitch-holes often contain pus on the seventh day. Krönig himself admits, from statistics collected by Abel, that in fifty-six laparotomies stitched with cumol-catgut, 10 per cent suppurated, 7 per cent without any other cause. This is not to be wondered at when we consider that catgut is nothing more or less than a dead organic nutrient substance. A serous secretion, free from bacteria, by no means implies, as Haegler and Gottstein showed, that the ligature causing it is not infected.

Claudius.[1] Neither have we given a trial to metal threads such as Socin's bronze aluminium, or to the tendon preparations of Snegiroff and Marey. While catgut prepared by Hofmeister's method (boiling in formalin) is very reliable, its absorbability is impaired, and Braun's celluloid thread, though worthy of notice, is less easy to prepare than sublimate silk. The same holds true for Schäffer's gutta-percha threads, and for Pagenstecher's celluloid threads, to which Keen gives high recommendation.

W. Bartlett places the catgut, after it has been dried at 105° for twelve hours, in fluid paraffin till it becomes transparent, when it is gradually heated up to 160° C. for two hours, after which it is kept for twenty-four hours in a 1 per cent solution of iodine in methylalcohol. Webster prepares his catgut by soaking it for eight days in tincture of cloves, and eight hours in 95 per cent alcohol, when it is then stored dry.

To demonstrate what absolute success can be obtained with silk we cannot do better than refer to the results of our goitre operations. In these operations, as a rule, large numbers of ligatures are applied, and yet in a series of hundreds of cases not a single case of infection occurred.

We cannot accept the statement that a properly-prepared silk ligature or stitch may cause either early or late inflammation, and we repeat that it is only antiseptically-prepared silk, in conjunction with prevention of accumulation of blood and retention of wound secretion, which safeguards us against both primary and secondary infection.

Haegler pointed out that in all cases where the ligatures were merely aseptic, even though the course of the wound be favourable or only a little serum gathers (which may be sterile), the tissues along the track caused by the suture itself contain embedded in its substance countless organisms. Every porous substance readily absorbs wandering germs and holds them fast, just as gloves do. Care, therefore, must be taken that the germs which have penetrated into the wound shall be unable to develop in the ligatures and sutures before an accumulation of blood or serum is no longer possible, and the normal circulation is re-established by perfect union, which renders the bacteria harmless or carries them away. Impregnation of silk with antiseptics is easily managed, and according to Haegler's experiments the threads keep the antiseptic, specially mercuric salts, for long periods. Indeed, it is only gradually washed out into the body fluids.[2] For this reason we attach great importance to the exclusive use of thin silk, because it is more easily impregnated and is still more closely enveloped by the healthy tissues. No trouble is experienced even when 50-100 fine silk ligatures are used, while coarse ligatures may give rise to suppuration.

The necessity for antiseptic ligatures is emphasised by the fact that each thread is tied with a certain amount of force round a bleeding vessel or round other tissues, and therefore causes a certain degree of tissue-necrosis. As may be demonstrated, necrosed tissues play the part of foreign bodies, and, moreover, foreign bodies capable of absorption; and the antiseptic in the ligature is therefore called upon to prevent the development of the organisms which may have penetrated into the necrotic tissue of the stump. From this point of view it may even be desirable that the thread should not be too rapidly absorbed. The early loss of mechanical support is therefore a grave objection to the use of catgut. If the ligatures are once rendered efficiently antiseptic, then, according to Haegler, it is of little importance whether they be tied with hands carefully cleaned or not. Nevertheless, as we should avoid infringement of any rule, we consider it advisable, at least, to attempt to prevent contact of the ligatures with the skin by putting on a pair of sterilised thread or rubber gloves, or to prevent the ligature passing from hand to hand by using small glass holders

[1] Stone (*New York Med. Record*, Nov. 1904) advises first putting the raw material in 4 per cent aqueous solution of formalin for twenty-four hours, washing for twelve hours and then treating with the solution of iodine in potassium iodide.

[2] This is the reason why the best of observers (compare the careful experiments of Krönig and Blumberg) constantly overrate chemical disinfection. The antiseptics cannot be completely washed out of a thread.

(Halsted and Lanz) which can be held in the hand. Our method of preparing silk, the absolute reliability of which we can vouch for, is as follows.[1]

The skeins of fine silk (Nos. 1 and 2) are treated as follows:—

1. Placed in ether for twelve hours.
2. Placed in alcohol for twelve hours.
3. Boiled for five minutes in a 1 per thousand colourless neutral solution of corrosive sublimate.
4. Wound round spools with hands covered with rubber or thread gloves.
5. The spools are again boiled in the same sublimate solution for ten minutes just before the operation.
6. The ligatures are then handed out of the sublimate solution in which they were last boiled. They have therefore always remained in the same glass.

(t) The Significance of Necrotic Tissue in regard to Infection. Prevention of Necrosis

Even though a fresh wound has been treated according to the principles enunciated, we must not conclude that we have necessarily obtained a condition of absolute sterility. It has been proved by endless recent researches that even where operations are conducted with the greatest care and with every attention to asepsis organisms are almost invariably found in the wound both during and after operation, while a great number of organisms are found in the drainage tubes which have been used for a day or two to draw off blood and serous exudate. In our clinic Flach and Lanz have for a whole year conducted exhaustive experiments on this subject, as has also Tavel, and more recently Brunner (*vide* his work on wound infective diseases). It must, however, be taken into account that when the wounds were examined by these investigators, the present precautions, such as the use of sterile rubber gloves, or cotton-wool respirators, etc., had not yet been introduced. Otherwise more favourable conditions would probably have been ascertained.

The undeniable fact that we are not yet able to secure absolute sterility, even in a wound which we inflict under the most favourable circumstances, renders it our duty to pay greater attention to certain technical factors other than the sterilisation and disinfection of dressings, and skin, and hands. This leads us to a consideration of what Tavel has called "*lesion infection*." It is a remarkable fact that even though our skin and mucous membranes are covered with enormous numbers of micro-organisms we do not in any way suffer. It requires an injury to the tissues before the bacteria can acquire power over the cells and produce a disturbance in the normal balance of the tissues. Tavel and his pupils have collected a great number of facts demonstrating the importance of this factor.

Any lesion, however small, of the epithelial covering of the skin or of a mucous membrane, be it a purely mechanical rupture of continuity, an injury due to chemical causes, to drying up, or to derangement of circulation, such as accompanies catarrh, may allow of the entrance and development of such micro-organisms as may have been in the neighbourhood. Walthard has proved this by a series of admirable experiments in the case of the peritoneum, and Haegler has shown that wherever the outer skin is wounded, however insignificantly, a portal is opened whereby the entrance of germs is rendered possible. Now in all operations a wound is obviously present. Without a wound there would be no injection, and therefore the term "lesion infection" seems to us too general and not explicit enough for what Tavel means to suggest.

The important factor which induces a predisposition to infection in the lesion is

[1] We have not employed silk impregnated with the powerful antiseptics recommended by Haegler, Merlin, and Stinson (Merlin, for example, recommended a 1 per cent ethereal solution of corrosive sublimate for silk or catgut, while Haegler boils for one or two minutes in a 5 per cent sublimate solution) because they are unnecessary, and because such strong sublimate impregnation produces a too energetic local chemical action; and if many ligatures were applied, poisoning is to be anticipated.

the death of larger or smaller portions of the tissue. We can, in carrying out an operation, very largely determine the amount of damage to the vitality of the tissues. Bumon, amongst others, has on this account recently pointed out that the technique of an operation has a much greater influence on the subsequent course of a wound than was ascribed to it during the period of enthusiasm which followed the introduction of the antiseptic method of treating wounds.

It is the technique which decides whether the germs which fall on every wound, especially on necrotic tissue, shall develop to a dangerous extent or not. As we have mentioned, we do not consider a wound infected until pathogenic organisms have developed in it. Until such a development has occurred a wound is only what Friedrich would call "under suspicion of infection," and can still heal if the bacteria are destroyed.

Recent researches, of which those of Schimmelbusch, corroborated by Ricker and Noetzel, have aroused most attention, have shown that if, for example, a wound in a mouse's tail be inoculated with anthrax, absorption of organisms and dissemination to distant organs takes place from the wound in an extraordinarily short space of time, even in a few minutes. Were the bacteriological conditions the same in every case, we should have to admit in every operation the presence, not only of wound infection from organisms gaining access to the wound itself, but also of a general infection of the whole organism. But the admission and absorption of bacteria do not constitute infection in the clinical sense. It is only when the organisms develop and produce harmful toxins in the body that inflammation and general symptoms appear. In the case of a wound in which, in spite of the presence of bacteria, complete union has taken place in a few days without inflammation and with the patient in perfect health, it is impossible clinically to speak of general infection. We therefore agree with Friedrich in asserting that it is wrong to consider such experiments as parallel to the process of repair in operation wounds.

On the other hand, we regard it as a matter of capital importance that, in speaking of the infection of a wound, one should distinguish not only between organisms which are pathogenic to man and those which are not pathogenic, but also between those which are virulent and those which, for the time being, are not virulent. These organisms which are neither pathogenic nor virulent get into the blood by purely physical processes of absorption. But this rapidity of absorption, far from acting prejudicially, exercises, on the contrary, an entirely favourable influence on repair. Micro-organisms which are not adapted to a particular soil are neither pathogenic nor virulent, and are destroyed in the blood and healthy tissues. This also holds good for pathogenic or virulent organisms so long as they gain access to the living blood or healthy tissues separately or in small numbers. But it is another matter when virulent organisms reach a stage of luxurious growth in a wound, due to the presence of suitable nutrient media (blood and lymph), and especially foreign bodies (ligatures) or necrotic tissue.

Friedrich has shown, by a series of admirable experiments, that if an animal be inoculated with a pathogenic organism in just such a manner as would occur if accidental inoculation occurred (*e.g.* malignant œdema in guinea-pigs), six to eight hours must elapse before the infective material which is developing disseminates itself through the tissues, and becomes injurious and dangerous on account of its toxin. This has a very important bearing on the treatment of wounds, and its importance is emphasised by the fact, proved by the same author, that if the inoculation be performed with organisms which have already passed through the animal, the incubation period is much shorter, and for this reason the clinical symptoms of infection appear much more rapidly. The germs are rendered much more virulent by passage through a similar soil.

Further, Friedrich has shown that pathogenic and virulent micro-organisms require a certain time for division, as Koch also found, and consequently serious infection cannot occur until this time has elapsed. This time is dependent on the presence of decayed tissue (ligatures, extravasation, necrosis).

We must see that micro-organisms should be offered no chance of developing in

the wounds until the defensive apparatus of the normal body is again set in working order by the re-establishment of the normal circulation. To prevent development we must not only prevent the access of "pathogenic" germs in the manner above indicated, but we must remove as many of the "saprophytic germs" as possible. Besides porous foreign bodies—especially ligatures—there are many other soils which serve as nutrient media for the growth of micro-organisms: they include especially, necrotic tissues in the form of portions of the surface of the wound itself (*e.g.* ligature pedicles), and fluid, chiefly blood, exudates into the wounds. Dorst, under Tavel's supervision, has shown how much easier it is to produce an infection of an artificial hæmatoma than of healthy tissues, and Linser, likewise under Tavel, has experimentally demonstrated the comparative harmlessness of an injection even of pathogenic organisms into healthy tissue, as compared with injection into tissues which have been artificially injured or whose circulation has been artificially obstructed. Even 1 c.cm. of a culture of staphylococcus aureus which is absorbed in healthy tissues, will rapidly cause an abscess with all its sequelæ if the circulation has been first of all impeded by strangulation of the tissues. A bactericidal property has been attributed to the secretions of the wound; but Brunner has already pointed out that though such may exist it is far outweighed by the nutritive value of the secretion for bacteria. Practical experience leads us very decidedly to question the defensive value of the secretions from the wound where inoculation has actually occurred.

To prevent "lesion infection" (Tavel) or, as we prefer to call it, "necrosis infection," everything must be avoided during an operation which causes severe damage to the tissues, *e.g.* splitting, crushing, and tearing. Incised wounds are most innocent in this respect, a fact long recognised and proved by Tavel, whereas crushing, even to a slight extent, is followed by a more or less extensive necrosis of the surface of the wound. For this reason an experienced operator has more prospect of obtaining uninterrupted repair in his wounds than a novice, though both operate under precisely similar conditions as to sterilisation and disinfection.

Besides refraining from unnecessary splitting, crushing, and tearing of the tissues, the avoidance of chemical or thermal injury is just as important for the prevention of necrosis. According to Walthard's experiments drying is more deleterious for certain tissues than anything else. This can be avoided by repeated irrigation with warm normal saline solution. The method of "dry operating," much advocated in earlier days, is thus contraindicated, although even by it the unfavourable effects can be minimised by covering up the tissues and so preventing cooling or evaporation. In certain operations, such as those on the abdomen, the covering of the contents with warm compresses or copious irrigation with salt solution at the proper temperature is of supreme importance, not only on account of the danger of infection, but also as a preventative against the shock which accompanies every severe operation, and in the splanchnic region often followed by circulatory trouble. This method was probably first introduced at the clinic at Berne.

No less important than the prevention of thermal injuries is the prevention of chemical injury. This indication is very frequently neglected. There are a certain number of surgeons who refuse to discontinue the practice of douching and washing out wounds with antiseptic solutions, in spite of the fact that it has been demonstrated that death of the micro-organisms on a wound surface cannot be brought about without severe injury to the tissues. The proof of this is due to Kontschewsky. He has demonstrated delay in karyokinesis and in repair, as Goldberg and others have also done. Antiseptic washing and douching can, therefore, only be occasionally justifiable when the chemical injury caused by it is more than counterbalanced by the infective material destroyed. This occurs in wounds which are already badly infected. In recent wounds, however, douching with antiseptics should be entirely given up and an indifferent osmotic fluid, such as normal saline solution at the body temperature, should be used instead. We never employ any other form of irrigation than this, which we use freely. It was not until we gave up antiseptics that we arrived at the knowledge of what perfect repair in wounds really meant. Koller, under Tavel's

active antiseptic measures increase the necrotic change in the tissues. For this reason, as a general rule, whether in infected wounds or in wounds only suspected of being infected, the principle must be observed that injury to the surface of a wound by means of chemical agents must be avoided, and when, owing to the presence of foreign bodies and germs, the wound requires to be cleaned this must be effected with an indifferent lotion, such as we possess in the most suitable form in normal saline solution. This is the best treatment for wounds which are accessible to it. But the condition met with in punctured wounds offers another point for consideration in the treatment of infected wounds. We refer to the prevention of all tension and pressure within the tissue, the importance of which has been emphasised by Friedrich. Free opening-up of the part as a precaution against tension must therefore be added to douching with a chemically and thermally indifferent solution (normal saline), because if infection sets up inflammation the resulting tension is much greater than that caused by effused blood and exudate.

No measure for relief of tension is so efficient as the open treatment of the wounds, a method which was introduced and most successfully employed by Kern, and especially by Burow before the days of antiseptics.

Friedrich, as the result of his researches, has arrived at the conclusion that there is only one method of treating spreading infection, namely, by open treatment of the wound ; and he points out that the difference of opinion as to the advantageous action of antiseptics is due to the fact that antiseptics were employed at one time in conjunction with, and at another time without, open treatment of the wound. The open method of treating a wound possesses the advantage that besides preventing tension on the surface of the wound and in the tissues, it induces a flow of the exudation from the deeper parts towards the surface. This results in a mechanical extrusion of germs, and owing to the bactericidal properties of the exuded serum, a retarding influence is exercised on their development. Infected wounds must, therefore, be freely laid open by a suitable incision (avoiding all unnecessary tearing and bruising) in order to prevent tension and to admit of aseptic douching. The salutary effects of this treatment, especially in the early stage of extravasation of urine, are very remarkable, as the temperature, which may have been as high as 42° C., falls to 36° immediately after incision.

Although even in infected wounds there is good reason for avoiding any further injury to the tissues, yet the fact must not be overlooked that a number of wounds are already so far under the influence of bacteria that these have already caused extensive necrosis by their toxic action. Only one course is here possible, namely, to remove as quickly as possible the necrosed tissues. This can easily be done as regards necrotic tissue, which is merely loosely adherent on the surface of wounds. Necrosed blood, leucocytes, and fibrin can easily be washed away by douching or sponging. Adherent sloughs and infected tissues require a different treatment.

Friedrich, in his experiments on wound infection with malignant œdema, succeeded in demonstrating that infection and death can be definitely prevented by careful and fairly free incision of the whole surface of the wound within an hour of infection and before development of the bacilli has begun. In the same way, excision of a wound is indicated where it is certain that changes are confined to the superficial layers only. That such is the case may often be recognised by changes in colour and consistency. Obviously-necrosed tissue may be removed with a knife and scissors. Where the changes in the tissues have led to induration and inflammatory thickening the sharp spoon may be advantageously employed for the removal of the necrosed granulation tissues.

But cases are frequently met with in practice in which the symptoms of deeper and more extensive infection have already supervened to an extent which absolutely precludes the possibility of complete excision of all the necrosed, or even of the infected tissues. In cases where this treatment cannot be carried out, even by amputation, we must be content to endeavour to prevent further spread of the disease from the necrosed areas by means which will hinder its development, but which will not further injure the subjacent tissues, and so cause more extensive necrosis. For this

purpose the various dry methods are most suitable when the relations of the wound are not such that the same end may be attained by continued douching and poulticing. If the latter methods are applicable, they should be carried out with antiseptic solutions just strong enough to exercise a retarding influence on organismal development (salicylboric solution, chloride of zinc, lysol 0·2 per cent, etc.). Starcke also recommends these weak lotions. The most satisfactory means of drying up the necrosed tissues are, on the one hand, swabbing with alcohol, which causes shrinkage of the tissues, and, on the other hand, the application of powders, the most important of which are iodoform and bismuth subnitrate, which entail no injurious effects on the deeper tissues.[1] A. Fränkel has recently made a praiseworthy attempt to show that the effect does not greatly depend on the nature of the powder, and that in many cases iodoform might be replaced by wood charcoal.

This method of freely laying open the diseased tissues, in order to limit putrefaction occurring in the necrosing parts of the wound, cannot be carried out in all infected wounds with necrosis of the tissues. Many deep wounds do not admit of being opened up in the sense understood by the open treatment of wounds. In such cases we must confine ourselves to open up the wound freely enough to admit of agents capable of preventing the development of germs being brought into contact with the most inaccessible parts of the wound. The most efficient means to this end may be grouped under the term "antiseptic tamponage." This method is specially designed to prevent the development of germs in the deeper parts of the wound, and it serves at the same time partly as a drain. When the skin, fasciæ, etc., have been sufficiently opened up and the wound has been washed with an indifferent lotion, the whole cavity is stuffed with iodoform gauze, or with a suitable substitute, which must be renewed as soon as the secretion raises it from the surface of the wound. Such tamponage is also employed in newly-made wounds when they are very liable to infection, and, as a rule, whenever an operation has been performed without preparation, or in the region of old foci of inflammation, or in the neighbourhood of the passages of the body which may be injured (as in the vicinity of the throat or intestine). In such cases recourse should be had to secondary sutures, which are highly recommended for doubtful cases, and the introduction of which was considered by Starcke to be epoch-making. The wound remains open, protected by aseptic dressings or tampons soaked in a weak antiseptic, and a few days later the sutures are tied and a large drainage tube is employed till the secretion from the wound has dried up.

[1] Considerable value should be attached to the application of diluted alcohol, recently revived and brought into favour again by Salzwedel. According to Epstein, 50 per cent alcohol is most efficient and increases the efficiency of other antiseptics, such as sublimate. Salzwedel, Elsner, as well as Minervini and Tschirikow, confirm the efficacy of 55 per cent alcohol, and they have shown that 7 per cent alcohol is capable of *preventing* the development of staphylococci. That touching with pure carbolic acid, as recommended by Bruns and Honsell, may be of use under certain circumstances, *e.g.* where sloughs are already present, is undoubted.

SECTION II

SURGERY OF THE VASCULAR SYSTEM

A. SURGERY OF THE HEART AND PERICARDIUM

THE heart, ever active and difficult to deal with, has at last yielded to surgical treatment. Several important works have now appeared on "The Surgery of the Heart," the most important being those of Brentano, Terrier and Reymond (translated and enlarged by Lardy and Beck) and of Braun. Previously Paré had recognised that every wound of the heart is not necessarily fatal, and Morgagni had shown that one of the chief causes of death was due to compression of the heart by the accumulation of blood in the pericardium. In 1888 Fischer gave a careful review of 452 cases of injury to the heart and pericardium, and showed that in a certain number of cases recovery had resulted. Rose has pointed out that to save life it is necessary to prevent the heart's action becoming oppressed by the extravasated blood.

The majority of persons who receive a cardiac injury, even a perforating wound of the heart wall, do not die directly from the injury (as in Kronecker's case of stab of the heart), but from the subsequent loss of blood combined with the emptying of the heart, the result of pressure of the extravasated blood on the large veins (Cohnheim). It has been proved by the statistics and experiments of Del Vecchio, Bode, Elsberg, Salomoni, Bloch, and Filipoff, that a perforating wound will cicatrise firmly if the results of bleeding are avoided. A fibrous scar is formed, which may, however, later on lead to the formation of an aneurism and rupture.

If a person who has sustained an injury in the region of the heart is found to be suffering from great dyspnœa with cyanosis, or from collapse and anæmia, and with corresponding variation in the pulse, and if on examination hæmorrhage into the pericardium, with or without simultaneous hæmothorax, is discovered, immediate exposure of the heart is clearly indicated, first, with the object of opening the pericardium and emptying out the extravasated blood which is compressing the heart, and, second, of suturing the wound in the heart.

1. Exposure and Suture of the Heart. When, from the position of the wound and the symptoms of collapse and dyspnœa described above, there is presumption of an injury to the heart, it is the duty of every surgeon to be prepared to promptly open the pericardium and lay bare the heart with the least possible damage to the neighbouring structures.

That this can be attained in various ways is shown by Terrier and Reymond, who found in 1900, that in eleven cases of heart injury, ten different operative methods were put into practice. The position of the injury as regards the heart naturally modifies the method employed, *i.e.* whether it is to the right or left of the sternum, above in the region of the auricles or below in that of the ventricles. But in such an operation as exposure of the heart, which demands rapidity of execution under

exciting conditions, it is urgently necessary that the surgeon be familiar with one method of procedure which can be adopted in any case with which he is called on to deal.

The surgeon must first of all be able to open the pericardium without increasing the danger from further severe hæmorrhage, or without the necessity of a severe preliminary operation, and especially without injuring the pleura. It generally happens that in injuries of the heart, the pleura is damaged as well, but we are not justified in causing still further injury and possibly producing a fatal collapse from the production of a sudden pneumothorax.

Although only a small area of the pericardium is uncovered by the pleura, incisions must be strictly maintained within these limits, the uncovered area corresponding to the junction of the sixth costal cartilage with the sternum (*vide* Fig. 27). According to Terrier and Reymond, the interpleural space varies considerably in size and position, but in the majority of cases one can only expect to succeed in avoiding injury to the pleura, and still more to be able to expose and retract the pleural reflexion by keeping within this limit.

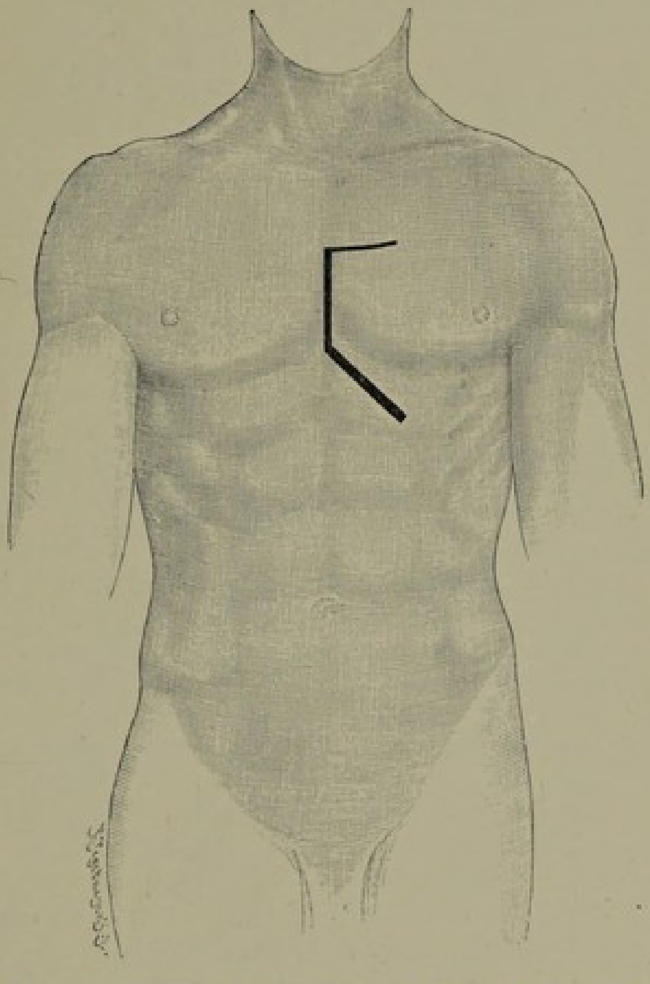

FIG. 24.—Incision for exposure of the heart. The primary incision along the sixth rib is indicated by a broad line, while the transverse cut along the third (or second rib) is represented by a finer line.

Secondly, after having rapidly exposed the pericardium, where it is in contact with the chest wall, the surgeon must know how to release it sufficiently from the overlying pleura so that it may be freely incised and the heart fully exposed. This necessitates turning back a portion of the chest wall ("volet" of the French), and this can only be done quickly and with safety when the pleura has been pushed aside at the site of incision.

If attention is paid to these preliminaries there is no risk of injuring the surrounding structures. We are glad to observe that Terrier and Reymond in their comprehensive work on cardiac surgery recommend the same procedure as we advised in 1902 (*vide* the 4th edition of this work).

The incision resembles that introduced by Delorme for exposure of the lung, and adopted by Podrez for exposure of the heart. The method of dividing the chest wall is that of Guidone and Fontan, while the treatment of the pleura is the method described by Launay. Terrier and Reymond give an admirable detailed description of the operation.

Operative Procedure. The skin is quickly but thoroughly disinfected with soap and warm water, ether and alcohol (avoiding antiseptics), sterilised gloves being worn. An incision, 10 cm. (4 inches) long, is made from the middle line of the sternum along the sixth costal cartilage as far out as its junction with the rib, dividing the costal attachment of the rectus abdominis. The fibres of the pectoralis major and of

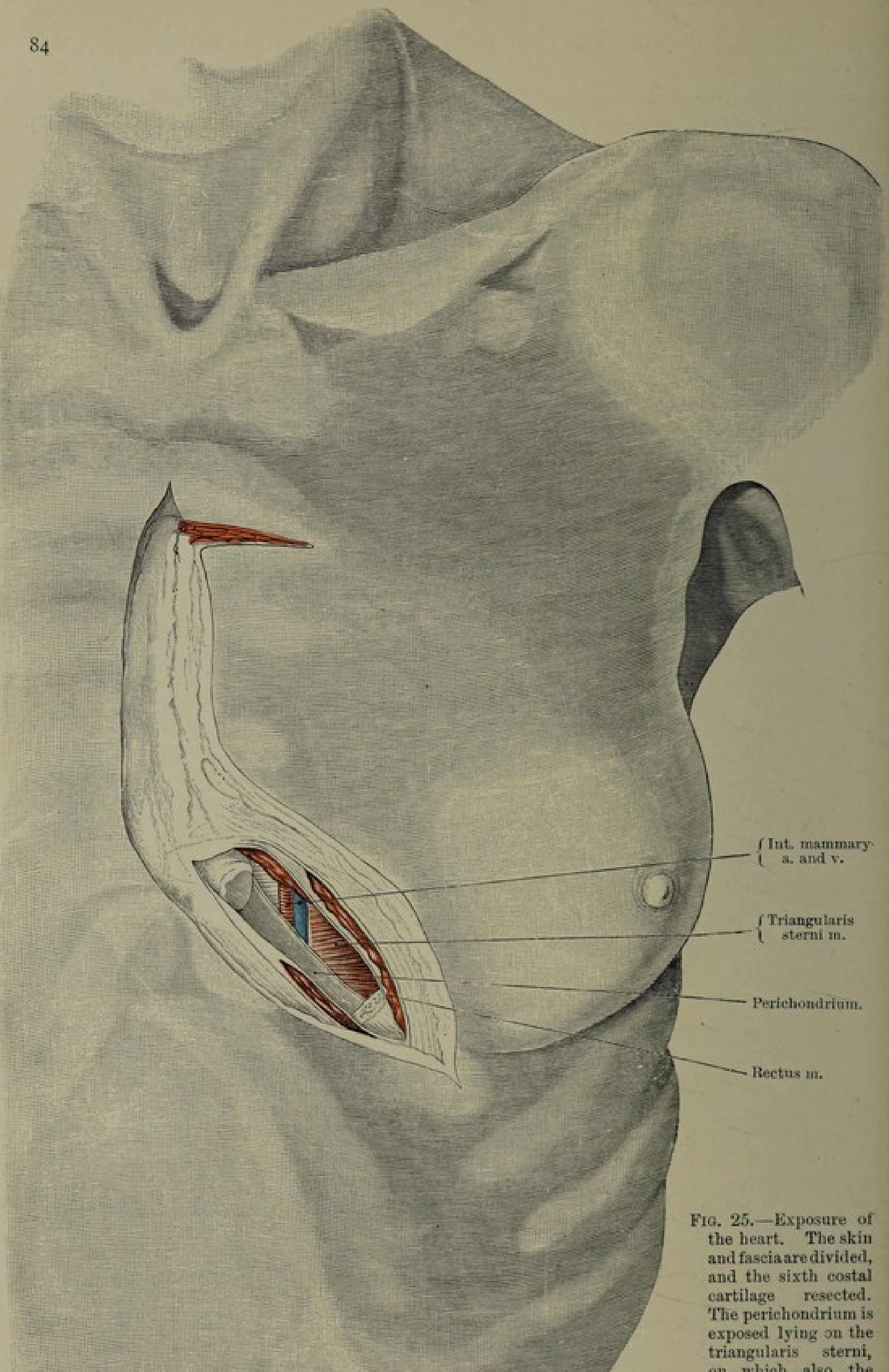

FIG. 25.—Exposure of the heart. The skin and fascia are divided, and the sixth costal cartilage resected. The perichondrium is exposed lying on the triangularis sterni, on which also the internal mammary vessels descend.

the rectus are separated from the upper and lower borders of the rib, while the intercostal muscles are also detached above and below with the knife. After the posterior surface of the perichondrium has been freed with a raspatory, the sixth costal cartilage is then divided close to the sternum, and when raised up with a hook, the connecting bridge between it and the seventh costal cartilage is cut through.

The internal mammary artery and vein are exposed descending vertically a finger's breadth from the edge of the sternum, and are divided between two ligatures. Behind them the musculo-tendinous triangularis sterni is seen spread out like a fan, and is divided close to the sternum.

The triangularis sterni which (as was first pointed out by Delorme and Mignon) is adherent to the pleura is retracted outwards. The pleural reflection can often be recognised by the presence of a layer of fat, and can be easily separated from the pericardium so that the anterior surface of the latter can be exposed down to its attachment to the diaphragm. The tough, glistening pericardium can then be safely opened, if urgent relief is required, *i.e.* if the heart is seriously compressed by effused blood.

If there is no great urgency the procedure is as follows:—According to the situation of the wound in the heart, the incision is prolonged upwards in the middle line of the sternum to the fourth, third, or, if the wound is situated higher up, to the level of the second costal cartilage. At the upper end of this wound, an incision, 8 cm. long (3 inches) is carried transversely outwards through the pectoralis major down to the cartilage and bone of the corresponding rib (usually the third), from the upper border of which the muscular and tendinous fibres of the intercostal muscles are detached.

The pleura, along with the triangularis sterni, is then carefully separated from the deep surface of the fifth costal cartilage and pushed aside, while the rib is divided with bone forceps close to the sternum, a finger being pushed behind the forceps. The costal cartilages of the fourth and third ribs are dealt with in exactly the same manner.

The costal cartilages are now raised, and after the triangularis sterni and pleura have been further retracted, are broken across at their junctions with the ribs, while if necessary the ribs themselves are broken further out. A flap of the thoracic wall is thus turned outwards and the pericardium exposed from the auricles above to the apex below. It may now be freely incised if this be found necessary.

Terrier and Reymond assert that by throwing back a flap in this way one can readily detect and clamp any tear in the pleura.

When the injury is situated in the region of the heart, the operation is naturally commenced over the seat of injury so that it may thus be limited in extent. For example, in Grekow's case (a wound of the left ventricle through the second intercostal space), the heart was sutured after removal of the third and fourth costal cartilages. In such a case as this the incision described may be begun above, although it introduces a risk of injuring the pleura. The second rib must also be divided, if an examination of the great vessels has to be undertaken.

If better access is required to the right heart, especially to the region of the right auricle, the soft parts (muscle, fascia, and pleura) of the other side are separated from the posterior surface of the sternum, the latter being then divided transversely above and below with cutting forceps, and turned back as a flap by bending the costal cartilages of the other side. When this flap is fully bent backwards the cartilages break, according to Terrier and Reymond, at the junction with the rib, and not at the junction with the sternum.

Exposure of the heart from the front by resection of the sternum (the method adopted by Podrez, Wehr, Rydygier and Pagenstecher) is in our opinion too mutilating an operation in the majority of cases, and should be reserved for cases of injury of the right heart. For wounds in this situation Rotter recommends the formation of a flap, which is turned back like a folding door on a median hinge, when the right auricle, right ventricle, great veins, and arch of the aorta are thoroughly exposed. Access can only be obtained to these structures by turning back the sternum to the right, and we consider that the method of Ninni, Rydygier and Rotter, in which the

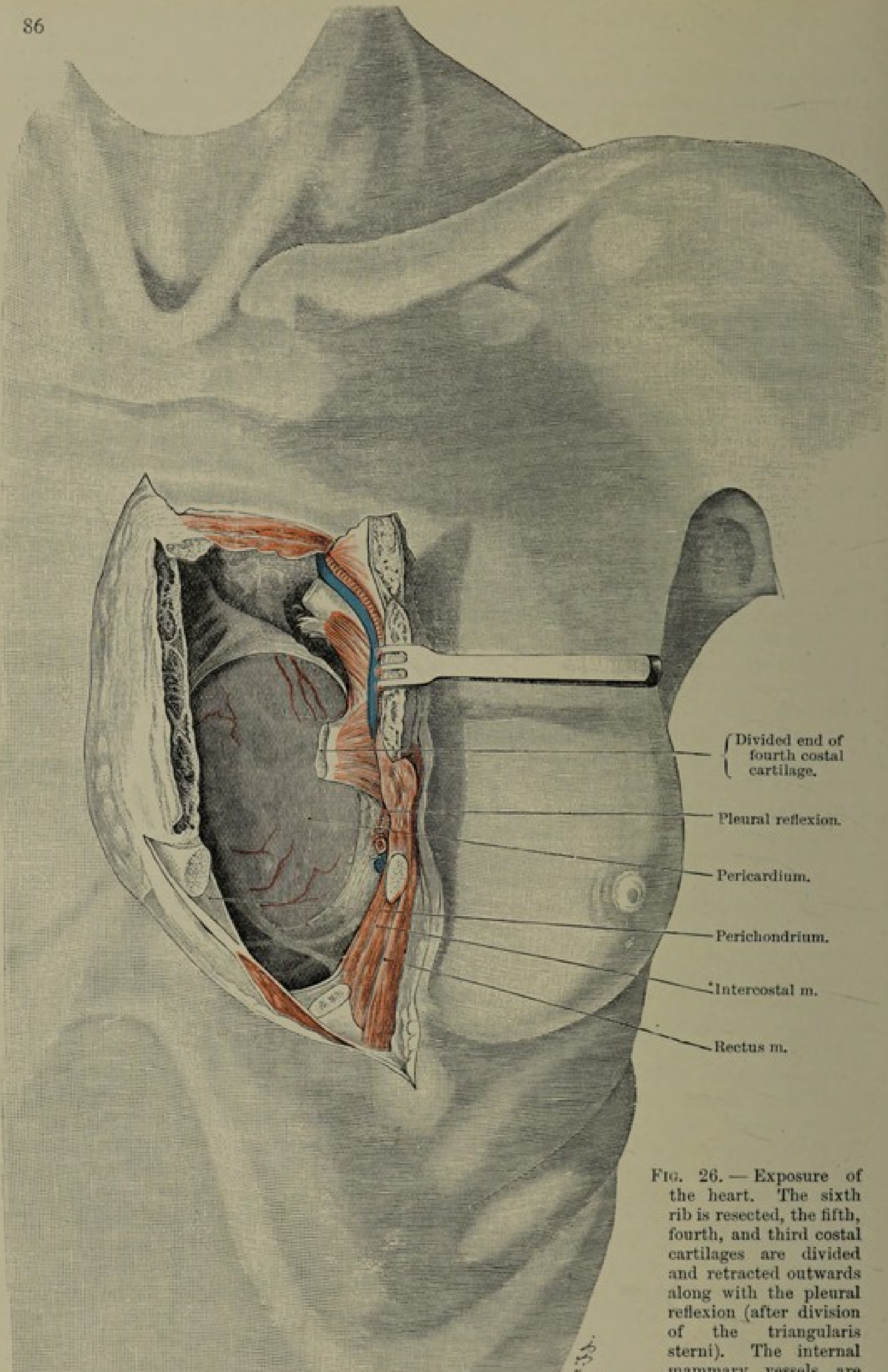

Fig. 26. — Exposure of the heart. The sixth rib is resected, the fifth, fourth, and third costal cartilages are divided and retracted outwards along with the pleural reflexion (after division of the triangularis sterni). The internal mammary vessels are seen ligatured and divided, and the pericardium is fully exposed.

base of the flap is made at the sternum, produces more injury than the operation we recommend.

Two fingers should be passed behind the heart, which should be raised up before the sutures are inserted. To explore the posterior surface of the heart Terrier and Reymond grasp the apex with a pair of Museux's forceps, the same instrument which Longo uses for securing the edges of the wound.

According to Rehn, it is important to leave the ends of the first suture long, as the seat of the injury can then be pulled up and the insertion of a continuous suture is facilitated. Heitler recommends that the heart should be painted with cocain before introducing the sutures so as to prevent reflex arythmia.

The strictest asepsis must be observed throughout the operation as otherwise death may result from pericarditis and pleurisy. If the operation is aseptically carried out the pericardium and pleura should be immediately stitched up, while a drain is necessary only in infected cases.

Vaughan has observed that the prognosis is better if several hours have already elapsed since the injury, for in these cases the damage is not so severe. His case died of hæmorrhage, 2000 c.cm. of blood being found in the pericardium and pleura, so that it is well to resort as early as possible to saline transfusions.

It is beyond doubt that we can attain our object by various methods, and the position of the external wound is to be considered in choosing our procedure. Rehn, Parozzanni and Pagenstecher have reported successful cases of suture of the heart. The latter surgeon was able to collect 10 cases of heart suture with 6 recoveries (all being wounds of the ventricles). Other methods have been employed unsuccessfully by Farina, Cappelen, Giordano; and for exposure of the heart only, by Stelzner, Podrex, and others.

The results of cardiac surgery up to the present time show that it is the duty of every physician and surgeon to take immediate and active measures in cases of injury in the cardiac region, associated with symptoms of involvement of the heart. The latter consist, apart from acute anaemia, of "herztamponade" (impairment of the heart's action by effusion), specially referred to by Morgagni, and described by Rose as a diagnostic symptom of cardiac injury. In this connection the following points are to be specially noted :—

1. Blunt force may also damage the heart without producing any external wound. Mansell-Moulin removed a large quantity of blood from the pericardium, the result of a heavy blow three weeks previous, and the patient recovered.

2. Still more remarkable are the effects of gunshot injuries, where, although the shot had not penetrated the pericardium, serious injury to the heart was produced, as in eight cases collected by Deschamps. On the other hand, shot can be tolerated in the heart for a considerable time without the appearance of severe symptoms.

3. Further, one must not forget that punctured wounds inflicted by a needle are often very serious. Loison collected 23 such cases, 14 of which resulted in death. The worst cases are those in which the needle remains stuck in the thoracic wall, as the heart then tears itself against it. Terrier and Reymond found 3 recoveries (cases described by Foy, MacDougall, and Stelzner), in which the needles were simply pushed right into the heart, as they could not be removed.

4. It must be remembered that the initial symptoms are not necessarily of a serious nature, as some patients can even walk (as in A. Paré's case), but afterwards die suddenly, Stewart adducing such a case observed by a colleague and another by Izzo. There may even be an entire absence of dyspnœa and cyanosis, the result of compression of the great veins (Cohnheim) or of associated pulmonary complication (hæmothorax). If these complications are present the pulse is almost insensible, the cardiac region is dull, and when there is an associated injury to the lung the heart's action makes a gurgling noise which naturally renders the diagnosis much easier.

Watson, Senn, Begouin, Bruhl, and others have proved the efficiency of cardiocentesis in animals in cases of entrance of air into the veins, and thence into the right side of the heart, and in cases where the right side of the heart was over-distended with blood. The procedure has also been employed in the human subject.

5. Finally, it must be borne in mind by the resident physicians who generally see these cases first, that in rupture of the heart secondary to diseases of the arteries, the patient does not die immediately, but may live for twenty-four hours or more. Even in these cases, therefore, it is justifiable to attempt to relieve the pressure on the heart (herztamponade), and even to suture the ruptured organ.

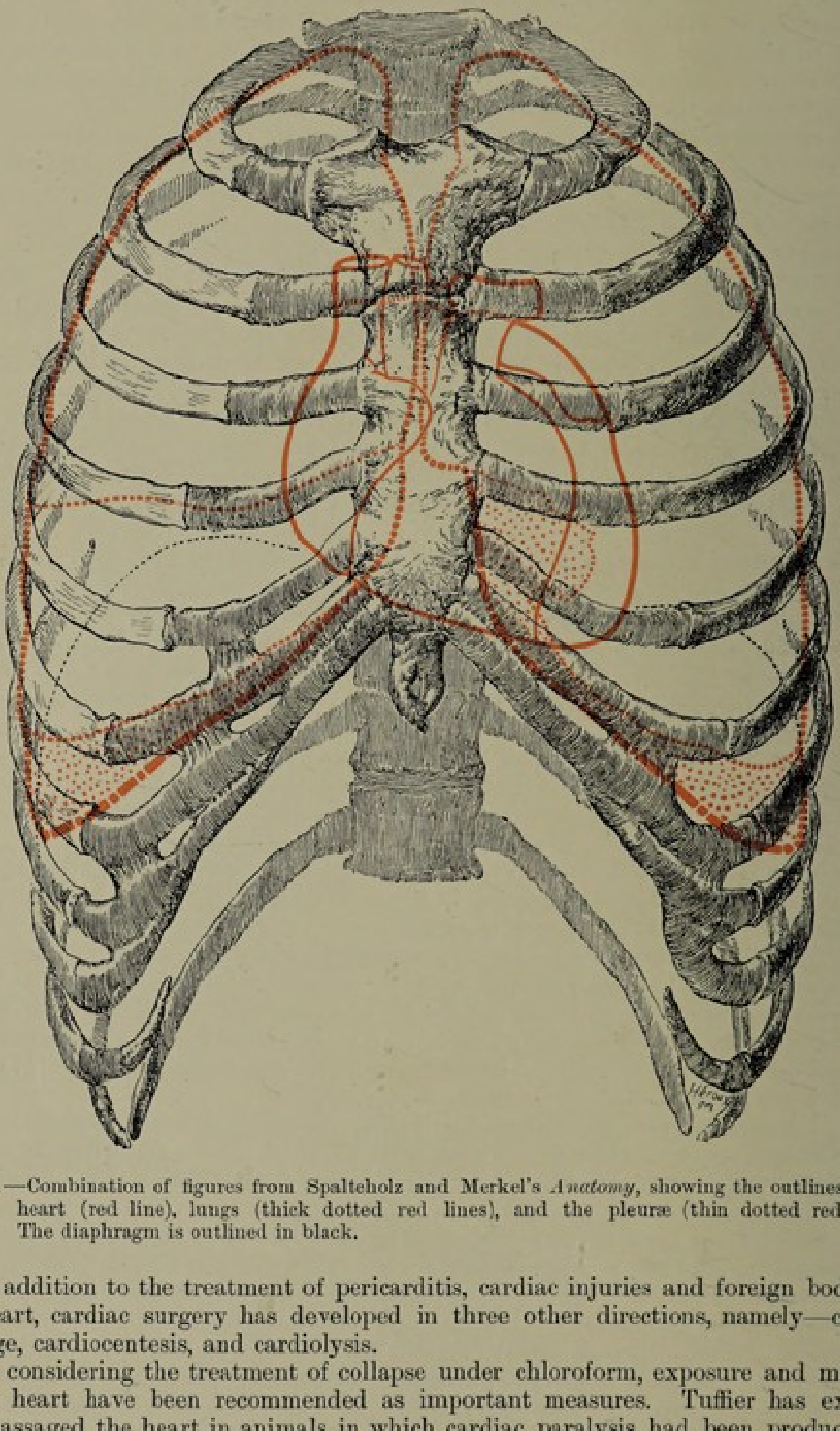

FIG. 27.—Combination of figures from Spalteholz and Merkel's *Anatomy*, showing the outlines of the heart (red line), lungs (thick dotted red lines), and the pleuræ (thin dotted red lines). The diaphragm is outlined in black.

In addition to the treatment of pericarditis, cardiac injuries and foreign bodies in the heart, cardiac surgery has developed in three other directions, namely—cardiac massage, cardiocentesis, and cardiolysis.

In considering the treatment of collapse under chloroform, exposure and massage of the heart have been recommended as important measures. Tuffier has exposed and massaged the heart in animals in which cardiac paralysis had been produced by

means of an anæsthetic, and also in a case of syncope from embolus while Rotter refers to Kuliabko's and Maag's experiments on animals. Sick succeeded in resuscitating a case by means of cardiac massage when there had been complete collapse for the space of an hour (Helfreich's clinic).

It is interesting to note that since J. Wolf reported a recovery from a wound of the heart in 1642, Del Vecchio in 1895 was the first to suture the heart successfully in the case of a dog, and after two unsuccessful attempts by Cappelen and Farina in 1896, Rehn in 1897 published the first famous successful cardiorrhaphy in man. Elsberg later on laid down precise directions for the treatment of the exposed heart, and Terrier and Reymond were able to collect 51 published cases in which operation was undertaken for cardiac injury, in 19 of these cases with complete success.

F. T. Stewart, in 1904[1] collected 60 cases with 23 recoveries. To show the importance of asepsis, it is interesting to note that not less than 13 of the 37 deaths were due to infection. In 57 cases the pleura was injured as well. Of the 4 cases

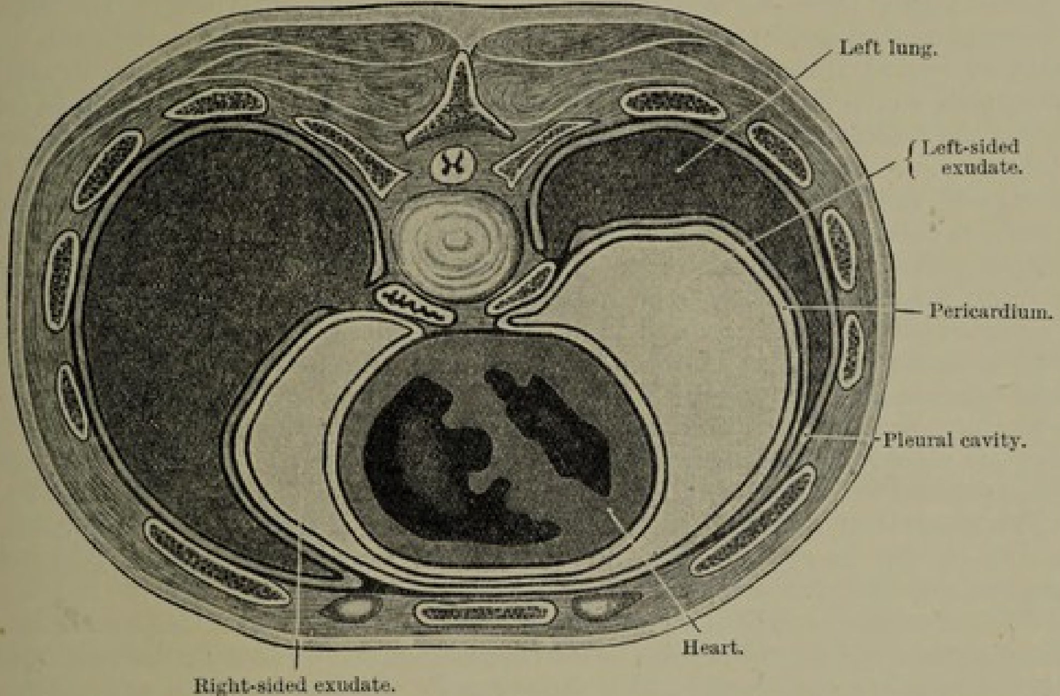

FIG. 27*a*.

in which there was injury to the coronary arteries, Stewart's patient only, in whose case the injury was produced at the operation, recovered by means of suture.

2. Puncture, Incision and Drainage of the Pericardium. Fig. 27 (after Spalteholz) indicates the outlines of the heart and pericardium in relation to the anterior wall of the thorax. The base of the pericardium extends transversely across the root of the ensiform process from a point 2 cm. ($\frac{3}{4}$ inch) to the right of the sternum, to a point 7 cm. (3 inches) to the left of the sternum, *i.e.* to the apex beat in the fifth intercostal space. Above, it reaches as high as the second rib, *i.e.* the root of the great vessels—in other words, the origin of the brachio-cephalic trunk (innominate artery) from the aorta, and the bifurcation of the pulmonary artery. A corresponding portion of the superior and inferior venæ cavæ is enclosed within the pericardium. Its posterior surface, according to Luschka, reaches as high as a line drawn through the middle of the manubrium sterni.

Paracentesis of the pericardium is indicated, according to Curschmann, in cases of serous, sero-fibrinous and hæmorrhagic effusion:—(1) when the fluid is rapidly increasing and oppressing the heart and lungs, causing dyspnœa, cyanosis, and a small

[1] *Transactions of the Coll. of Phys. Philadelphia*, 1904.

rapid pulse; (2) and when absorption does not take place, especially if there is concurrent disease of the heart and lungs or the presence of fluid in the pleura.

Curschmann uses a flat trocar with a lancet-shaped flattened point. It is fitted with a stop-cock, to which a rubber tube is attached, and the fluid is very slowly drawn off.

In selecting the site where we should make the puncture, which is only indicated when there is an extensive effusion, Curschmann has shown that the choice is determined by conditions quite different from those which fix the site when the heart itself is to be reached in cases of injury to the organ. The portion of the pericardium, which is in closest contact with the thoracic wall, is to be avoided in performing paracentesis, for when fluid accumulates in the pericardium it does so chiefly laterally, and at the same time distends the pericardium outwards, specially to the left, and backwards. In this way the heart itself comes to be closest to the chest wall. Fig. 27*a* reproduces in horizontal section the appearance of an extensive effusion after Curschmann's excellent demonstration.

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The removal of a serous effusion is only indicated when there are symptoms of pressure on the heart, *i.e.* when the effusion is very extensive. In these cases puncture, according to Curschmann's directions, is of itself sufficient.

When the effusion is of a sero-fibrinous or hæmorrhagic character, in addition to causing pressure on the heart there is the further risk of pericardial adhesions forming after the fluid has coagulated. This formation is best prevented by pericardiotomy rather than paracentesis, as the coagulated lymph can only be thoroughly removed by the former procedure.

The statistics in regard to suppurative pericarditis are so convincing that aspiration by simple puncture is no longer regarded as adequate. Terrier and Reymond quote a thesis by Fevrier, in which 9 cases of suppurative pericarditis treated by puncture are reported with 9 deaths. On the other hand there were 6 recoveries in 19 cases treated by incision without resection, and 8 recoveries in 14 cases treated by incision and resection. Reichardt reports 2 cases successfully operated on by Lindner (in Ewald's clinic).

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To avoid the necessity of resecting a rib, Larrey reaches the pericardium through an incision along the lower border of the seventh rib, a route which Mintz has recently approved. An incision, 7 cm. long (3 inches), is made along the lower border of the seventh rib, and the abdominal muscles are detached and the cartilage divided in two places and turned upwards. In this way the pericardium is exposed in a few minutes. Delorme and Mignon resect both the sixth and fifth ribs.

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3. Cardiolysis. The term cardiolysis is applied to the operation in which the pericardium is opened for the treatment of extensive pericardial adhesions. Delorme devised the operation originally for the treatment of pleural adhesions, and afterwards applied it to the heart.

Very free access is essential, and for this reason a preliminary operation, similar to that described for injuries to the heart, is required. In our fourth edition we observed that in the real "symphyse cardiopericardique" of Delorme this operation is not free from danger, as the heart may be torn in spite of the greatest care.

When the adhesions involve the structures adjacent to the pericardium, namely, the sternum, mediastinum, diaphragm, and lungs, Brauer has endeavoured in another way to free the heart from the great mechanical disadvantage to which it is subjected in pushing the surrounding structures, *e.g.* when it pulls in the chest wall at every systole.

He makes no attempt to separate the indurated adhesions, but endeavours to mobilise the thoracic wall in front of the heart by means of resection. The term cardiolysis does not therefore quite aptly describe the operation. It might be termed pericardiolysis as it implies removal of portions of the sternum, although it is really a thoracolysis præcardiaca.

Simon (who with Peterson operated on Brauer's cases) employed a method similar to that Rotter uses to expose the pericardium, viz. by means of a swing-door flap with the base at the middle line. A flap of skin and muscle is thrown back, several ribs are resected, and a corresponding portion of the sternum is removed. Simon considers that it is absolutely necessary to remove the posterior layer of the periosteum of the sternum in order to prevent a fresh formation of bone. The removal of the sternum is the most critical stage of the operation.

This method undoubtedly affords relief from the cardiac insufficiency, dyspnœa, cyanosis, hepatic congestion and ascites, which result from indurated adhesive pericarditis, and has been suggested as a means of access to effusions in the pericardium, the complete removal and permanent drainage of which has to be taken into consideration.

There seems to be no reason why one should not proceed to the removal of effusions in the pericardium in the same way as with exposure of the pericardium for injuries of the heart. As there is only a limited area where it is tolerably certain that the pericardium is not covered with pleura, there is a double reason for choosing this region for puncture and incision when dealing with purulent effusions, so as not to infect the pleura.

In the case of a simple pericardiotomy, we therefore advise resection of the sixth rib at its junction with the sternum, using an oblique incision along the course of the rib (*vide* the low oblique incision in Fig. 26). The cartilage is removed, the posterior layer of the perichondrium and the triangularis sterni pushed aside together with the pleura, and an incision is then made into the pericardium large enough to admit a finger.

If this does not give sufficient room for separating the indurated adhesions, the fifth rib also may be removed, by means of a short vertical incision, as is advised by Ollier, Porter, Delorme and Mignon. If a pocket of pus still remains in the anterior cul-de-sac of the pericardium, the seventh rib may also be removed (Mintz) and free drainage obtained by pushing the pleura aside. If necessary the pericardium may be incised as far as the cardiac apex, a procedure which Reichard regards as essential.

To prevent the formation of dense adhesions between the heart and pericardium,

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it is well in all cases of suppurative pericarditis to interfere at an early stage and wash out the coagulated fibrin. Normal saline is employed for this purpose as the use of corrosive sublimate, carbolic and other antiseptics must be regarded as positively harmful. Irrigation with weak (1 per cent) iodoformol may be considered in the recumbent position, but the semi-recumbent posture should be adopted to ensure good drainage of the exudate.

Beck [1] has reported three cases of mediastino-pericarditis (Brauer). The patients exhibited symptoms of tugging on the thorax during systole, diastolic cardiac impulse, degeneration of the myocardium, congestion of the liver and kidneys, and ascites due to pleuritic effusion.

The operation consisted in a partial resection of the bony thorax. A flap of skin and muscle was turned upwards, extending from the sternum to the anterior axillary line, and the convex free-border reaching down to the lower border of the sixth rib. The third, fourth, fifth, and sixth ribs were resected from the sternum to the anterior axillary line. The three patients recovered, and all the symptoms of congestion were relieved.

B. SURGERY OF THE LARGE ARTERIES

1. Ligature of the Abdominal Aorta. Keen of Philadelphia (1900) [2] has published the most recent article on ligature of the aorta giving 13 recorded cases. The first case was operated on by Sir Astley Cooper (25th June 1817), and the latest by Tillaux and Riche.[3]

In no instance has ligature proved successful. Tillaux and Riche's patient died thirty-nine days after the ligature from the effects of the altered circulation. The ligature did not give rise to ulceration, but, in this case, the occlusion of the aorta was incomplete. Keen's patient lived forty-eight days after the operation and died as a result of ulceration at the site of ligature, with consequent hæmorrhage.

Further attempts to ligature the aorta cannot therefore be justified, and other methods must be adopted for the treatment of aneurysm (the most common indication), such as the insertion of silver wire, or the use of intra-muscular injections of gelatine (2 to 5 per cent in 200 g.). In injuries to the aorta ligature must be effected by other methods.

Keen has devised a special instrument for compressing the aorta. By means of a screw, two horizontal plates are gradually approximated and the aorta is obstructed, the instrument being left in position for the requisite time (two to three days) and then removed. We venture to think that it would be more advisable to follow Lambotte's advice and use a metal clamp which would flatten the aorta from the front backwards, as in Keen's case circular constriction proved disastrous. Such a clamp could easily be removed at any moment.[4]

From the evidence afforded by the literature on the subject it is quite clear that in man, as in dogs, it is possible to ligature the aorta without producing fatal circulatory disturbances. The profound initial congestion—in Keen's case, the head and neck becoming livid — the acceleration of the pulse and the altered circulatory relations associated with paralysis of the legs, strangury and diminution in the secretion of urine may all disappear without permanent evil results.

As in previous cases, the operative procedure must be regulated by the prevalent conditions. When the peritoneum can be easily separated from the abdominal wall the operation may be satisfactorily performed extra-peritoneally, and we refer the reader for details of the operation to our description of ligature of the left common iliac artery, a method which we regard as a distinct improvement on its predecessors. The primary oblique incision is simply made a little higher up, convenient access is obtained, and the fasciæ, not the muscles, are divided. The vertical

[1] *Deutscher Chirurgencongress*, 1904.
[2] *American Journal of Med. Science*, Sept. 1900.
[3] *Revue de chir.*, 1901.
[4] *Brit. Med. Journ.*, Oct. 1904.

and transverse limbs of the angled incision through the fascia may be enlarged to any extent without any resultant harm.

If the peritoneum cannot be readily separated on account of inflammatory or hæmorrhagic infiltration, access to the aorta must be obtained by means of a median laparotomy. In Keen's case the pancreas was pushed up, and the vertebral column was reached between the pancreas and the stomach after division of the gastrocolic omentum, certainly no easier a route to follow than by access from the left side. Every case must be carefully considered before a decision is arrived at as to the method of procedure, while no one but an expert surgeon should attempt the operation. The advantages of arterial suture can only be observed in special cases, but, *a priori*, there is no reason why arterial suture should not be employed, more especially if the line of suture can be strengthened by the superposition of a reinforcing tissue such as fascia, periosteum, or peritoneum. Cases have been recorded where fatal hæmorrhage was prevented simply by the relation of the injury in the aorta to the spinal column.

2. Ligature of the Innominate Artery. To ligature the innominate artery an oblique incision (Gräfe, Winniwarter) is made from the junction of the middle and lower thirds of the anterior border of the right sterno-mastoid to the anterior surface of the manubrium sterni. After the skin and fascia are divided, the sternal origin of the sterno-mastoid is separated from the sternum. Two veins are to be avoided, namely, the transverse vein connecting the two anterior jugulars at the suprasternal notch, and the transverse terminal portion of the anterior jugular behind the origin of the sterno-mastoid. The outer borders of the sterno-hyoid and sterno-thyroid muscles, which are attached to the posterior surface of the manubrium sterni, are drawn inwards along with the branches of the descendens noni nerve, and the second layer of fascia is then divided. In this way the common carotid artery is reached behind the sterno-clavicular articulation. The right inferior thyroid vein is ligatured and divided. After passing between the sterno-mastoid and the muscles last named we follow the carotid downwards to its junction with the subclavian, below which the trunk of the innominate is ligatured, the pleura, which lies posterior and external, being avoided. The left innominate vein crosses from left to right in front of the artery. The vagus nerve, which descends in front of the subclavian artery, the recurrent laryngeal nerve, which winds round it, and the phrenic nerve remain uninjured.

Mott, who first attempted ligature in 1818, employed a horizontal incision along the clavicle. In our opinion this is not so effective a method and is only necessary in cases where it is desirable to expose the subclavian as well. On the other hand, a vertical incision in the middle of the neck in the interval between the sterno-thyroid muscles (Pirogoff) is the simplest method and entails the least amount of damage in cases where the pulsation of the artery can be felt above the sternum. In these cases, as well as in the performance of low tracheotomy, the artery can easily be reached with the finger.

Smith[1] has reported a case in which the innominate, common carotid, and vertebral arteries were successfully ligatured after an injury to the subclavian.

3. Ligature of the Common Carotid Artery (*vide* Fig. 28). The common carotid artery passes vertically upwards in the shortest direction from the chest to the head. It may be felt in its entire extent alongside of the trachea and œsophagus, and may be securely compressed against the vertebral column, preferably at the level of the cricoid, opposite which may be felt the projecting transverse process of the sixth cervical vertebra, the so-called carotid tubercle. The level of the cricoid cartilage is the seat of election for ligaturing the artery. The incision to expose it runs transversely in the line of cleavage of the skin, at the level of the cricoid cartilage, the middle of the incision being at the anterior border of the sterno-mastoid, the direction of which corresponds to a line passing from the angle of the jaw to the sterno-clavicular articulation.

The skin and platysma having been divided, the *transverse superficial cervical nerve* is seen passing forwards over the sterno-mastoid from its posterior border. The nerve

[1] Cf. Jordan, *Handbuch der prakt. Chir.*, Stuttgart, 1900.

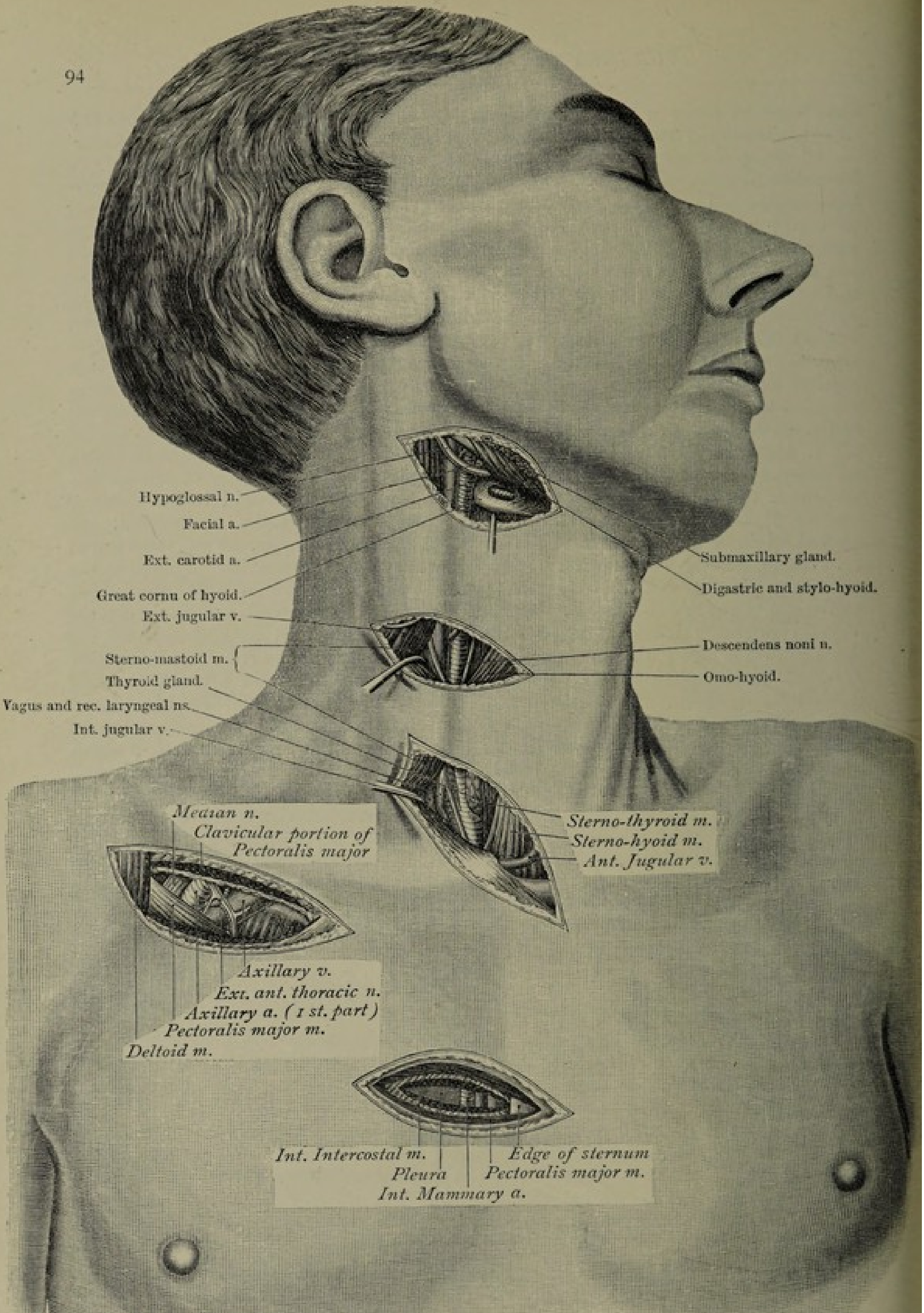


FIG. 28.—Ligature of the lingual artery above the greater cornu of the hyoid. Ligature of the common carotid at the level of the cricoid cartilage. Ligature of the innominate artery. Ligature of the first part of the axillary artery. Ligature of the internal mammary artery.

is avoided, and the fascia is divided so as clearly to expose the muscular fibres of the sterno-mastoid, the anterior border of which is drawn outwards with a blunt hook, exposing beneath it the omo-hyoid muscle, which passes upwards and somewhat inwards. The artery is now sought for in the angle formed by the divergence of those two muscles. It is still covered by a second fascia, which at the same time forms the sheath of the vessel. On opening the sheath the artery is exposed. The descendens noni nerve passes downwards upon the sheath and gives off branches passing forwards to the muscles which ascend to the larynx. This nerve is carefully drawn inwards. Great care must be taken that the vagus, which lies close to the posterior surface of the artery, is not included in the ligature. It may here be remarked that this close apposition occasions symptoms of pressure upon the vagus (slowing of the pulse, dyspnœa, and syncope) when the artery has to be compressed. The internal jugular vein lies upon the antero-lateral aspect of the artery, with the sympathetic nerve behind.

The risk associated with ligature of the common carotid artery is very considerable. According to Pilz, Lefort, and Zimmermann,[1] in antiseptic as well as in pre-antiseptic days, about one-third of the patients operated on died of cerebral disturbances. The condition of the arteries is an important factor in this respect as, if the collateral circulation is defective, the risks are considerably increased. Ligature is therefore to be avoided, if possible, when there is any arteriosclerosis, although in young robust individuals there is no risk of untoward results.

Temporary ligature of the common carotid is generally of great service. It is indicated, *e.g.*, when the source of hæmorrhage in the region of the pharynx cannot be ascertained, or when bleeding in the area of the internal carotid cannot be controlled by other means, while it also proves invaluable during arterioraphy.

G. Fowler[2] has even attempted to render excision of the Gasserian ganglion bloodless by the temporary ligature of both common carotids.

We suggest that the metal clamps used by Lambotte in the case of small arteries are suitable appliances for securing temporary closure, since less injury is caused by merely flattening out the intima and muscularis than by adopting a circular ligature.

Ceci[3] has proposed as a means of diminishing the danger incurred by ligature of the common and internal carotid, the method of tying the jugular vein on the same side in order to prevent anæmia of the brain. (Cf. Ligature of the Internal Carotid, No. 4.)

(a) Branches of the Common Carotid Arteries

4. Ligature of the Internal Carotid (see Fig. 29). In intracranial hæmorrhages (with the exception of those due to the middle meningeal artery), ligature of the internal carotid is preferable to that of the common carotid, as the collateral supply through the angular termination of the facial and the ophthalmic arteries is retained. The operation is identical with that for ligature of the external carotid, except that intervening between the two vessels we find the stylo-glossus and stylo-pharyngeus muscles, along with the deep fascia and the stylo-maxillary ligament.

In pharyngeal operations, in which sudden profuse hæmorrhages may occur, as well as in occasional cases of tonsillotomy, it is important to be certain as to whether the bleeding arises from the internal carotid, or from the branches of the external carotid (pharyngeal and tonsillar arteries). As regards tonsillotomy, although the internal carotid can be felt pulsating behind the tonsil, injury of the artery is not usually to be apprehended. The tonsillar branch of the palatine artery and the ascending pharyngeal artery are more likely to be the seats of injury, as they ascend towards the base of the skull within and in front of the internal carotid.

Boari[4] has shown the value of simultaneous ligature of the internal carotid and jugular vein (Ceci's theory), as he performed this operation with complete success

[1] Cf. Jordan, *loc. cit.*
[2] *Buffalo Med. Journ.*, June 1903.
[3] Paris Surgical Congress, 1904.
[4] *Policlinico*, 1905.

on a man aged forty-nine, for a gunshot wound inflicted on the carotid and the cavernous sinus.

5. External Carotid (Fig. 29). When ligature of the external carotid is sufficient for the arrest of hæmorrhage, the common carotid must never be ligatured in its place, as the procedure is dangerous, giving rise, according to Pilz and Friedländer, to brain disturbances in 19 to 32 per cent, and to a fatal termination in 13 to 18 per cent, of the cases in which it has been adopted.

Wyeth has reported similar results in a collection of 789 cases, but, in his experience,

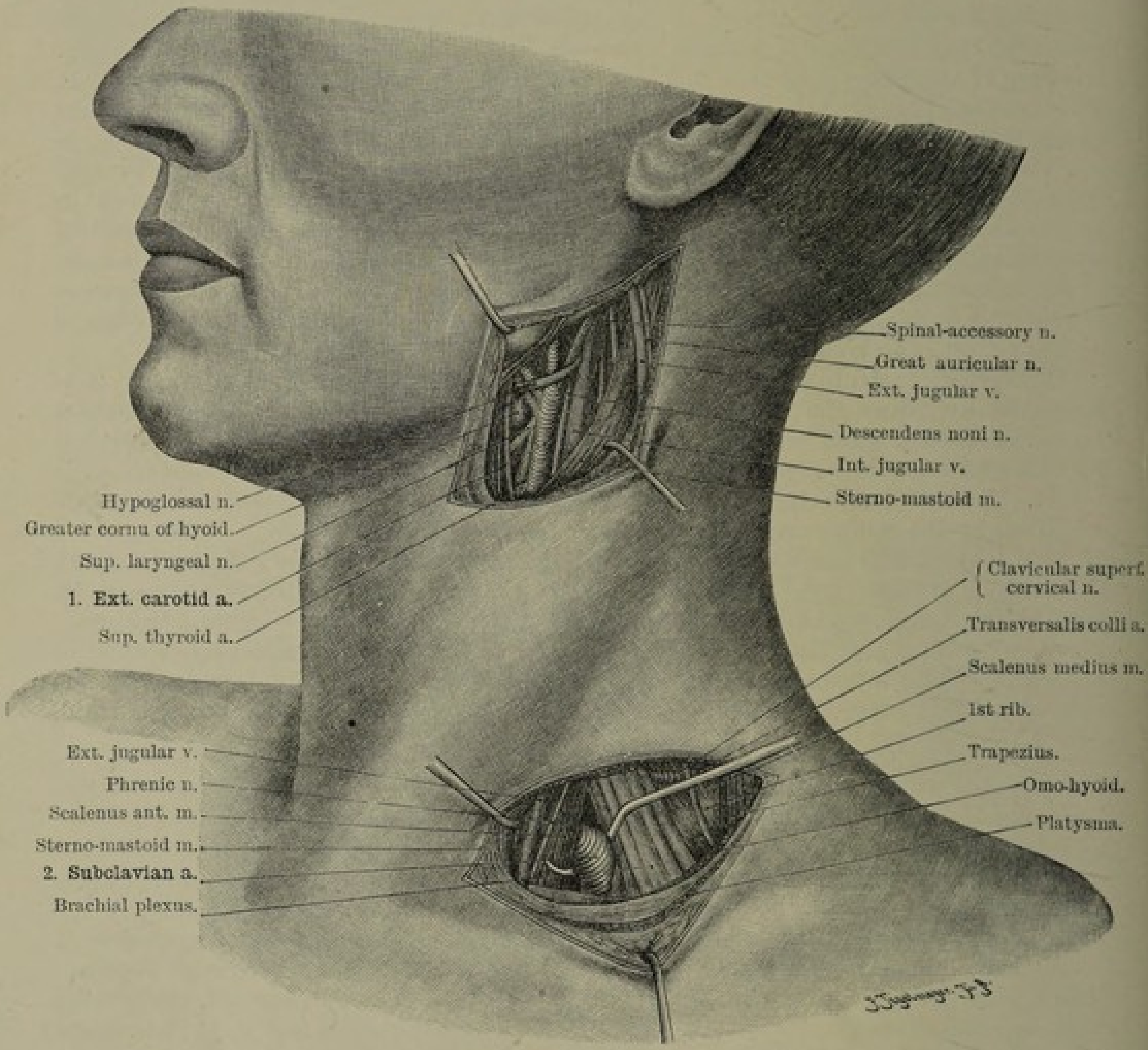


Fig. 29.—Ligature of the external carotid with the origins of the lingual, facial, and occipital arteries. Ligature of the subclavian artery.

the mortality from ligature of the external carotid is only 4·3 per cent (169 cases), while Lipps in 130 operations had only two fatalities. Ligature of the external carotid is not only indicated in hæmorrhage and when malignant tumours are adherent to it, but also as a prophylactic measure in extensive operations upon the jaws, the nose, and the face, while it also diminishes to a very great extent the hæmorrhage during resection of the jaw and operation on the naso-pharynx.

All hæmorrhages in the region of the head, with the exception of intracranial and intraorbital ones, can be arrested by ligaturing the external carotid artery and also the arteries from the vessels of the dura mater.

The point in our normal incision where the artery is felt to pulsate and where it is ligatured is at the anterior border of the sterno-mastoid muscle. The edge of this muscle is considerably more vertical than is usually represented, being drawn forwards towards the angle of the jaw by the cervical fascia. The artery is ligatured opposite a point which lies a finger's-breadth vertically below the angle of the jaw. To expose the vessel, therefore, we employ that part of our normal incision which courses over this region. The incision divides the skin and the platysma, the fibres of the latter passing upwards and forwards over the margin of the jaw, forming occasionally a well-developed muscular layer. At the posterior part of the wound is the external jugular vein, and behind it the great auricular nerve, both ascending vertically upon the sterno-mastoid. They are not divided, but are drawn backwards. On division of the cervical fascia the anterior border of the sterno-mastoid is exposed, and the facial vein is seen passing downwards over the digastric muscle to join the jugular. After drawing downwards the former vein, and ligaturing some of its branches, we get the external and internal carotid arteries into view, the latter lying posteriorly. The internal carotid gives off no branches, whilst the external carotid is identified by giving off the superior thyroid close to its origin, and farther up the lingual and other branches. These vessels cannot by this means be mistaken. Ligature of the external carotid is not an easy operation, because the only guides are soft parts (especially the sterno-mastoid muscle), which may vary with each operation. It is an excellent rule, therefore, after retraction of the sterno-mastoid to begin the dissection at the lower border of the digastric muscle. The hypoglossal nerve, which is recognised by the curved course it pursues, and from which the descendens hypoglossi is given off, is here the chief landmark. By division of the fascia immediately below the loop, the external carotid artery will be exposed, with the nerve curving from behind round it. Before applying the ligature, however, the operator must make certain, by observation of its branches, that it is not the internal carotid which has come into view. The descendens noni nerve, which supplies the depressors of the larynx, must be avoided, and it is still more important to avoid the *superior laryngeal nerve*, which passes transversely forwards behind the artery and the thyro-hyoid muscle.

The majority of the branches of the external carotid, viz. the *superior, thyroid, lingual, facial, and occipital arteries*, may be ligatured at their origin from the same incision. The course of these four important branches is sufficiently characterised by their direction, namely, downwards, forwards, upwards, and backwards respectively; and for practical purposes they may be regarded as springing from that part of the carotid which is crossed by the hypoglossal nerve. When those arteries are to be ligatured more peripherally, situations are to be selected which are more readily accessible and less dangerous.

(b) Branches of the External Carotid

6. Ligature of the Superior Thyroid Artery (Fig. 30). Ligature of the superior thyroid artery by itself is not easily performed. Unless there are any special difficulties in the way we always tie the artery in goitre operations, after the thyroid has been freed and "dislocated."

The operation is effected in the following manner:—An incision 6-7 cm. ($2\frac{1}{2}$ to 3 in.) long is carried obliquely upwards from the middle of the thyroid cartilage across the anterior border of the sterno-mastoid muscle. The skin, platysma and fascia are divided, and the anterior border of the sterno-mastoid is defined and retracted, the external jugular vein and the great auricular nerve being carefully avoided in the posterior angle of the wound.

The omo-hyoid muscle, which runs upwards and inwards under cover of the sterno-mastoid, is then freed along its outer border and is drawn inwards, while the facial vein, which joins the common facial vein above and behind, is freed and retracted backwards.

If the loop of the superior thyroid artery has not come into view, the guide to the situation of the artery is furnished by the large anterior branch, which can

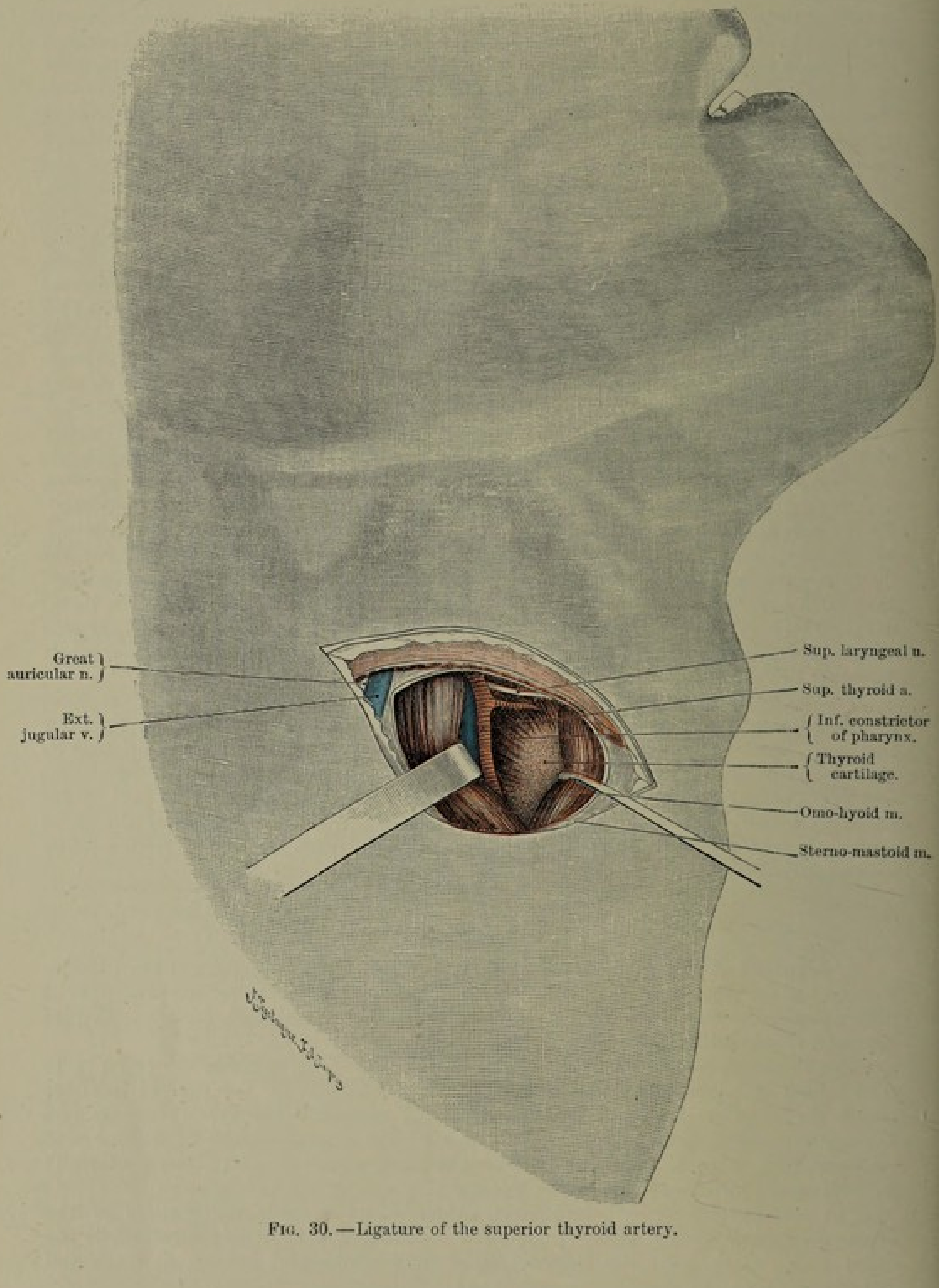


FIG. 30.—Ligature of the superior thyroid artery.

almost invariably be felt at the posterior border of the thyroid cartilage in the interval between the larynx and the upper pole of the thyroid body when this is high in position. By following this guidance we find the main trunk lying on the outer surface of the inferior constrictor of the pharynx, with the superior laryngeal nerve situated a little higher up.

As the trunk of the superior thyroid is extremely short, it is more effective to place the ligature beyond the hyoid and superior laryngeal branches, so as to cause no interference with the circulation in the larynx. The muscular branches must be included, particularly the crico-thyroid branch, which forms a free anatomosis with the vessel of the other side.

The artery is most satisfactorily divided between two ligatures, so that the operator may be able to pull the upper pole of the thyroid downwards and ensure the certainty of having also ligatured the posterior branch. Otherwise the danger is incurred of the establishment of collateral circulation from the numerous communications of the hyoid and laryngeal branches.

A nerve which accompanies the artery must be isolated, since its inclusion in the ligature may cause severe toothache and earache.

In difficult cases it is advisable to expose the external carotid artery by the same incision and isolate the superior thyroid artery at its origin, otherwise the large veins connected with the upper pole of the thyroid gland often make isolation of the artery near the gland very difficult. In women suffering from Basedow's disease, in whom it is important to obtain a fine scar, the incision should be carried not too obliquely but rather more transversely over the middle of the wing of the thyroid cartilage on to the sterno-mastoid muscle. At the upper pole of the gland the artery lies under cover of the capsule, which must therefore be divided, by which means the upper pole can be drawn downwards, and the operation consequently facilitated.

7. Ligature of the Lingual Artery. Ligature of the lingual artery is of great importance because it supplies a deeply-situated organ, the direct arrest of hæmorrhage from which is not always easy of attainment. So it is often desirable to perform a prophylactic ligature. The artery has a very definite course, inasmuch as it is directed towards the hyoid bone, and is placed close to the posterior extremity of its great cornu. It is most conveniently ligatured at this situation, because in most people the extremity of the great cornu of the hyoid bone can be felt through the skin, and therefore serves as a very distinct guide for the incision, which is made in the direction of our normal incision from the edge of the sterno-mastoid muscle along the great cornu of the hyoid bone as far as its body. The incision extends through skin, platysma, and fascia, just as if the object was merely to expose the great cornu of the hyoid bone. The facial vein often passes vertically downwards, or downwards and backwards, across the field of operation. The lower border of the submaxillary gland appears beneath the upper edge of the wound, below which the posterior belly of the digastric and the stylo-hyoid muscles descend towards the body of the hyoid bone. Those muscles are at a higher level than the seat of ligature.

It is advisable to press forward the hyoid bone from the opposite side of the neck. After exposing the great cornu in this way, we seize it with a hook and the bone is drawn forwards, a process which has the great advantage of rendering the entire field of operation more superficial. At the thickened posterior extremity of the cornu of the hyoid bone the fibres of the hyo-glossus muscle ascend vertically in a characteristic manner. The hypoglossal nerve passes from behind forwards upon the outer surface of this muscle, and behind the extremity of the hyoid bone it winds round the external carotid artery. The operator must now be very careful to cut through neither more nor less than the muscular fibres of the hyo-glossus close above the club-like extremity of the great cornu of the hyoid bone, immediately above which the artery is situated. We consider this to be the most reliable method of ligature.

As a second method for ligaturing the lingual artery, the incision above the digastric muscle has been recommended in the space known as Pirogoff's triangle. This is described by Winiwarter as due to Pirogoff-Hueter, while Roser, Malgaigne and Béclard incised underneath the digastric. The incision is made parallel to the great

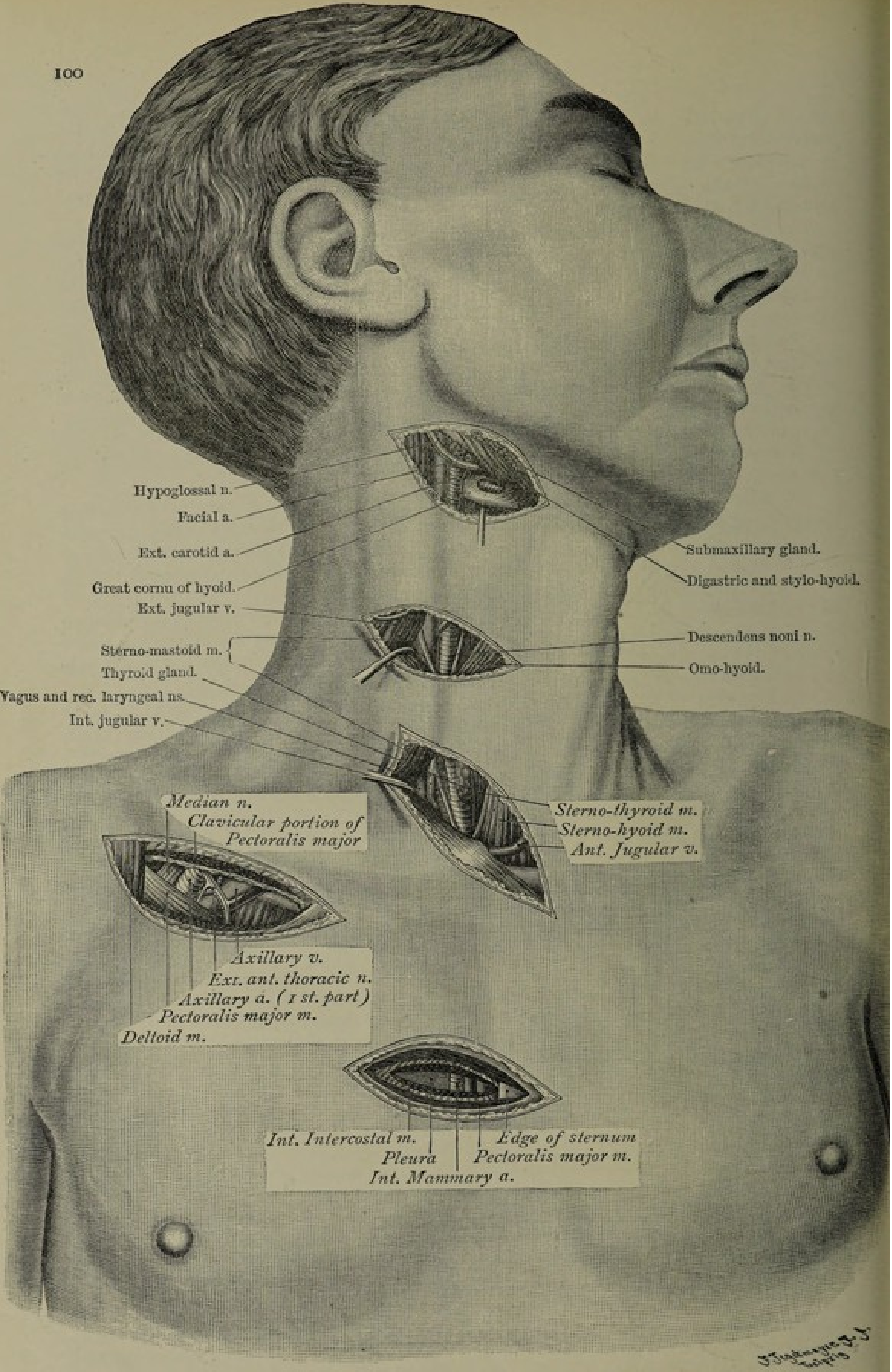


FIG. 31.—Ligature of the lingual artery above the greater cornu of the hyoid. Ligature of the common carotid at the level of the cricoid cartilage. Ligature of the innominate artery. Ligature of the first part of the axillary artery. Ligature of the internal mammary artery.

cornu of the hyoid bone through skin, platysma, and fascia, and the lower border of the submaxillary gland is drawn upwards along with the facial vein. The artery lies in the angle formed by the upper border of the digastric (together with the stylo-hyoid muscle) and the posterior border of the mylo-hyoid under the ascending fibres of the hyo-glossus. Upon the outer surface of this latter muscle is the hypoglossal nerve, and often the lingual vein.

We recommend ligaturing the artery in Béclard's triangle, and further consider it unnecessary invariably to look for the artery at its origin from the external carotid, as proposed by Mériel, for the above method is one of extreme safety and entails less

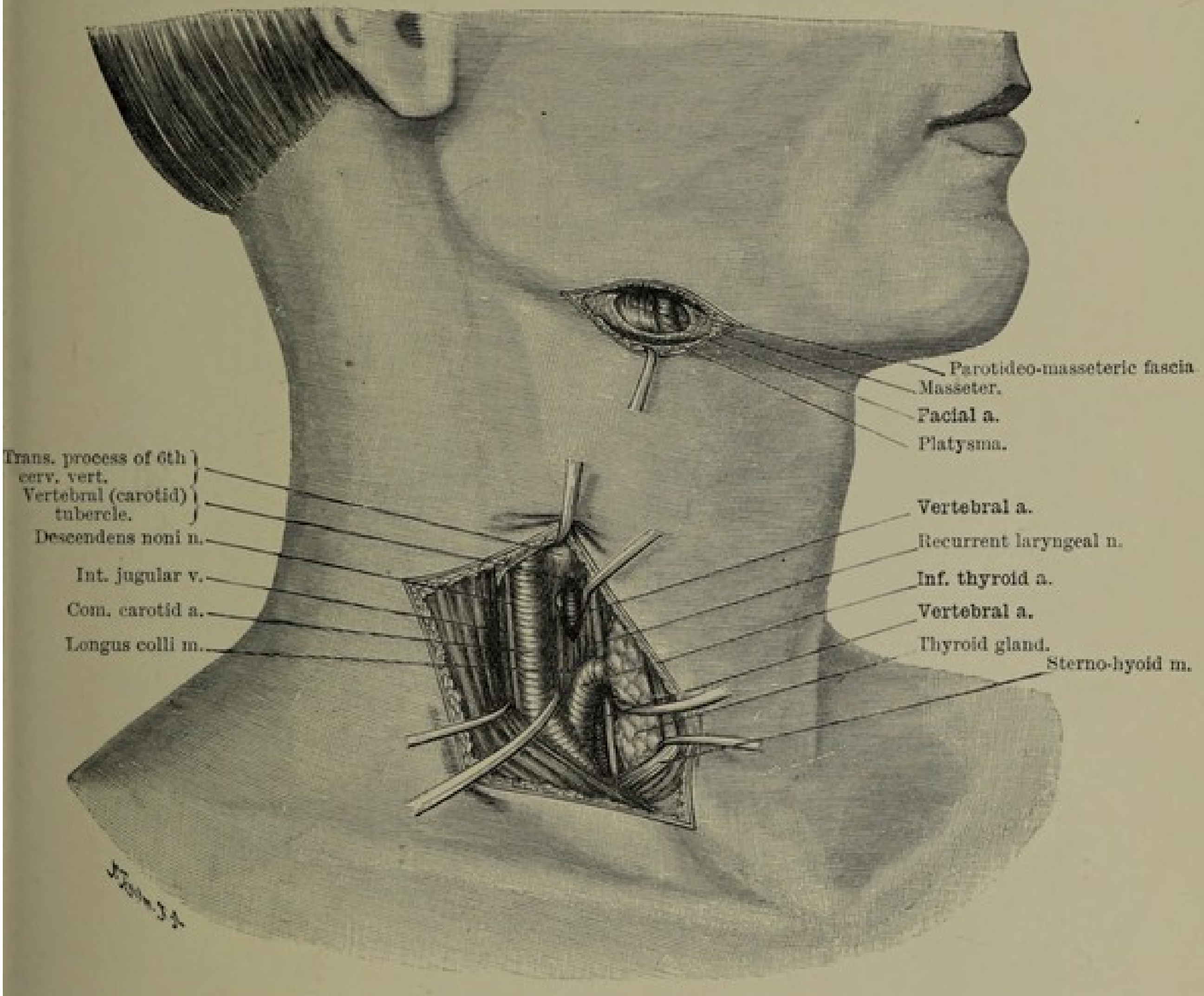


FIG. 32.—Ligature of the facial artery. Ligature of the inferior thyroid and vertebral arteries.

damage if care is taken to grasp the tip of the great cornu of the hyoid with one of our artery forceps or with a hook, and to make the incision close to the bone and just through the hyo-glossus muscle. Thiersch had previously recommended the method of pulling up the hyoid bone with a hook.

8. Ligature of the External Maxillary Artery (Facial) (Fig. 32). The place for ligaturing this artery can be very definitely determined, as it ascends over the lower border of the jaw just at the anterior border of the masseter muscle. It is accompanied by the facial vein, which, however, is not so constant in its course. An incision is made parallel to the margin of the jaw opposite the anterior border of the masseter. After dividing the skin, platysma, and fascia, we expose the artery, which is then to be freed from its surroundings. The supramaxillary branch of the facial nerve, which courses along the margin of the jaw, is to be carefully avoided.

Fig. 34 illustrates the incision suitable for ligature of the facial artery at the angle of the mouth. Bleeding from the labial arteries (*e.g.* in harelip operations) or from the angular artery can readily be controlled by the application of appropriate clamps to the cheek and lip.

9. Ligature of the Sterno-mastoid Artery is only undertaken in the case of injury.

10. Ligature of the Occipital Artery (Fig. 33). The occipital is the largest artery of the scalp, appearing at the inner border of the splenius muscle, midway between the external occipital protuberance and the highest point of the mastoid process, where it pierces the strong fascia and ascends over the occiput under the aponeurosis.

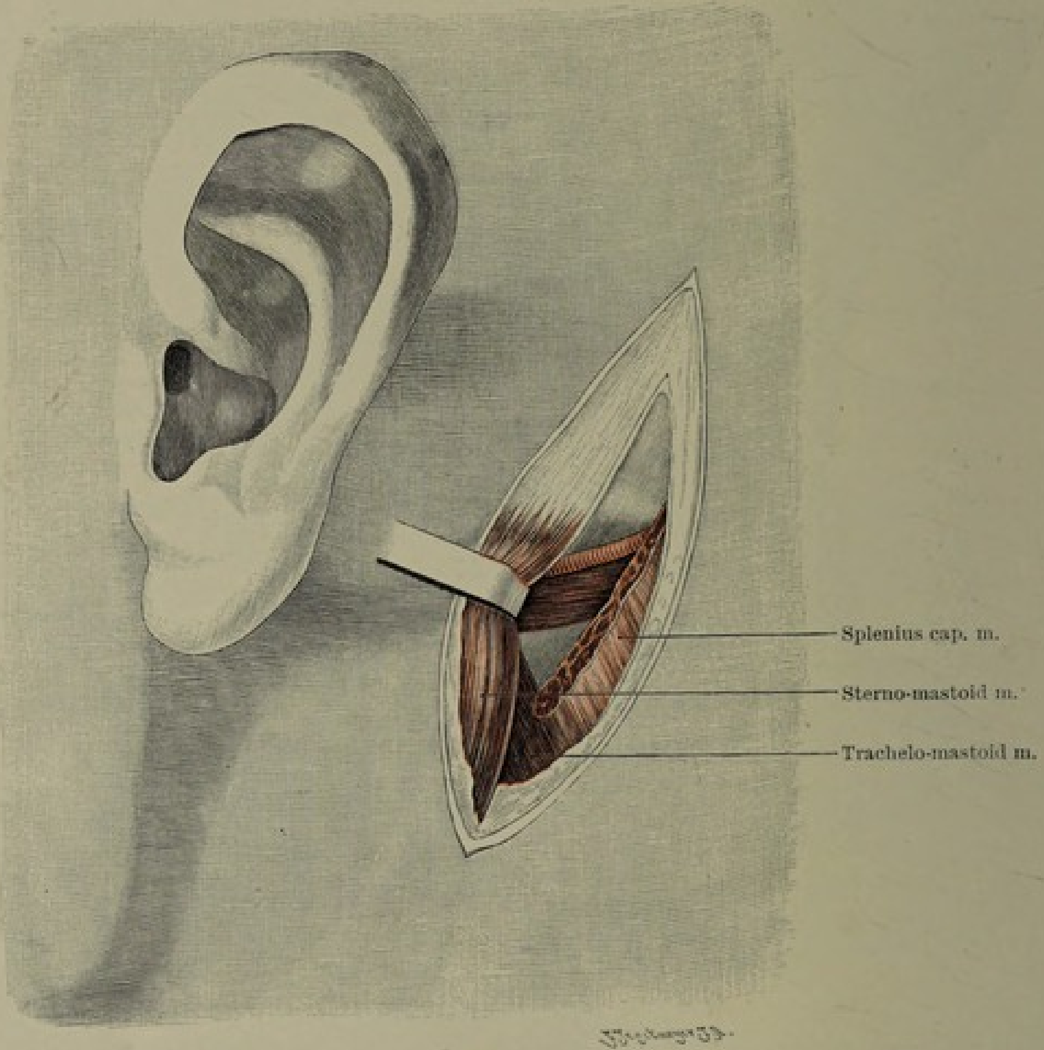


Fig. 33.—Ligature of the occipital artery underneath the splenius capitis.

The incision extends from a point immediately behind the mastoid process downwards along the posterior border of the sterno-mastoid muscle, the centre being placed opposite the tip of the mastoid process. The posterior border of the sterno-mastoid is exposed and its tendinous insertion is separated from the skull and retracted forwards. The splenius capitis, the fibres of which run obliquely upwards and forwards, is then exposed and divided transversely. At its anterior border the longissimus capitis muscle comes into view, under which the artery will be found running transversely backwards in contact with the skull.

The artery may be tied higher up where it lies underneath the fascia at the outer border of the trapezius muscle, and ascends to the skin of the occiput. Here the artery is joined by the great occipital nerve, which passes upwards and outwards.

The artery may also be ligatured at its *origin* by an incision similar to that for ligature of the external carotid. Here it passes under the digastric and stylo-hyoid. The occipital vein is not invariably found lying close to the artery.

Kappis[1] has collected 21 cases of aneurysm of the occipital artery in which either ligature or excision of the aneurysm was performed.

11. Ligature of the Posterior Auricular Artery. This artery, which ascends in the interval between the auricle and the mastoid process, is liable to be injured

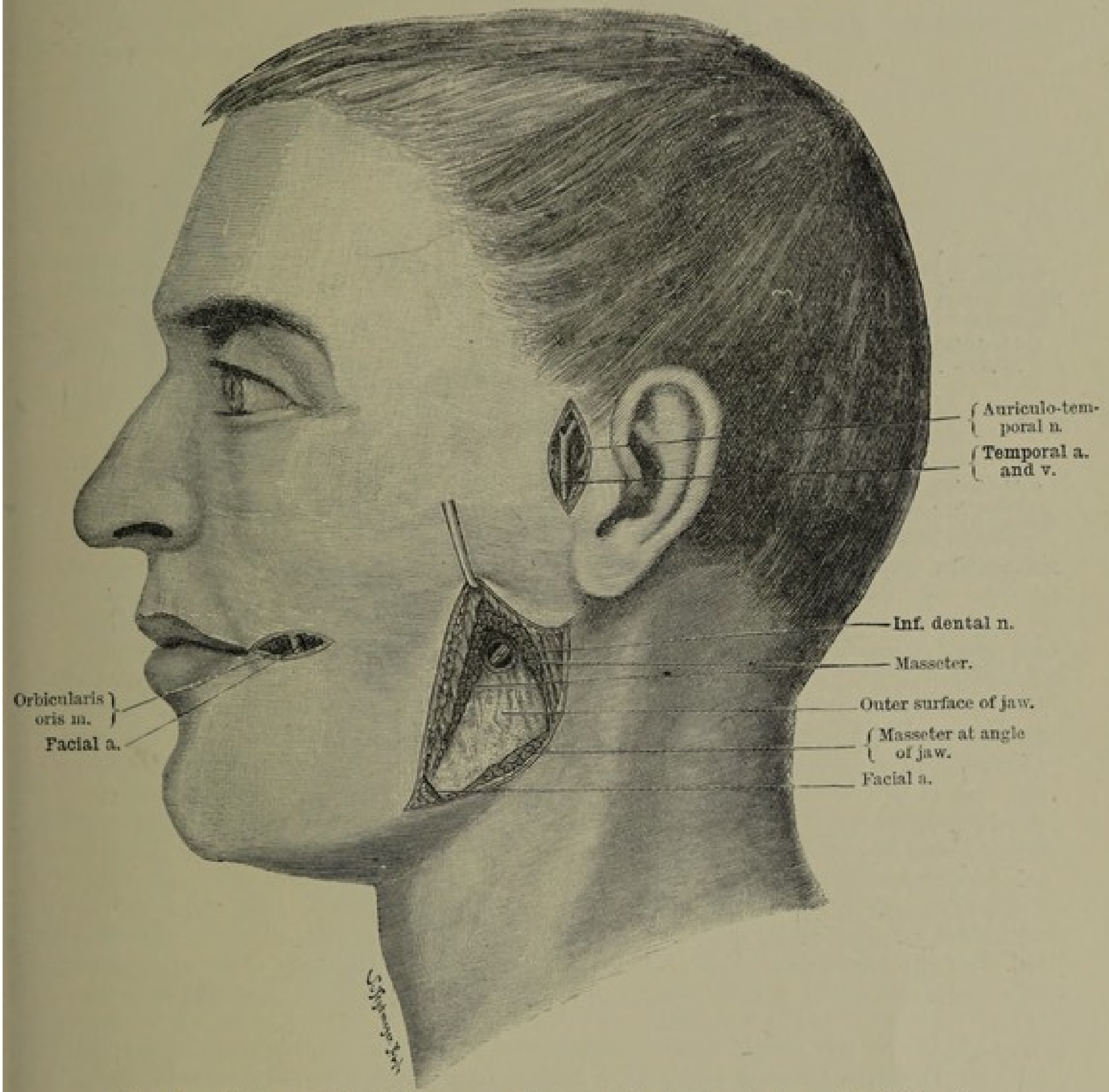


FIG. 34.—Ligature of the facial artery. Ligature of the temporal artery. Trephining the ascending ramus of the jaw to expose the inferior dental nerve.

only by an incision made too close to the auricle. With the incision we have described and which is now in general use for exposure of the mastoid process, the artery is pushed forwards along with the soft parts in operation on the antrum.

12. Ligature of the Ascending Pharyngeal Artery. 13. Ligature of the Ascending Palatine Artery. Ligature of these two arteries, which are in contact with the lateral wall of the pharynx, is only necessary in case of injury, ligature of the external carotid above the lingual artery, as a rule, being preferable.

[1] *Beiträge zur klin. Chir.* Bd. 40.

14. Ligature of the Internal Maxillary Artery. Notwithstanding the large size of this artery and its branches, ligature is seldom employed, as the artery lies entirely under cover of the lower jaw, at first behind the neck and then under the coronoid process.

Ligature of the external carotid above the origin of the facial artery is generally adopted in most cases of hæmorrhage in the region of the upper jaw, temple, or base

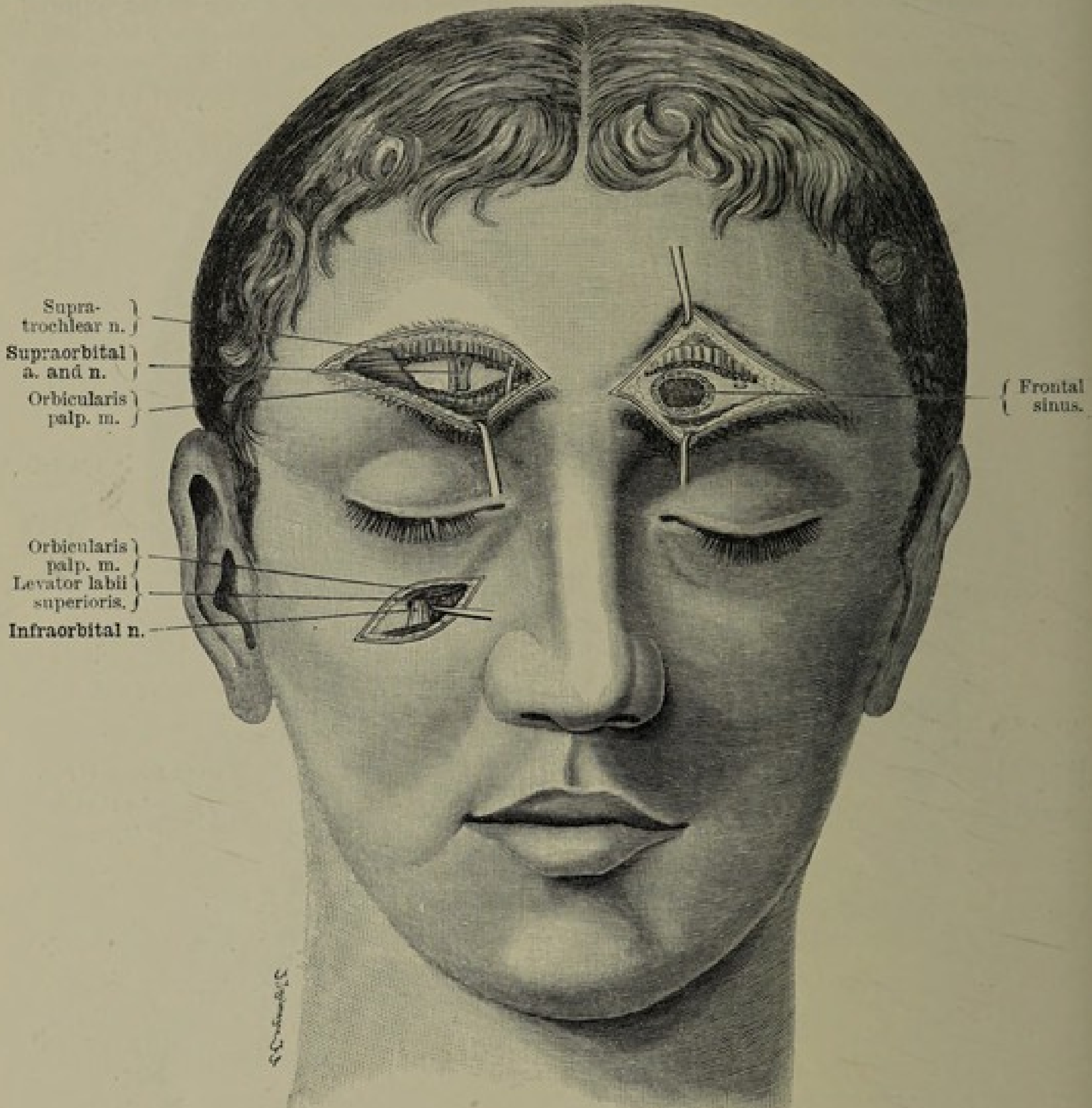


FIG. 35.—Ligature of the supraorbital artery. Exposure of the supraorbital nerve. Infraorbital nerve. Opening of the frontal sinus.

of the skull, when the bleeding cannot be controlled by simple ligature of the bleeding points or by other means.

The most important of its branches is the large middle meningeal artery, exposure of which branch is frequently necessary. But since the procedure of trephining is unavoidable in order to ligature this artery, we refer the reader to the chapter on Surgery of the Brain (section on Surgery of the Nervous System) for consideration of the subject.

15. Ligature of the Superficial Temporal Artery (Fig. 34). In contrast with the internal maxillary artery, the other terminal branch of the external carotid,

namely, the superficial temporal artery, is easily accessible for ligature, and it can be traced from the point where it crosses the zygoma as far as the temple and forehead.

The pulsation of the superficial temporal can be felt by inducing pressure on the zygoma ½ cm. in front of the attachment of the helix, bleeding from its branches being easily controlled by pressure over this point, where it may also be ligatured, a vertical incision being made 1 cm. in front of the anterior end of the helix. After the skin is divided, the fascia and then the superficial layer of the aponeurosis are exposed, the artery lying under the fascia.

The position of the *temporal vein* is not constant. It is generally parallel to and behind the artery.

(c) Branches of the Internal Carotid

16. Ligature of the Ophthalmic Artery or of its terminal branches the **Supraorbital and Frontal Arteries** (Fig. 35). The supraorbital is the principal artery of the forehead. It is smaller than the temporal artery, and leaves the orbit at the supraorbital notch, which serves as the guide in ligaturing the vessel. The course of the artery is vertically upwards through the fibres of the orbicularis and under the aponeurosis. After the eyebrow is shaved off, a transverse incision is made over the supraorbital margin.

(d) Subclavian Artery and its Branches

17. Ligature of the Subclavian Artery (Fig. 36). Arising behind the manubrium sterni, the artery arches over the pleura and apex of the lung and above the first rib between the scalenus anticus and medius, then passing beneath the middle of the clavicle between the subclavius and the serratus magnus to the outer surface of the thorax. It may be securely compressed at the outer border of the scalenus anticus muscle.

To ligature the artery a transverse incision is made a finger's-breadth above the clavicle, the operator beginning over the clavicular portion of the sterno-mastoid and passing outwards and slightly upwards to end at the anterior border of the trapezius. After division of the skin and platysma, the clavicular branches of the descending superficial cervical nerve are seen and must be divided. They pass over the clavicle to supply the skin over the shoulder and chest down to the level of the second rib. The external jugular vein, which lies along the posterior border of the sterno-mastoid, and finally winds round it to join the internal jugular, is to be avoided. It is dangerous to open this vein, because it is kept patent where it passes through the fascia, and air may be drawn into it during inspiration. In case it cannot be drawn inwards, a double ligature is to be applied before it is divided. After division of the fascia the omo-hyoid muscle appears at the inner angle of the wound, and passes upwards and inwards in the fatty tissue which contains the lymphatic glands of the triangle. The muscle is drawn either upwards and outwards, or downwards and inwards. In the fatty tissue lie the suprascapular artery, running outwards behind the clavicle, and the superficial cervical artery, running backwards and upwards. Above the latter, but under the deep fascia, is the larger transversalis colli artery, which passes backwards either upon or through the cords of the brachial plexus. After the adipose tissue has been removed the large nerve cords of the brachial plexus (covered by a thin fascia) appear between the scaleni, and pass almost vertically downwards under the clavicle. The relation of the artery to the plexus is very definite. The scalenus anticus is now followed downwards in front of the plexus to its attachment to the scalene tubercle (*tubercle of Lisfranc*) of the first rib, behind which lies the artery overlapped by the nerves. Internal to the scalenus anticus is the bulbous portion of the internal jugular vein; in front of the artery, and separated from it by the scalenus anticus, is the subclavian vein. The phrenic nerve descends into the chest upon the anterior surface of the scalenus anticus. The thoracic duct ascends from the chest into the neck close

to the scalenus anticus, and opens into the angle between the subclavian and internal jugular veins.

18. Ligature of the Vertebral Artery (Fig. 37). The operation for ligaturing the vertebral artery is similar to that for the inferior thyroid, but is more difficult, as the artery lies much deeper, behind the prevertebral fascia, and overlapped by the outermost fibres of the longus colli. The so-called *carotid tubercle* at the transverse process of the sixth cervical vertebra affords an excellent guide to the artery. The same tubercle is also made use of in tying the common carotid—hence its name. It

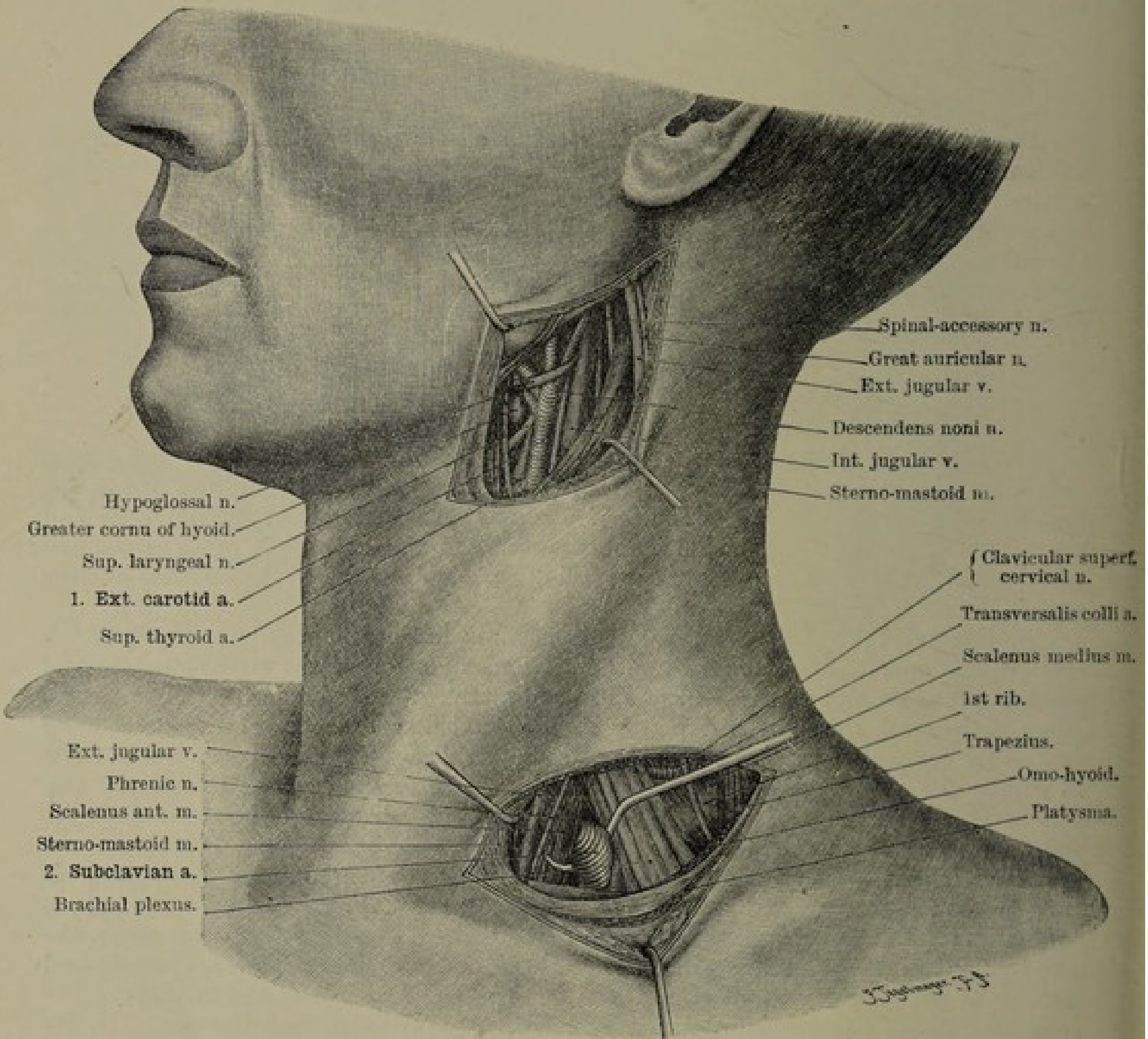


FIG. 36.—Ligature of the external carotid with the origins of the lingual, facial, and occipital arteries. Ligature of the subclavian artery.

is of no great significance, however, in ligaturing the carotid, but is very important in tying the vertebral, because the artery passes under it to enter the foramen in the corresponding transverse process. It would, therefore, be more to the purpose to speak of the projection as the *vertebral tubercle.* The artery passes towards the under surface of this tubercle. After drawing the sterno-mastoid outwards along with the large vessels, and the sterno-hyoid and sterno-thyroid inwards, we divide the prevertebral fascia above the arch of the inferior thyroid artery, when the vertebral artery will be felt ascending vertically upon and partly within the fibres of the longus colli, and disappearing at the lower surface of the transverse process of the

sixth cervical vertebra. Externally lies the scalenus anticus, and upon it the *phrenic nerve*, which descends from the outer border of the muscle across its anterior surface to enter the upper aperture of the thorax. Below the arch of the inferior thyroid artery the vertebral ascends almost vertically along with the recurrent laryngeal nerve.

Ligature of the vertebral artery on one side presents no point of special interest. Both arteries have been ligatured by Alexander and Baracz for epilepsy. Jordan attributes the operation we described to Frays and Kocher.

19. Ligature of the Internal Mammary Artery (cf. Fig. 37). The internal mammary artery supplies the inner surface of the anterior wall of the thorax, and

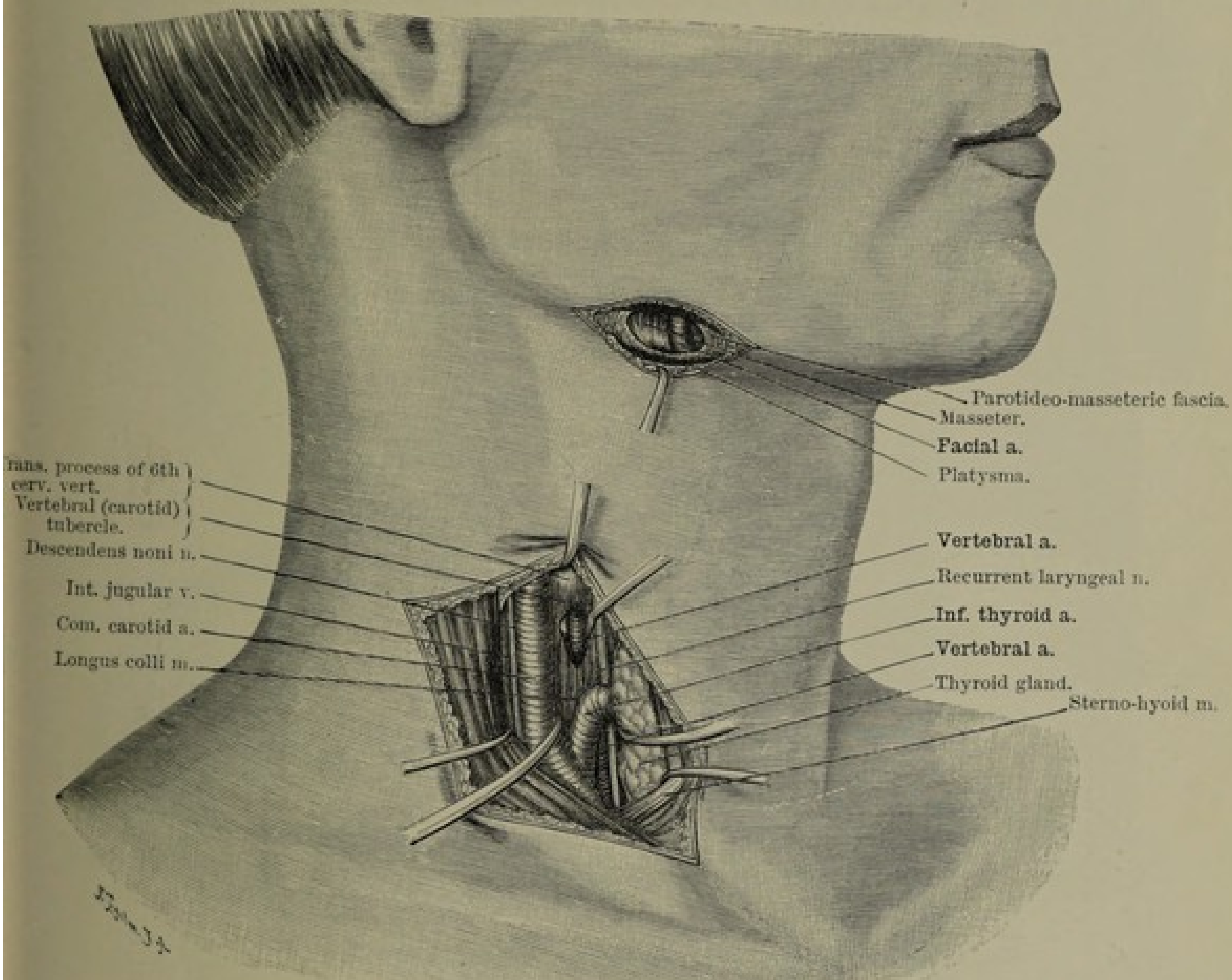


Fig. 37.—Ligature of the facial artery. Ligature of the inferior thyroid and vertebral arteries.

gives off perforating branches to the skin. It lies, with its accompanying vein, upon the pleura, separated from it only by a very thin layer of fascia, and lower down also by the triangularis sterni muscle. Anteriorly lie the costal cartilages and the intercostal muscles.

It is ligatured by making a transverse incision in those intercostal spaces opposite which the sternum is narrowest, preferably, therefore, the second. The incision is carried from the middle line of the sternum transversely outwards between the costal cartilages. After dividing this very thin and often interrupted membrane we reach the muscular fibres of the internal intercostal, which pass downwards and outwards with a well-marked fascia upon their under surface. After these are divided the artery is seen descending upon the pleura about ½ to 1 cm. from the border of the sternum,

the vein lying to its inner side. In the lower intercostal spaces the internal mammary artery lies somewhat farther from the border of the sternum ($1\frac{1}{2}$ to 2 cm.) than it does higher up, and is separated from the pleura by the triangularis sterni muscle, on which it lies. In these intercostal spaces the artery requires consideration mainly in the operation for opening the pericardium.

Of its two terminal branches (superior epigastric and musculo-phrenic), ligature of the superior epigastric has only to be considered when the rectus abdominis is divided transversely in a laparotomy, the artery being found on the posterior surface of the muscle included within the sheath.

20. Ligature of the Superior Intercostal Artery. This artery is so deeply placed that the question of ligaturing it only arises when it has been accidentally injured during excision of the inferior cervical sympathetic ganglion.

21. Ligature of the Inferior Thyroid Artery (cf. Fig. 37). From a surgeon's

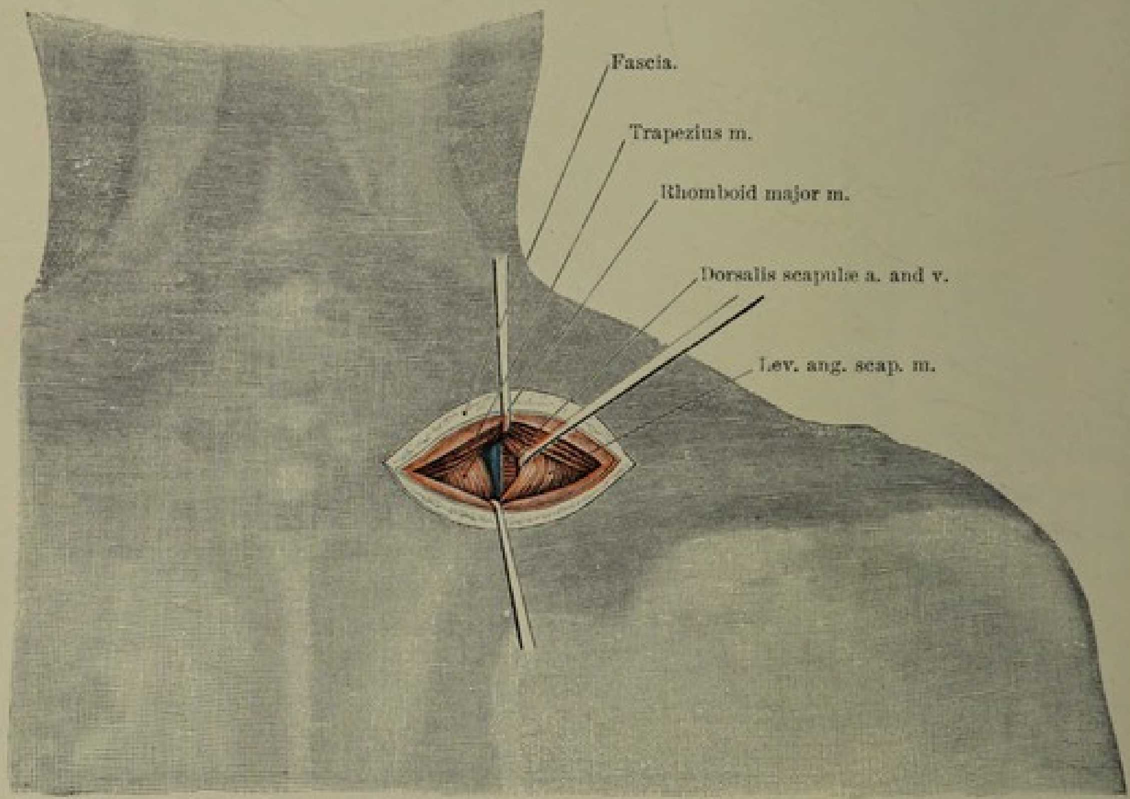


FIG. 38.—Ligature of suprascapular artery at the superior angle of the scapula.

point of view, the inferior thyroid artery is certainly the most important branch of the thyroid axis, on account of its relation to the thyroid gland. The ascending cervical, superficial cervical, and suprascapular arteries have frequently to be ligatured in operations in the region of the supraclavicular fossa. The last-named artery, which runs behind the clavicle to reach the scapula, is specially liable to injury.

[In this connection *vide* Ligature of the Subclavian Artery, p. 105 and Fig. 36.] The suprascapular artery may be ligatured with advantage in operations involving the scapula, as it sends large branches to the supra- and infra-spinous fossæ.

Ligature of the inferior thyroid artery is not easily performed. Its isolation may be so difficult that we often prefer to remove half the thyroid gland, while, on the other hand, during goitre operations it can be readily ligatured, if the lateral lobe is dislocated,—according to the method we describe,—the ligature always being applied after dislocation of the thyroid.

The artery passes inwards behind the common carotid, describing at the same

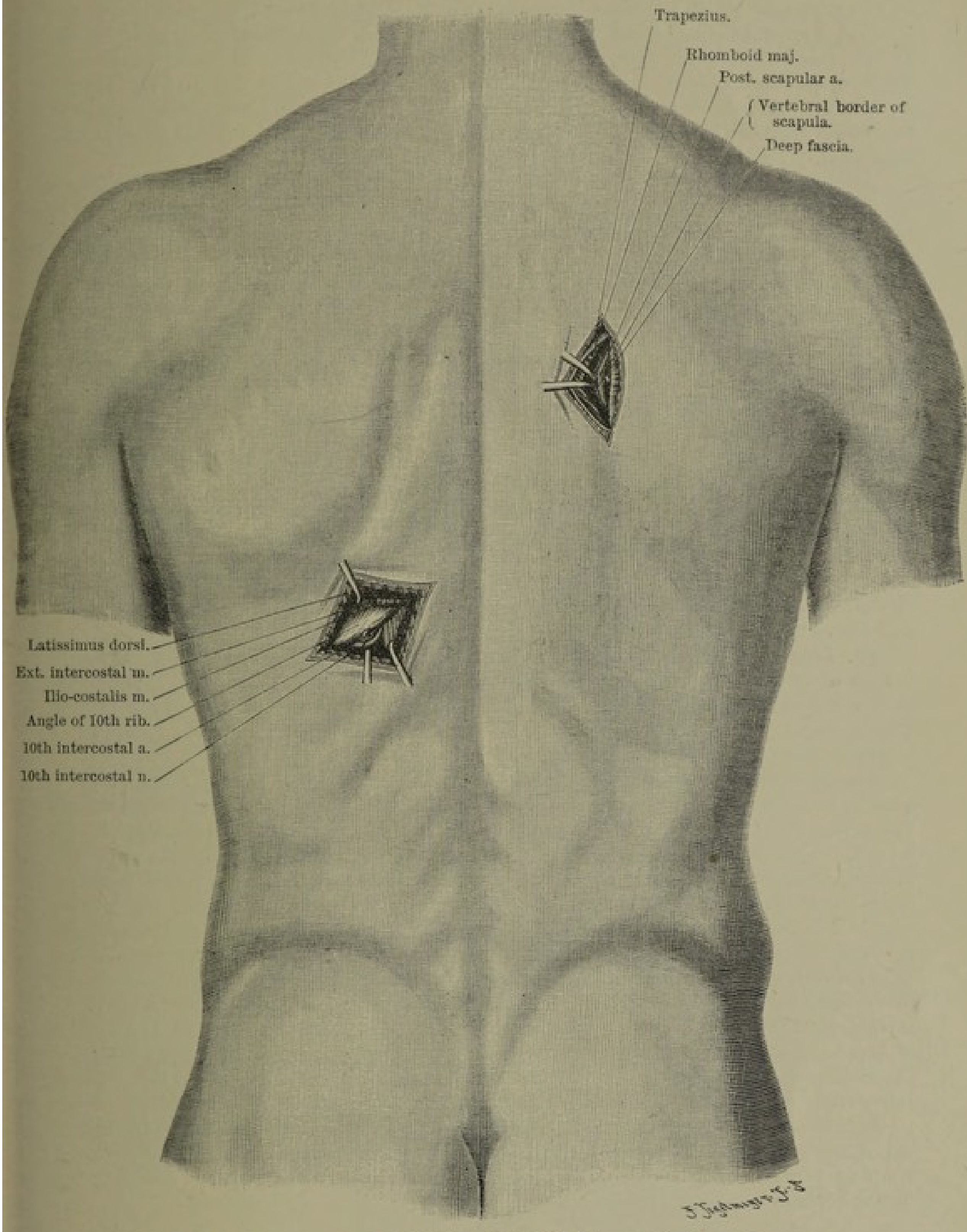


FIG. 39.—Exposure of the 10th rib and the 10th intercostal artery and nerve. Ligature of the posterior scapular artery.

time a well-marked curve convxe upwards. It can be safely exposed here on the anterior surface of the vertebral column, or in the transverse part of its course on the longus colli muscles.

A transverse incision of some length is required in the lower third of the neck,

in the direction of the "collar" incision which we recommend for excision of the thyroid, and extending from the prominence of the sterno-mastoid muscle to the middle line. The skin, platysma, and deep fascia are divided as already described. By forcible retraction of the sterno-mastoid outwards (see Fig. 37) and the sterno-thyroid inwards, the carotid artery is exposed in the outer and the thyroid gland in the inner part of the wound. By division of the capsule of the gland they can be separated. The inferior thyroid artery lies behind the gland.

All hæmorrhage must be carefully arrested during the operation, in order that a satisfactory view of the parts may be obtained, and the recurrent laryngeal nerve (which is the main motor nerve for the larynx) thereby preserved from injury where it crosses behind the artery. The nerve usually crosses behind the bend of the artery and ascends upon the longus colli muscle, from which it continues upwards in the groove between the trachea and œsophagus to the lower border of the cricoid cartilage. The cardiac branches of the sympathetic must not be injured, nor indeed the trunk of the sympathetic, which often consists of two parts embracing the artery. When the thyroid gland is enlarged the fascia must be freely divided so that the gland may be raised and drawn towards the middle line with a large blunt hook-retractor, in the course of which the inferior accessory thyroid vein is divided between two ligatures, while the sterno-thyroid muscle must be freed in the middle line, detached high up, and retracted outwards.

22. Ligature of the Transversalis Colli Artery (*vide* Fig. 36). This large artery is ligatured by the method adopted for the subclavian artery above the clavicle. The artery is readily recognised from its position at the outer border of the scalenus medius and the course it takes between the trunks of the brachial plexus. The suprascapular and the superficial cervical arteries lie respectively below and above it.

23. Ligature of the Posterior Scapular Artery (Fig. 38). This terminal branch of the transversalis colli deserves special mention, as it can be ligatured both at the superior angle of the scapula where it lies under the insertion of the levator anguli scapulæ, and at the vertebral border of the scapula beneath the insertion of the rhomboids.

(*a*) *At the upper angle of the scapula.* An incision is made from a little outside the vertebra prominens, obliquely outwards and slightly downwards towards the shoulder. It passes over the place where the superior angle of the scapula can be felt. The skin, fascia, and trapezius are divided parallel to the fibres of the muscle, whereby the upper border of the rhomboideus minor is exposed, running from above downwards and outwards. Externally is the thick belly of the levator anguli scapulæ descending from the neck to be attached to the angle of the scapula. By pulling this muscle outwards we find the artery upon its under surface. Upon the thorax lie the upper part of the ilio-costalis muscle internally, the insertion of the scalenus posticus superiorly, and the ribs and intercostal muscles externally.

(*b*) *At the inner border of the scapula* (Fig. 39). At the level of the middle of the infra-spinous fossa the artery will be found by making an incision along the inner border of the scapula. At the upper angle of the incision is the oblique lower edge of the trapezius muscle, the strong aponeurosis of which is divided close to the edge of the scapula. On detaching the tendinous insertion of the rhomboideus major from the scapula the artery will be seen upon the under surface of the muscle, running parallel to the border of the scapula on the serratus posticus crossing the upper border of the rhomboideus minor.

(e) Axillary Artery and Arteries of the Arm (Figs. 40 and 41)

24. Ligature of the Axillary Artery (Figs. 42, 43, 44). According to anatomical description, the axillary artery extends from the subclavius muscle on the under surface of the clavicle to the lower border of the pectoralis major (anterior axillary fold). It can be ligatured at three points in its course.

(*a*) *By a transverse incision below the clavicle* (Fig. 42). The incision is made 1 cm. below the middle third of the clavicle, dividing the fibres of the platysma together

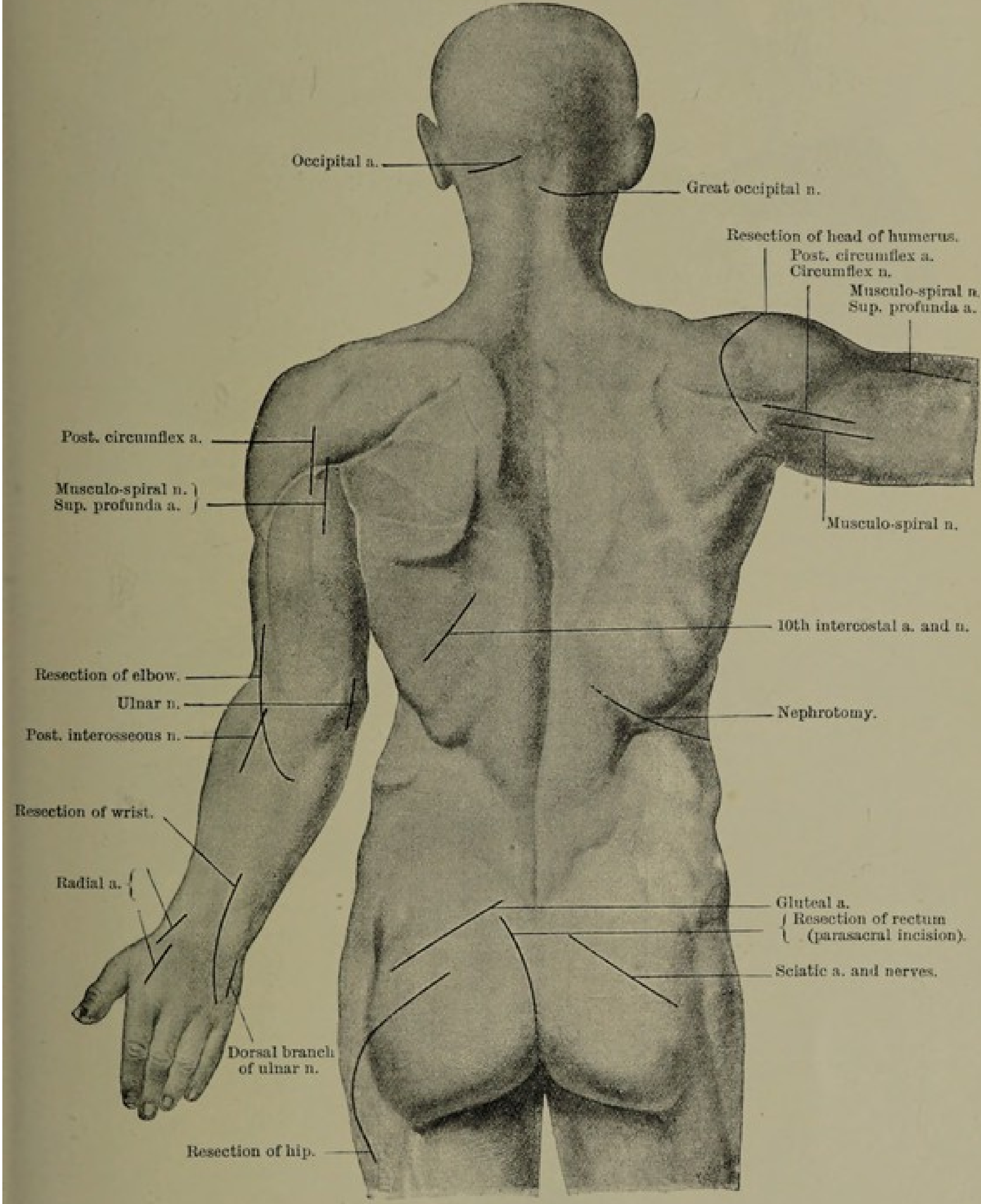


FIG. 40.

with the sensory *supra-clavicular nerves.* In dividing the fascia, we must avoid the *cephalic vein* at the anterior edge of the deltoid. The clavicular fibres of the pectoralis major are now divided, and the cephalic vein, together with the branches of the acromio-thoracic artery and the anterior thoracic nerves, is drawn upwards. The

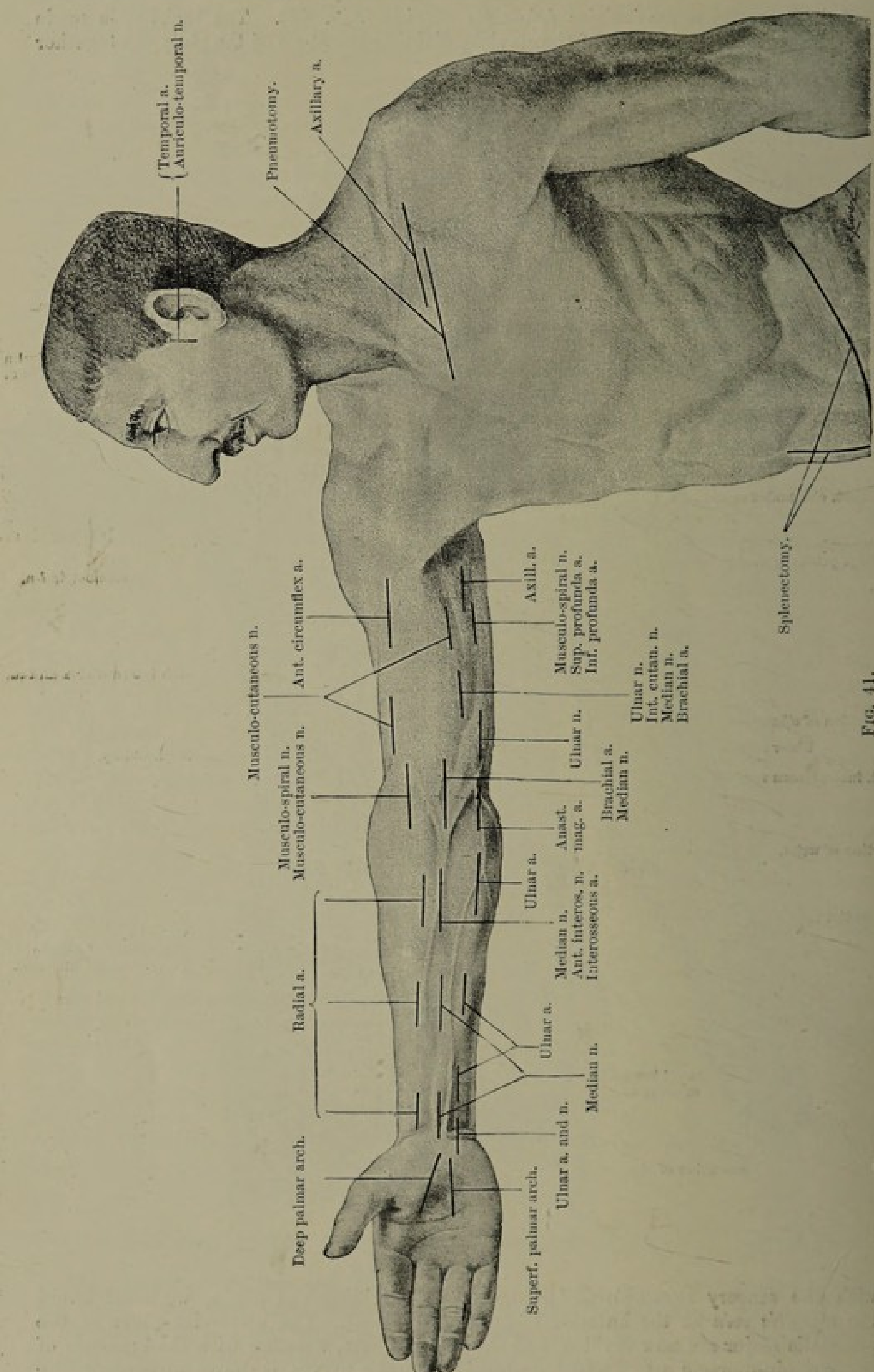

Temporal a.
Auriculo-temporal n.
Pneumotomy.
Axillary a.
Musculo-cutaneous n.
Ant. circumflex a.
Musculo-spiral n.
Musculo-cutaneous n.
Radial a.
Deep palmar arch.
Superf. palmar arch.
Ulnar a. and n.
Median n.
Ulnar a.
Median n.
Ant. interos. n.
Interosseous a.
Ulnar a.
Anast. mag. a.
Brachial a.
Median n.
Ulnar n.
Ulnar n.
Int. cutan. n.
Median n.
Brachial a.
Axill. a.
Musculo-spiral n.
Sup. profunda a.
Inf. profunda a.
Splenectomy.

Fig. 41.

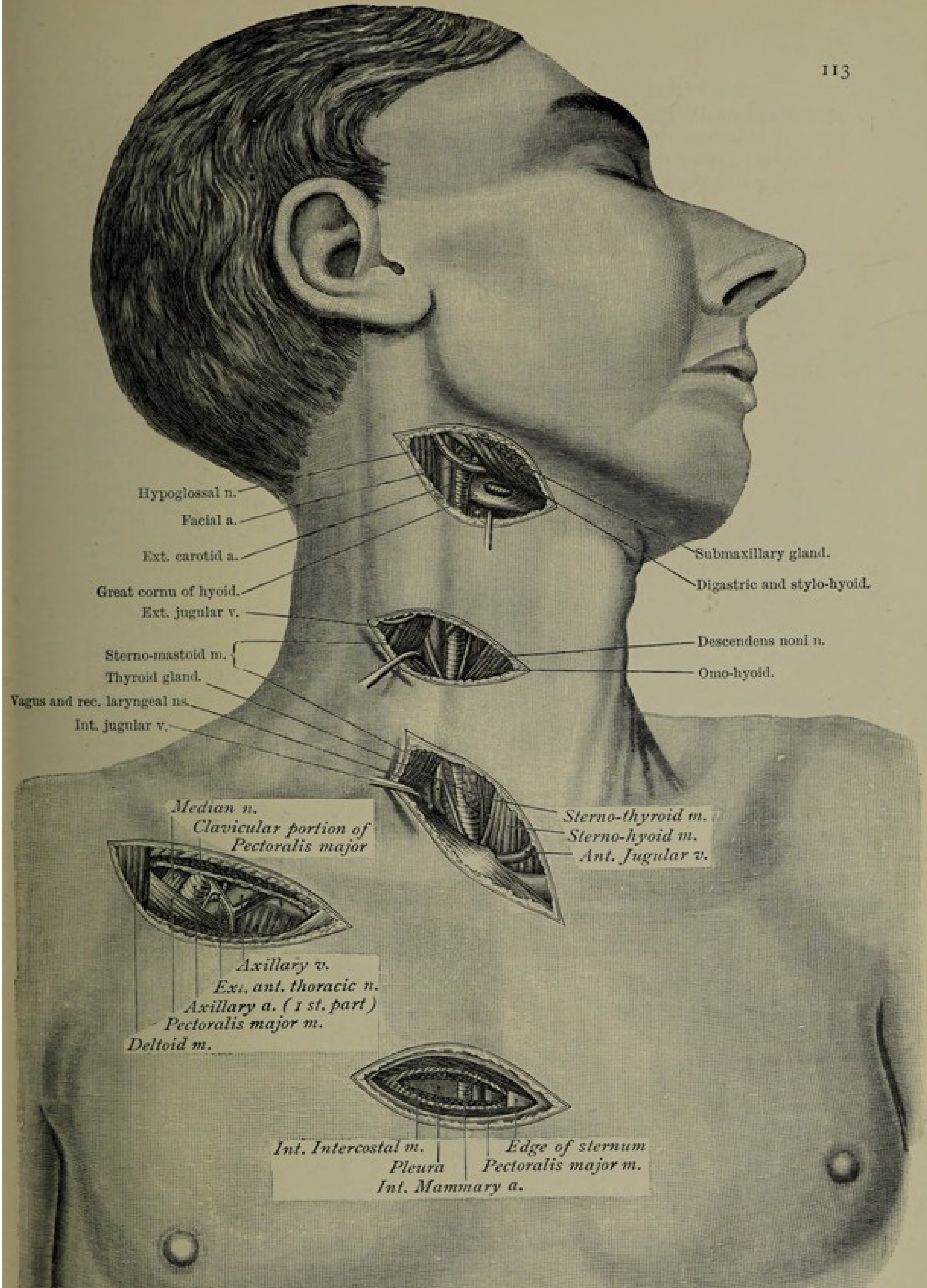


FIG. 42.—Ligature of the lingual artery above the greater cornu of the hyoid. Ligature of the common carotid at the level of the cricoid cartilage. Ligature of the innominate artery. Ligature of the first part of the axillary artery. Ligature of the internal mammary artery.

nerves are small, appearing below the clavicle, and cross the vessels to supply the pectoral muscles. The costo-coracoid membrane is divided below the clavicle, and the upper edge of the pectoralis minor is exposed. The *axillary vein* now appears, and externally the *cords of the brachial plexus* are exposed. The most superficial of the larger nerve trunks alongside the vein is the outer head of the median. After it is freed along its inner edge, the artery comes into view underneath it in the angle between the clavicle and the upper border of the pectoralis minor, lying upon the serratus magnus muscle.

(*b*) *By a longitudinal incision between the deltoid and the clavicular portion of the pectoralis major* (Fig. 43). The surface guide to the vessel is afforded in this situation by the visible and palpable hollow between the deltoid and pectoralis major muscles. The incision is begun over the junction of the outer and middle thirds of the clavicle, and passes downwards over the coracoid process along the groove between the deltoid and the clavicular portion of the pectoralis major as far as the junction of the anterior fold of the axilla with the upper arm. The cephalic vein appears at the edge of the deltoid. The muscles are separated as far down as the upper edge of the tendon of the pectoralis major. On drawing the arm downwards the short head of the biceps appears from beneath the deltoid, and under the inner edge of the former is the coraco-brachialis muscle, pierced by the musculo-cutaneous nerve.

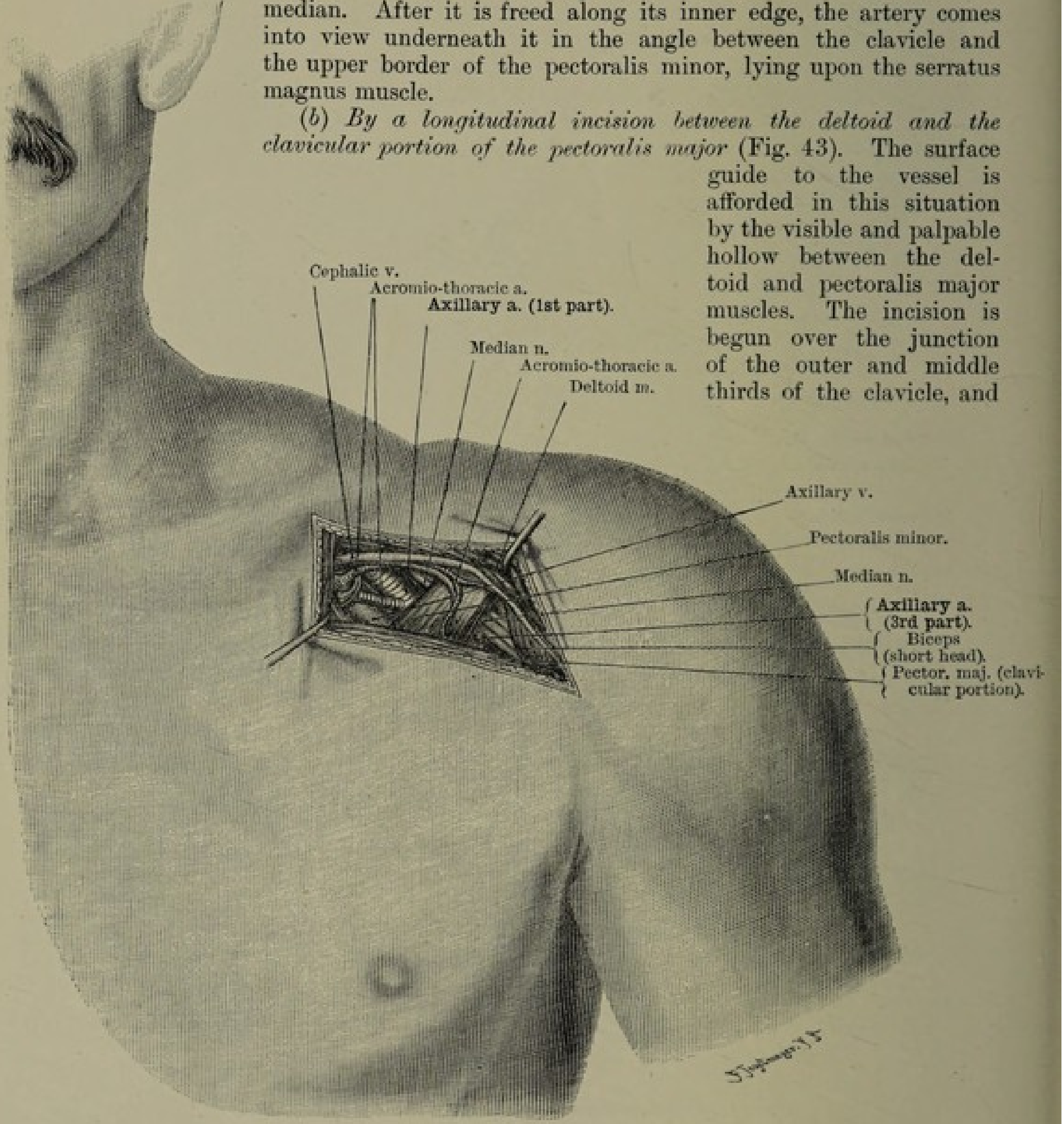


Fig. 43.—Ligature of the axillary artery, above or immediately below the pectoralis minor.

The lower border of the pectoralis minor is exposed from the coracoid process towards the thorax: between it and the coraco-brachialis lie the vessels and nerves, the large vein being internal. The axillary vein and the median nerve [inner head] are now drawn inwards, when the axillary artery will be seen lying beneath and external to them. External to the artery is a smaller collateral vein.

The operation is more easily performed by separating the pectoralis major muscle from the clavicle for a short distance. The artery may also be ligatured above the pectoralis minor with this incision.

As will be observed from Fig. 43, the operation is rendered simpler if the pectoralis minor is divided at the coracoid process. Kolliker[1] even regards division of the pectoralis major as the normal method for exposing and ligaturing the axillary artery. It should, however, be reserved for specially-difficult cases. As already stated in clearing out the axilla in disease of the breast, the pectoral muscles are divided so that the main vessels may be completely exposed up to the clavicle.

(c) *From the axilla to its lowest end* (Fig. 44). The line of the vessel is from the middle of the clavicle to the middle of the anterior fold of the axilla. The artery is in contact with the outer wall of the triangular prismatic space between the thorax internally, the pectoralis major and minor anteriorly, and the scapula covered by the subscapularis muscle posteriorly. With the arm fully abducted, an incision is made through the skin and fascia along the line of the internal bicipital groove over the inner edge of the prominence of the coraco-brachialis. The muscular fibres of the coraco-brachialis are exposed, with the large nerves of the axilla—which may be felt through the skin upon the prominence of the head of the humerus—lying along its inner border. The dissection is now to be continued between the musculo-cutaneous and median nerves, otherwise a collateral vein running alongside the coraco-brachialis may easily be taken for the artery. The smaller external nerve is the *musculo-cutaneous*; the larger internal one is the *median*, which is single below, but higher up consists of two cords, the external of which unites above with the musculo-cutaneous, the artery lying in the fork between the two heads of the nerve. The *ulnar* and *internal cutaneous nerves* lie internal to the artery, the *musculo-spiral* and *circumflex* behind it. The main *vein* is quite internal to the artery, and a smaller collateral vein lies external to it.

25. Ligature of the Superior Thoracic Artery (Fig. 42). This artery arises from the axillary at the lower border of the subclavius muscle, and in ligaturing it the operator must be careful not to include the internal and external anterior thoracic nerves, which supply the pectoral muscles. The operation is similar to that of ligature of the axillary (see 24*a*).

26. Ligature of the Acromio-thoracic Artery. This is the chief artery of supply to the acromial region, and is exposed at the upper border of the pectoralis minor, through the incision described in 24*b*. It has most frequently to be ligatured in opening into the shoulder-joint by an incision between the deltoid and pectoralis major, as its acromial branch which runs outwards over the coracoid, and its humeral branch which descends in the above interval, are divided.

27. Ligature of the Lateral Thoracic (Long Thoracic) Artery. This branch of the axillary is given off at the lower border of the pectoralis minor. With the arm fully abducted, an incision is made immediately behind the swelling formed by the pectoralis major in the anterior fold of the axilla. The lower border of the pectoralis minor is exposed, and the artery is found under cover of this muscle lying on the serratus magnus. Behind it, the posterior thoracic nerve runs downwards on the serratus magnus, which it supplies.

28. Ligature of the Anterior Circumflex Artery (Fig. 45). Incision along the anterior border of the deltoid opposite the surgical neck of the humerus. The cephalic vein lies upon the fascia. It is important to define the groove between the deltoid and pectoralis major, and after division of the fascia the muscles are separated from one another, the deltoid being drawn outwards and the pectoralis major inwards. The outer borders of the short head of the biceps and the coraco-

[1] Lindner, *Inaug. Diss.*, Leipzig, 1904.

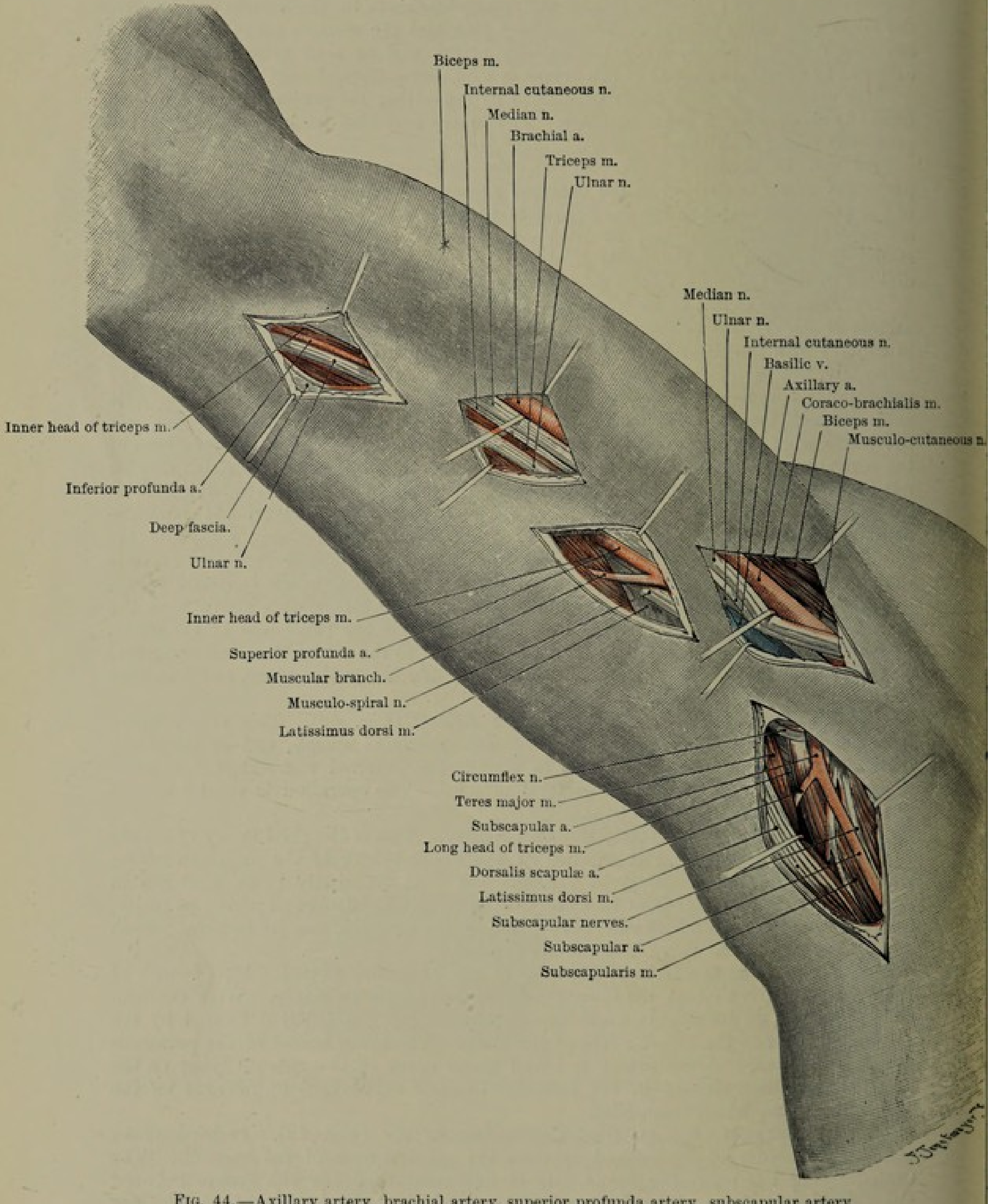


FIG. 44.—Axillary artery, brachial artery, superior profunda artery, subscapular artery, median, subscapular, musculo-spiral, and circumflex nerves.

brachialis muscles which descend under the pectoralis major are exposed and drawn inwards. The artery is seen between the two heads of the biceps, running transversely in some fat immediately below the head of the humerus and above the insertion of the pectoralis major.

29. Ligature of the Posterior Circumflex Artery (Fig. 46). If the posterior border of the deltoid muscle be pressed towards the surgical neck of the humerus, the angle which this muscle forms with the posterior scapular muscles may be distinctly felt. The skin and the fascia (which is adherent to the deltoid) are divided longitudinally over the above-mentioned situation. The posterior border of the deltoid having been exposed and drawn forwards, the lower edge of the teres minor

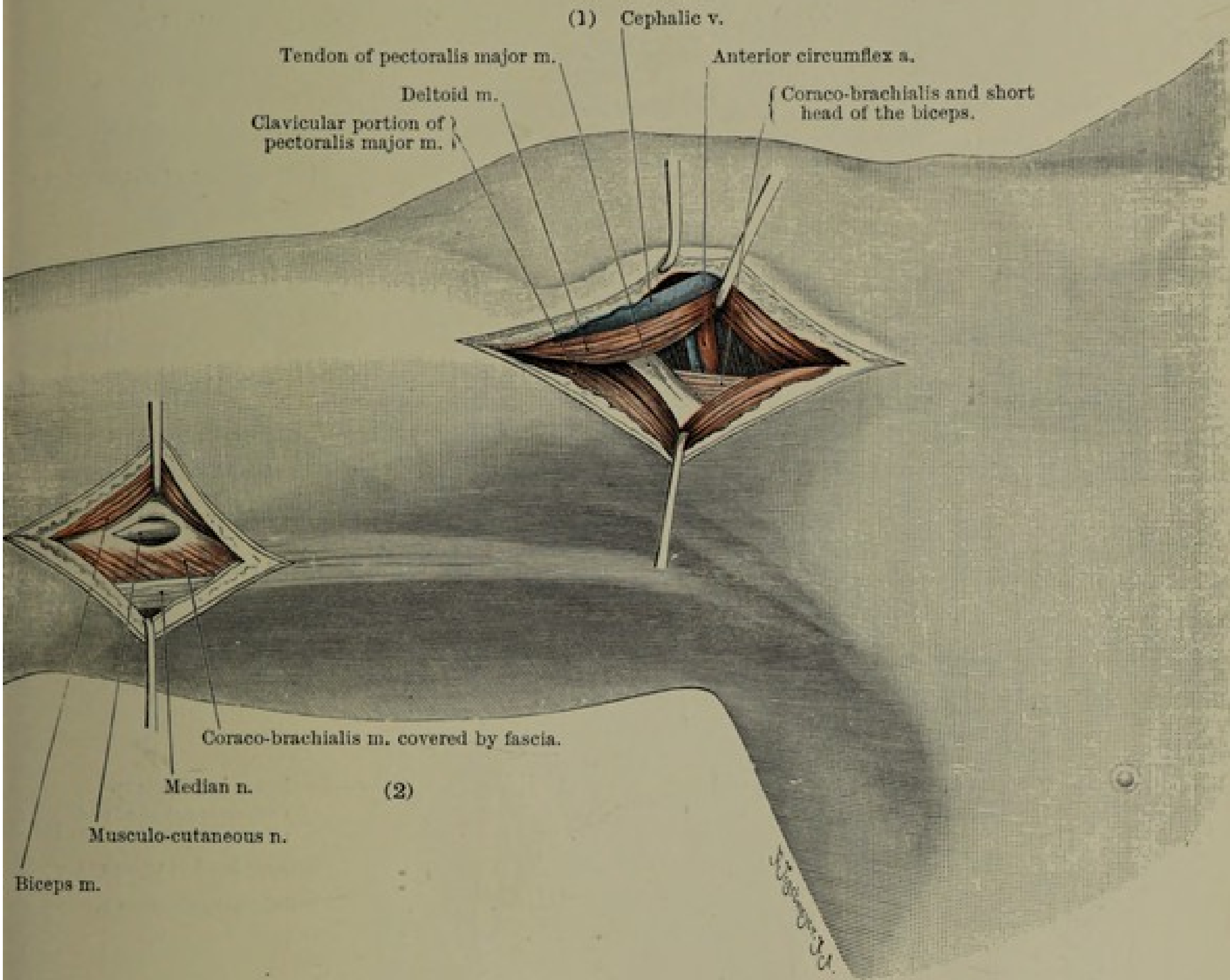


FIG. 45.—(1) Ligature of anterior circumflex artery. (2) Musculo-cutaneous nerve.

and, in front of it, the tendon of the long head of the triceps are brought into view. In the angle between the teres minor and the upper border of the long head of the triceps the posterior circumflex artery, along with the circumflex nerve which is above it, comes out from before backwards. The latter curves round the posterior surface of the humerus in order to enter the under surface of the deltoid, after having given off a branch which runs downwards along its posterior border. Below the nerve the posterior circumflex artery curves forwards out of the interspace between the teres minor above and the teres major below, and divides into ascending and descending branches. The main trunk surrounds the neck of the humerus. Below the posterior circumflex, and separated from it only by the long head of the triceps, the *dorsalis scapulæ artery* will be seen winding round the axillary border of the scapula.

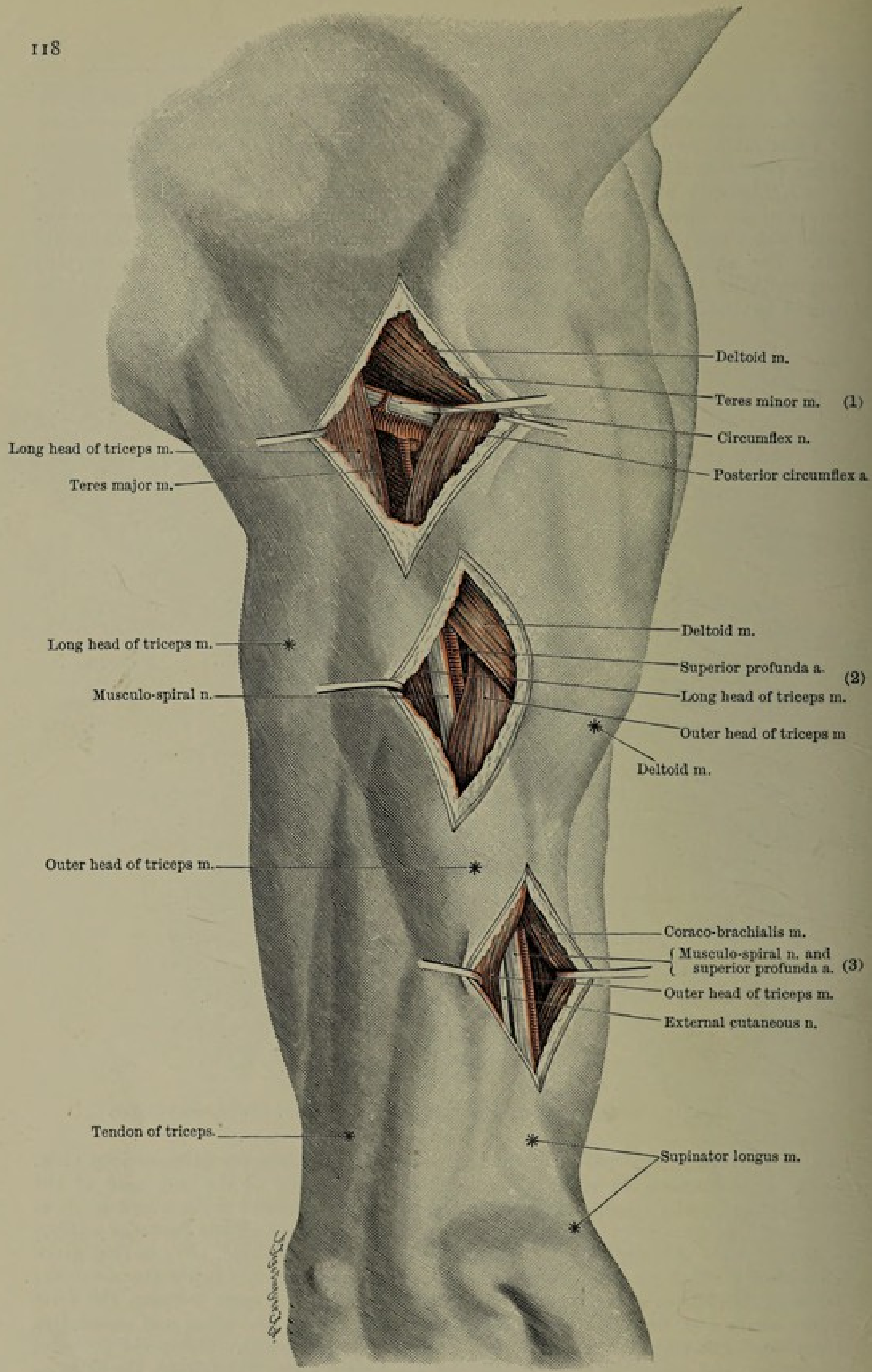


FIG. 46.—(1) Ligature of posterior circumflex artery, circumflex nerve. (2) and (3) Musculo-spiral nerve and superior profunda artery.

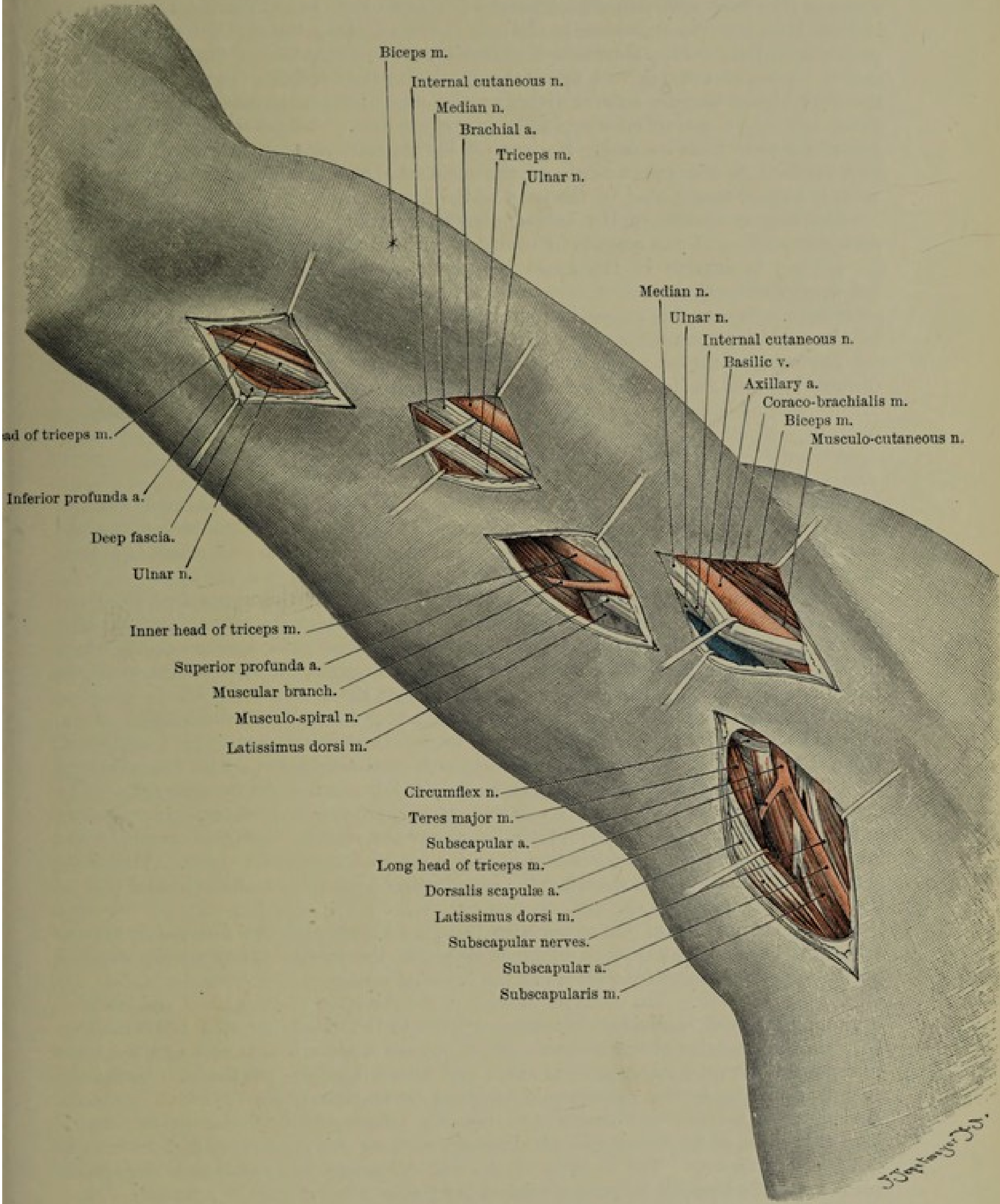


FIG. 47.—Axillary artery, brachial artery, superior profunda artery, subscapular artery, median, subscapular, musculo-spiral, and circumflex nerves.

30. Ligature of the Subscapular Artery and its branches, the Circumflexa scapulæ (Dorsalis scapulæ) and Thoraco-dorsalis (Fig. 44). The limb being fully abducted, an incision beginning at the arm is carried along the anterior surface of the posterior axillary fold. Intercosto-humeral branches going to join the lesser internal cutaneous nerve may appear upon the fascia. After dividing the fascia we find the artery lying in loose cellular tissue at the edge of the insertions of the latissimus dorsi and teres major muscles, which together form the posterior axillary fold. About an inch from its origin it gives off the dorsalis scapulæ artery, which passes backwards. At the upper angle of the incision the circumflex nerve may be seen upon the projection caused by the head of the humerus.

The largest branch of the subscapular artery, the dorsalis scapulæ, reaches the posterior surface of the scapula in company with a branch of the subscapular nerve, by passing backwards in the space between the teres major and latissimus dorsi below, the subscapularis and teres minor above, and the long head of the triceps externally. It can be exposed from behind by the same procedure as described for the posterior circumflex artery (No. 29 and Fig. 46).

The other main branch is the thoraco-dorsalis, the continuation of the trunk in the gap between the latissimus dorsi and the serratus magnus (Fig. 44).

(f) Brachial Artery and its Branches

31. Ligature of the Brachial Artery (Fig. 47). The best landmarks in examining the upper arm are the internal and external bicipital sulci: the biceps and the long head of the triceps can be gripped between the fingers and raised up from the bone.

The brachial artery can be felt in the entire length of the upper arm along the internal bicipital sulcus, from the head of the humerus, which can be palpated through the axilla, down to the middle of the bend of the elbow: the median nerve, which crosses the middle third of the artery from without inwards, can also be felt, while the artery can be compressed in its whole length against the biceps.

(*a*) *In the middle.* An incision is made along the line of the median nerve, which is very distinctly felt in the internal bicipital sulcus when the arm is abducted. Upon the fascia is the slender *lesser internal cutaneous nerve.* The fascia having been divided, the inner border of the biceps is defined and drawn outwards. The median nerve is then completely exposed, freed, and drawn inwards. Immediately under it is the brachial artery (with its two venæ comites) lying in front of the intermuscular septum. Internal to it is the internal cutaneous nerve. The ulnar nerve lies under the fascia covering the inner head of the triceps at the hinder part of the internal bicipital sulcus.

Below the middle of the upper arm the *basilic vein* and the *internal cutaneous nerve* will be seen at the place where they pierce the fascia. They may be exposed by the same incision as for ligature of the brachial artery.

(*b*) *At the elbow.* We make an incision in the direction of the axis of the forearm, beginning internal to the biceps tendon a little to the ulnar side of a point midway between the condyles of the humerus. The oblique median basilic vein and the main branches of the internal cutaneous nerve are seen lying upon the fascia. Under the superficial fascia is the aponeurotic bicipital fascia, the fibres of which run in a characteristic manner downwards and inwards. Immediately under it, or covered by a thin layer of fat, lies the brachial artery, with its two venæ comites. Externally is the biceps tendon. The division of the brachial artery into radial and ulnar takes place a finger's breadth below the level of the joint.

32. Ligature of the Arteria collateralis radialis superior. Ligature of this artery is performed only in the case of injury and then at its site.

33. Ligature of the Arteria profunda brachii (Superior profunda) (Figs. 44 and 46). (*a*) *Upon the inner aspect of the arm in its upper third—at the lower border of the latissimus dorsi muscle* (Fig. 44). An incision commencing at the level of the

posterior axillary fold is carried downwards along the internal bicipital sulcus. The lesser internal cutaneous nerve is met with upon the fascia. The fascia is divided over the prominence of the long head of the triceps behind the white line of the internal intermuscular septum, and the dissection is continued towards the bone upon the anterior surface of the long head and above the origin of the inner head of the triceps. By following up the large branch to the inner head of the triceps, we meet with the trunk of the superior profunda artery lying against the bone.

Behind the artery lies the musculo-spiral nerve, which descends from above over the tendon of the latissimus and passes towards the posterior surface of the humerus between the inner and the long heads of the triceps. An operator must be careful not to go too far backwards, as otherwise he would pass behind the nerve and artery which are situated close to the bone in the internal bicipital groove. The musculo-spiral nerve is identified by its resting upon the latissimus.

(*b*) *Above the middle of the posterior surface* (Fig. 46). As a guide to the incision, a line is drawn along the posterior surface of the upper arm from a point a finger's-breadth behind the posterior border of the deltoid and close to the long head of the triceps down to the tip of the olecranon. The incision begins below the level of the posterior axillary fold, and passes downwards along this line in the interval between the long and outer heads of the triceps, which are separated from one another down to the bone. The nerve lies between the inner and outer heads of the triceps after having passed under the long head at the lower border of the latissimus dorsi. Parallel to and in front of the nerve lies the superior profunda artery, which is also in contact with the inner surface of the humerus.

(*c*) *Upon the outer aspect of the upper arm in the lower third* (Fig. 46). An incision is made at the outer border of the outer head of the triceps (the limits of which can easily be made out by grasping it from behind), extending vertically upwards from the external condyle of the humerus to a point midway between it and the insertion of the deltoid. The muscular fibres of the triceps are exposed by continuing the dissection along the external intermuscular septum, and separating the brachialis anticus muscle from it as far as the bone. The artery passes obliquely from behind forwards, accompanied by the musculo-spiral nerve, which lies close to the bone.

34. Ligature of the Arteria collateralis media (branch to Inner Head of Triceps). This vessel, which runs in the fibres of the inner head of the triceps, is ligatured only in wounds incurred by the latter muscle.

35. Ligature of the Arteria collateralis radialis inferior. This is the terminal branch of the superior profunda, lying behind the external intermuscular septum, and found in the lower third of the arm at the lateral border of the outer head of the triceps. The posterior interosseous nerve is closely associated with it.

36. Ligature of the Arteria collateralis ulnaris superior (Inferior profunda Artery) (Figs. 47 and 44). This artery accompanies the ulnar nerve. In the *upper third* of the arm it lies along with the nerve posterior to the large vessels, and is to be ligatured by the same incision as for the brachial artery, with this difference, that the median nerve is drawn outwards, and one passes internal and posterior to the main vessels.

From the middle of the arm downwards the artery lies behind the internal intermuscular septum. The incision (Fig. 44) is the same as for exposure of the ulnar nerve, the fascia being divided behind the intermuscular septum. The artery lies beside the nerve upon the muscular fibres of the inner head of the triceps.

At its *lower end* the artery can be felt upon the posterior surface of the internal epicondyle, and is to be looked for accompanying the ulnar nerve behind the internal intermuscular septum.

37. Ligature of the Arteria collateralis ulnaris inferior (Anastomotic Artery). The artery lies upon the base of the internal epicondyle above the origin of the pronator radii teres. It can be felt there. It is found after dividing the strong fascia upon which lie the anterior branch of the internal cutaneous nerve and the junction of the median basilic with the basilic vein.

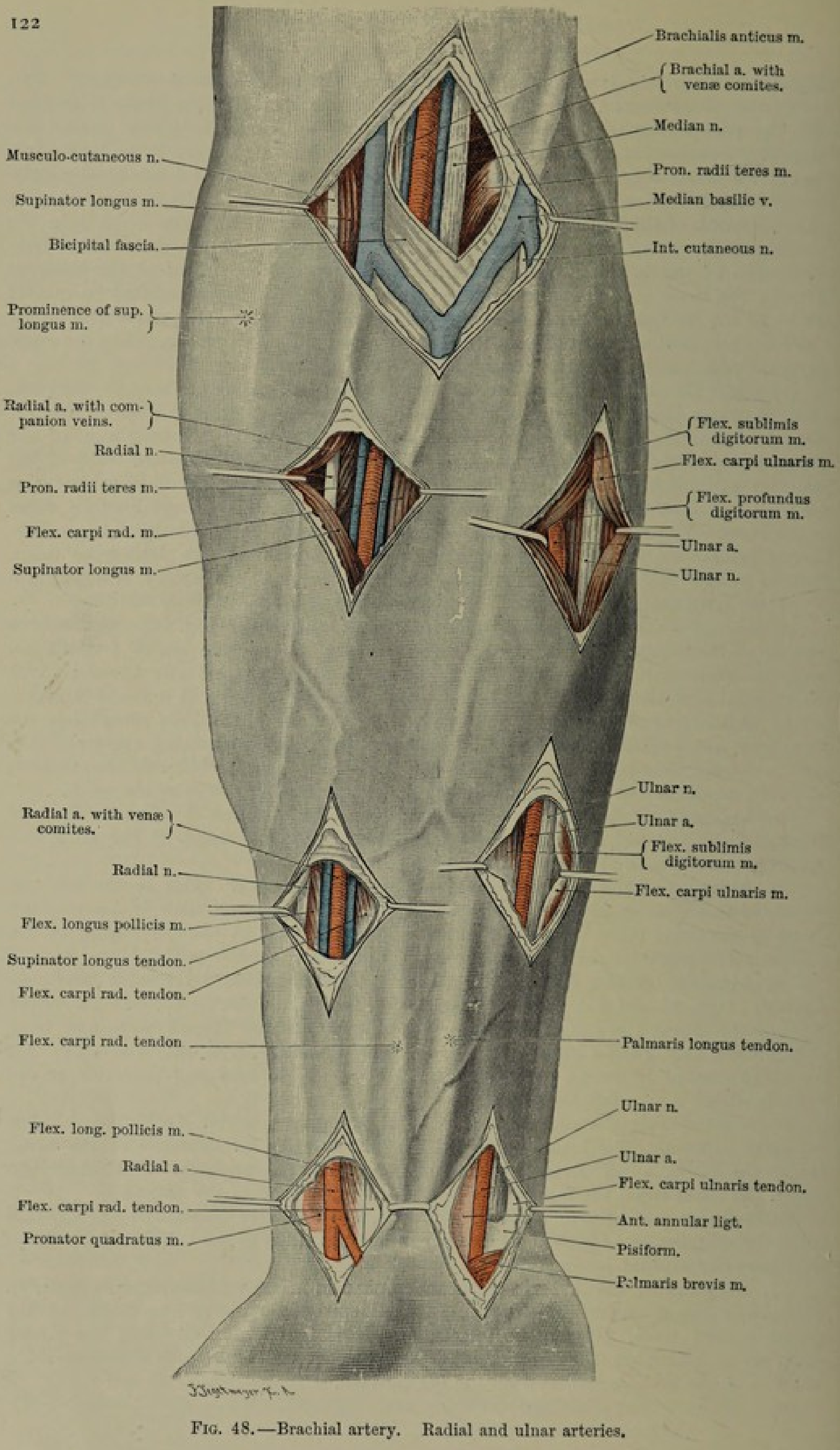


FIG. 48.—Brachial artery. Radial and ulnar arteries.

(g) Arteries on the Forearm and the Hand

38. Ligature of the Radial Artery (Figs. 48 and 49). This vessel, the direct continuation of the brachial artery, is easily felt in two-thirds of its length. It is nowhere covered by muscles, except in the upper third, where it is slightly overlapped by the supinator longus muscle. The direction of the artery is indicated by a line from the middle of the bend of the elbow, down the front of the forearm, and along the "pulse" to the ridge on the trapezium.

(*a*) *In the upper third* the artery lies more deeply upon the supinator brevis and the pronator teres, between the projecting supinator longus and the flexor carpi radialis muscles. An incision is made along the interval which may be distinctly felt between the two latter muscles. The median cephalic vein and a large branch of the musculo-cutaneous nerve appear upon the fascia. The fascia is divided, and the supinator longus muscle is drawn well outwards. The artery is found lying deeply upon the insertion of the pronator radii teres. To the radial side of the artery, and at some distance from it, is the radical nerve covered by the supinator longus.

(*b*) *In the middle third.* Incision in the interval (in which the radius may be felt) between the flexor carpi radialis and supinator longus muscles. In this interval the artery lies upon the radial origins of the flexor longus pollicis and flexor sublimis digitorum muscles. The *radial nerve* lies at a little distance to its radial side, more under cover of the supinator longus, beneath which it passes backwards.

(*c*) *Above the wrist.* The hand being dorsiflexed, an incision is made between the prominent tendon of the flexor carpi radialis and the edge of the radius. The skin and fascia are divided. At the lower border of the pronator quadratus the artery passes deeply towards the radial aspect of the wrist-joint, and sends merely the small superficial volar branch downwards to the palm over the ridge on the trapezium. The tendons of the extensor ossis metacarpi and extensor primi internodii pollicis lie enveloped in their sheath external to the artery at the edge of the radius. The radial nerve is no longer to be seen, as it passes backwards under the tendon of the supinator longus at the lower third of the forearm.

(*d*) *On the back of the wrist* (*in the so-called Tabatiere*) (Fig. 49). Longitudinal incision from the lower end of the radius to the base of the first metacarpal bone between the prominent tendons of the extensor primi and extensor secundi internodii pollicis. The vessel can here be felt through the skin. In the subcutaneous tissue parallel to the tendon are the radial vein and nerve, which are to be avoided: the latter can be felt upon the outer side of the radius. The artery courses obliquely beneath the above-mentioned structures upon the scaphoid and external lateral ligament.

(*e*) *On the back of the hand* (Fig. 49). This vessel goes to form the main part of the deep palmar arch.

Incision from the upper end of the first interosseous space along the ulnar side of the tendon of the extensor secundi internodii pollicis. The vessel can be felt here. The branches of the radial nerve and vein which lie upon the fascia are to be avoided. The dissection is continued between the bases of the first and second metacarpal bones, upon which the artery lies just before it passes towards the palm, under the tendinous arch joining the two heads of origin of the first dorsal interosseous muscle. The broad tendon of the extensor carpi radialis longior, which is inserted into the second metacarpal bone, appears upon the ulnar side. The artery has previously given off the common digital branch for the forefinger and thumb, which may readily be mis-taken for the main trunk.

The radial recurrent, posterior radial carpal, and superficial volar, branches of the radial artery, are only ligatured in the case of injury. The superficial volar is a small twig which assists in forming the superficial palmar arch (*q.v.*), and runs down-wards under the delicate fascia of the muscles of the thenar eminence.

39. Ligature of the Ulnar Artery (Fig. 48). The ulnar artery can be felt in the lower third, being for the most part uncovered by muscles. After arising at an angle from the brachial artery, it passes between the flexor sublimis and flexor profundus

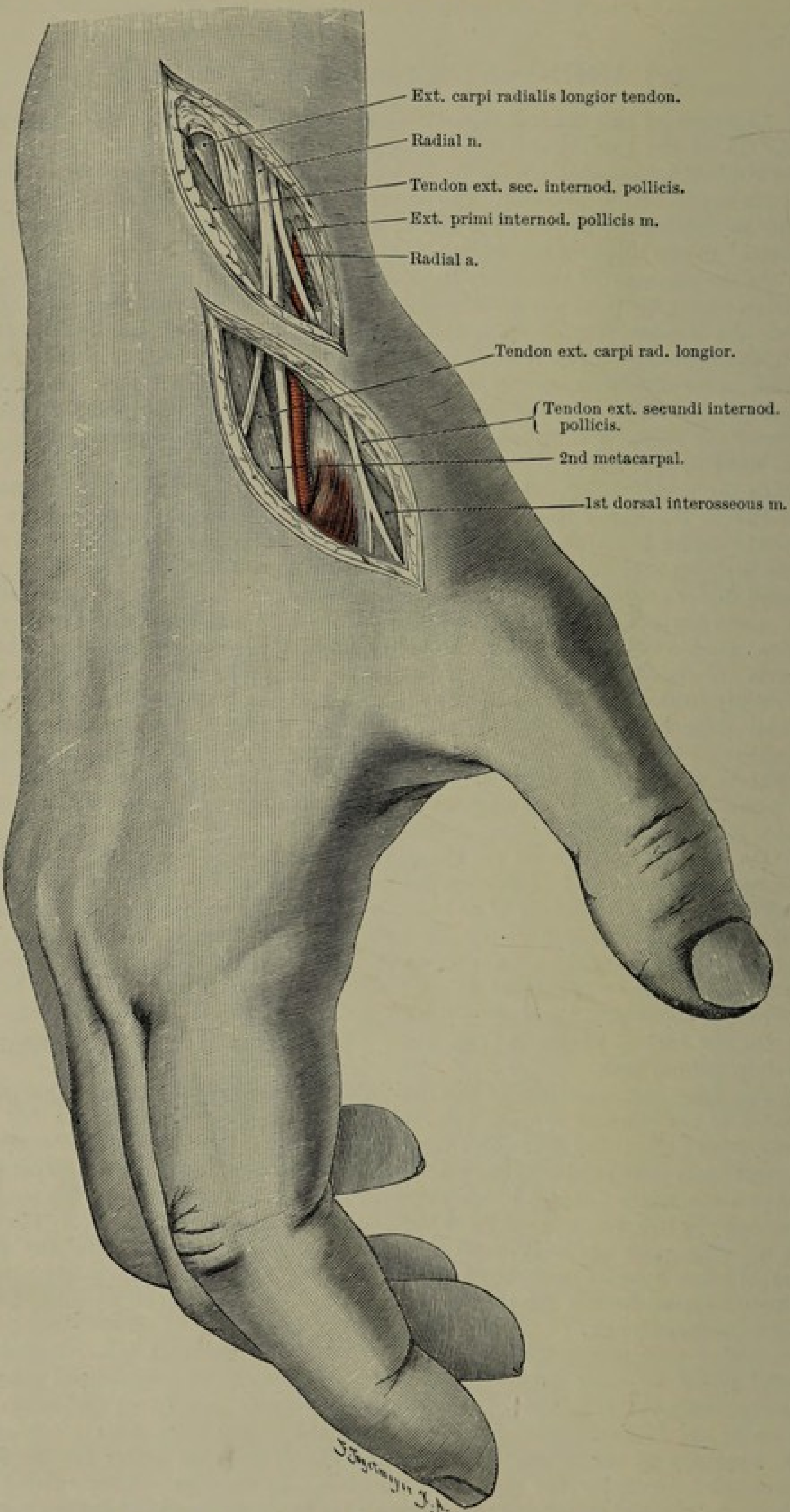


FIG. 49.—Radial artery on the back of the wrist. Radial nerve.

digitorum muscles. Incisions for ligaturing the artery are made along a line extending from the internal condyle for the humerus to the projection of the pisiform bone. This line does not correspond to the course of the artery, which in its upper part lies much more towards the middle line. To ligature it at its origin, the directions already given for ligature of the brachial at the bend of the elbow suffice, except that the incision is prolonged somewhat more downwards.

In the upper half. With the arm held abducted, an incision is made in a line descending vertically from the posterior edge of the internal epicondyle of the humerus. The incision must not be begun higher than four finger-breadths below the epicondyle (*i.e.* at the junction of the upper and middle thirds of the forearm), and must not fall in front of the above line: it strikes the radial edge of the flexor carpi ulnaris, which is indicated by a distinct intermuscular septum. Occasionally the ulnar nerve can be felt through the skin. After division of the skin, the anterior ulnar vein along with a branch of the internal cutaneous nerve comes into view. In the fascia is the intermuscular septum between the flexor carpi ulnaris and the subjacent flexor sublimis, indicated by a distinct white line. The fascia having been divided along this line, the finger is passed deeply at the outer border of the flexor carpi ulnaris and somewhat outwards upon the anterior surface of the flexor profundus digitorum, the flexor sublimis being drawn aside. If the right intermuscular space has been struck, the ulnar nerve will first be met with. By passing external and somewhat anterior to the nerve, we find the artery lying $\frac{1}{2}$ to $1\frac{1}{2}$ cm. (according to the height) to its outer side. Higher up, the artery is still further external to the nerve.

In the lower half. An incision is made down to the flexor sublimis in the interval between the flexor carpi ulnaris and the palmaris longus. This interval is definitely marked out by projecting a line vertically upwards from the radial border of the pisiform bone. After the skin and fascia have been divided the dissection is carried down upon the flexor sublimis and *not under* the flexor carpi ulnaris. The artery lies between two venæ comites. The ulnar nerve is close to its ulnar side.

40. Ligature of Common Interosseous Artery (Fig. 50). This branch of the ulnar artery may be exposed by the same incision as that for the ulnar artery in its upper third (Fig. 48), by passing down upon the flexor profundus digitorum until the median nerve with its branches is met with. The interosseous artery passes under the nerve towards the interosseous membrane between the flexor profundus digitorum and the flexor longus pollicis. The interosseous branch of the median nerve lies upon the artery. The interosseous artery may also be exposed by the same incision as that for the median nerve in the upper third. The ulnar artery here lies deeply towards the supinator brevis and above the tendinous arch of the flexor sublimis digitorum, beneath which, close to the radius, the interosseous artery is given off.

Of the other branches of the ulnar artery, ligature of both the ulnar recurrent arteries at the elbow, or of the anterior or posterior ulnar carpals at the wrist, need no special consideration. For ligature of the profunda branch of the ulnar, which helps to complete the deep palmar arch, see No. 42.

41. Ligature of Superficial Palmar Arch (Fig. 51). Longitudinal incision from the junction of the thenar eminence towards the ring finger, the middle of the incision being opposite a line drawn across the palm at the level of the web of the abducted thumb. The superficial arch may be felt pulsating at the point where these two lines intersect. After division of the skin, the superficial fascia (which is often of considerable thickness), and the strong aponeurotic palmar fascia, the arch is at once exposed embedded in fat beneath the smooth under-surface of the latter. The arch is the continuation of the ulnar artery, and at this point it curves outwards towards the thumb. Passing downwards from the arch are the common digital arteries. The arch lies upon the digital branches of the median and ulnar nerves, the latter being exposed. If the artery cannot be found here, the ulnar artery may be ligatured at the pisiform bone.

The *ulnar nerve* may be exposed by a similar incision. Its superficial division

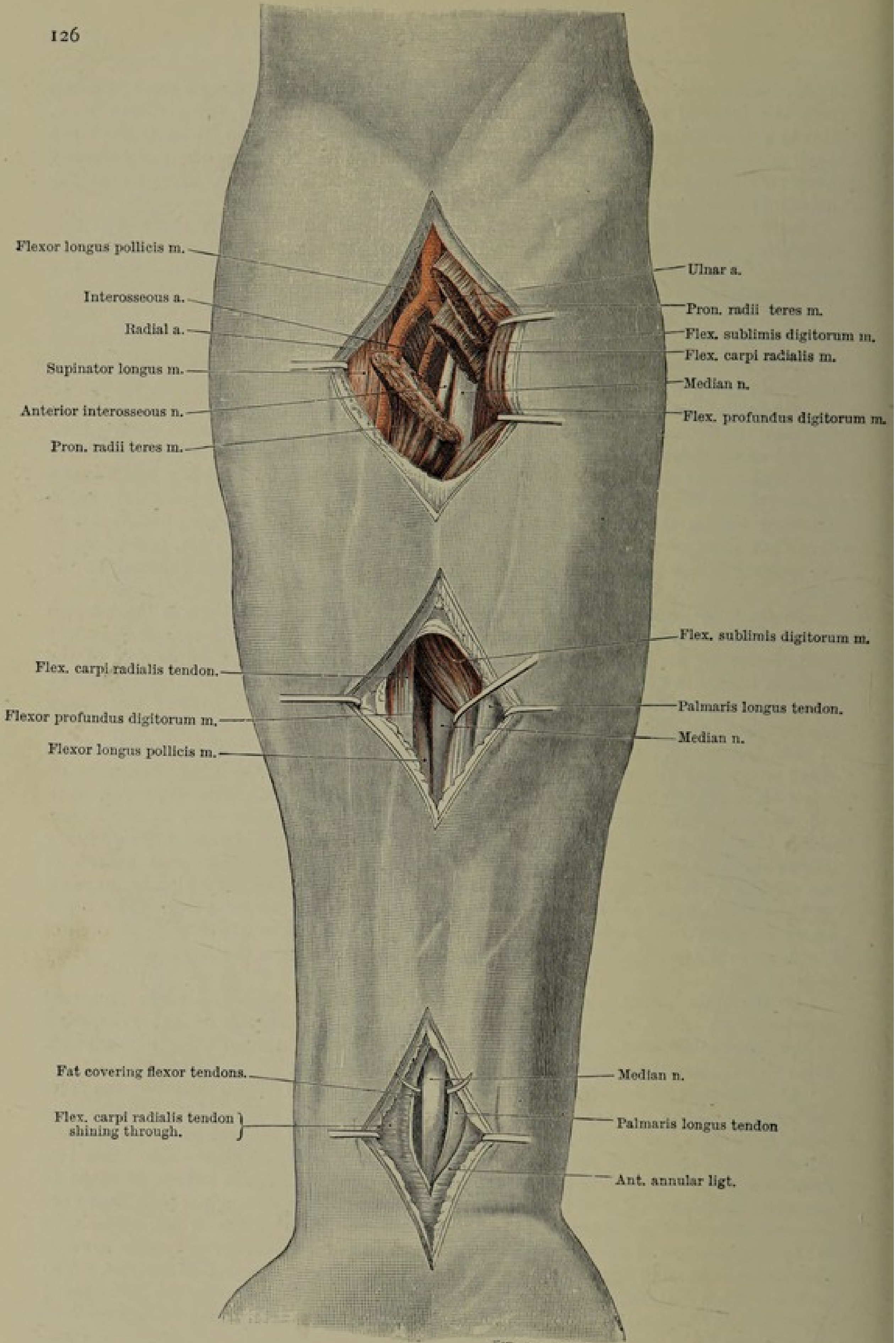


Fig. 50.—Median nerve, anterior interosseous nerve, interosseous artery.

descends over the hook of the unciform bone, which can be felt through the skin. The deep division passes between the abductor and flexor brevis minimi digiti at the ulnar side of the hook of the unciform, and supplies the flexor brevis and opponens minimi digiti, the two inner lumbricals, and all the interossei, together with the adductor pollicis.

42. Ligature of the Deep Palmar Arch (Fig. 51). In the contrast with the superficial arch, the deep arch is formed mainly by the radial artery. It gives off large branches to the radial side of the hand, whilst its interosseous branches are small. It does not reach so far downwards as the superficial arch. To expose it, an incision is made from the junction of the two thenar eminences along the opponens crease towards the index finger, the middle of the incision corresponding to the middle of the ball of the thumb. After division of the skin and palmar fascia the superficial arch is ligatured. The superficial muscular layer of the thumb (opponens pollicis) is ligatured, and, together with the anterior annular ligament, is slightly incised at the upper end of the wound. At a deeper plane is the slender first lumbrical muscle with the white flexor tendon of the index finger to its ulnar side. The dissection is continued along the radial side of the lumbrical between it and the thumb muscles. By retracting the muscles of the thenar eminence upwards, together with the branch of the median nerve supplying the muscles, and the adductor transversus pollicis downwards, we find the artery lying between the bases of the first and second metacarpals running transversely on the deep fascia covering the bones and the interossei muscles.

43. Ligature of the Digital Arteries in the Palm and of the Collateral Digital Arteries. The large digital branches of the superficial palmar arch are ligatured through an incision in the palmar fascia, similar to that for ligature of the superficial palmar arch.

The collateral digital arteries, which can easily be felt, may be tied on either side of the palmar aspect of each proximal phalanx, being distributed to the middle and distal phalanges.

The metacarpal arteries from the deep palmar arch, the dorsal interosseous branches from the carpal arch, and the small dorsal digital branches to the proximal phalanx are only ligatured in cases of wounds inflicted on the palm.

(h) Branches of the Thoracic Aorta

44. Ligature of the Intercostal Arteries (Fig. 52). Of the intercostal branches of the descending thoracic aorta, which extends from the fourth to the twelfth dorsal vertebra, only those from the third to the eleventh need be taken into consideration. In exposing the bodies of the vertebræ (costo-transversotomy) we have to ligature them near their point of origin, where they lie under cover of the lower margin of the head of the rib.

The anterior division of the intercostal artery, which is closely applied to the lower border of the rib, is the one most commonly ligatured. Primarily it lies on the pleura, but it is not generally long in insinuating itself below the internal intercostal muscles.

The chief branch of this artery runs between the two intercostal muscles at the lower border of the rib, a smaller branch running along the upper border of the subjacent rib. The artery is not easily ligatured, because it lies hidden under the overhanging lower margin of the rib. The oblique fibres of the external intercostal muscle are divided close to the rib and drawn downwards. The nerve, and with it the artery, can now be drawn down out of the groove of the rib, when an aneurysm needle is carefully passed round the artery. To secure the vessel with greater safety a piece of the overlying rib may be resected subperiosteally.

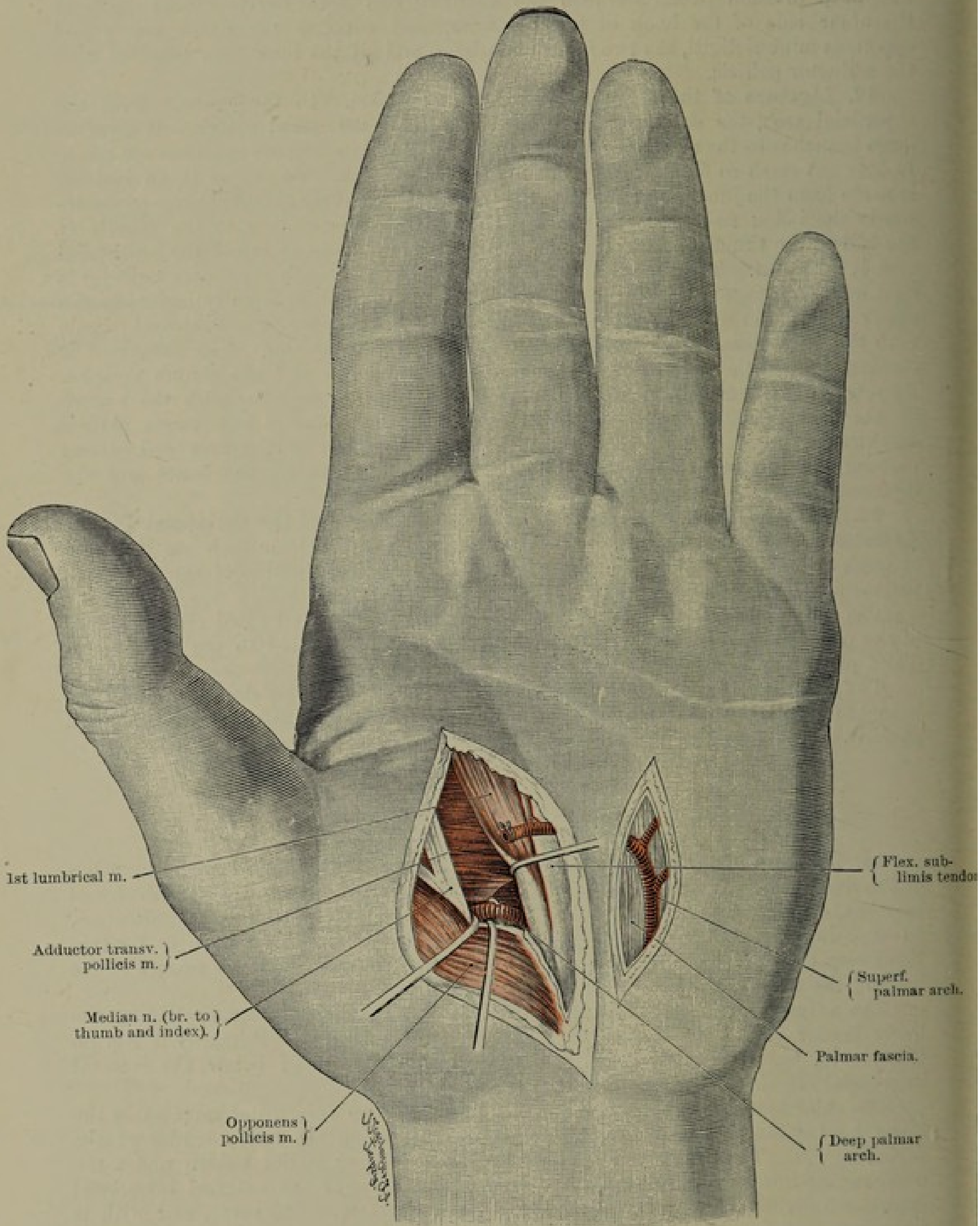


FIG. 51.—Ligature of the superficial and deep palmar arches. The stump of the superficial arch is represented as lying directly on the flexor sublimis, whereas the palmar fascia really intervenes.

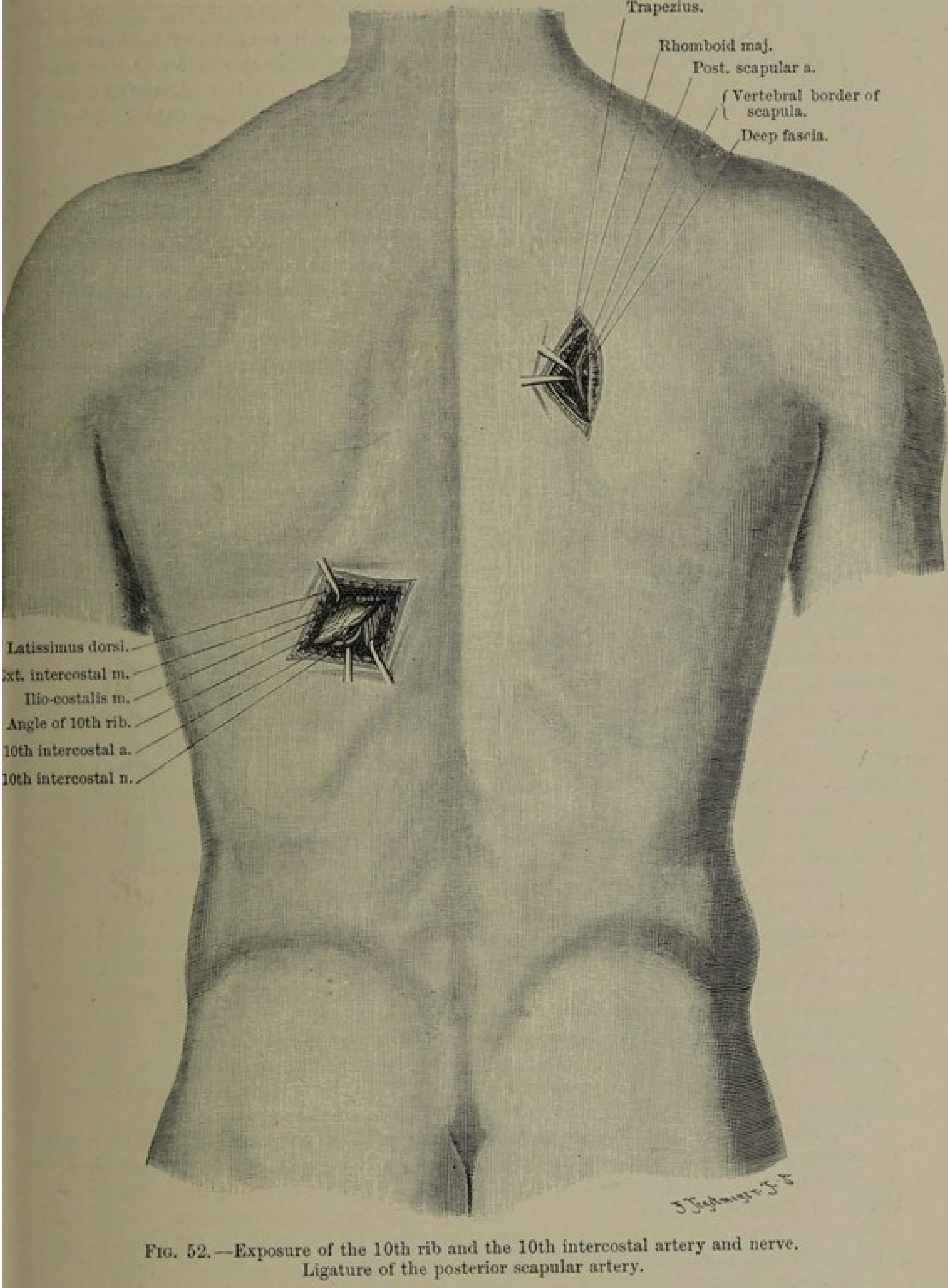


FIG. 52.—Exposure of the 10th rib and the 10th intercostal artery and nerve. Ligature of the posterior scapular artery.

(i) Branches of the Abdominal Aorta

Ligature of the abdominal aorta has already been considered (see p. 92).

45. Of the **Parietal Branches** of the abdominal aorta, the phrenic arteries which are distributed on the under surface of the diaphragm need not be considered. The

middle sacral artery, which is the terminal branch of the aorta, is ligatured in detaching the soft parts from the coccyx and sacrum, *e.g.* in excision of the rectum.

The large lumbar arteries, which are overlapped at their origin by the crura of the diaphragm and the ilio-psoas muscle, are distributed to the abdominal walls. Their position makes it impossible to ligature them without inflicting extensive injury on the surrounding parts.

Of the visceral branches of the abdominal aorta,

46. The Cœliac Axis, which arises above the pancreas, cannot be ligatured on account of the importance of its branches. Likewise, ligature of the hepatic artery, a branch of the cœliac axis which has occasionally suffered injury in the excision of a carcinoma of the stomach, proves fatal within a few days as the result of sudden interference with the function of the liver. Extreme care must therefore be exercised to avoid injury to the hepato-duodenal ligament in which it lies to the left of the common bile duct and the portal vein. According to Haberer,[1] the hepatic artery may be ligatured at a point immediately before its division into the right and left hepatics (Art. hepat. communis), and also before it gives off the pyloric artery, beyond which point ligature is impossible.

But, if we may judge by the results of pylorectomy, the main branch of the hepatic artery (viz. the gastro-duodenal) as well as its two branches, the superior pancreatico-duodenal and the right gastro-epiploic arteries, may be ligatured without hesitation.

The pyloric branch may also be ligatured, even if the gastro-duodenal has been divided (according to Fricker's experiments, see note under 47).

After ligature of the superior pancreatico-duodenal a sufficient blood-supply is provided by the inferior pancreatico-duodenal branch of the superior mesenteric (Fricker).

47. Ligature of the Coronary Artery. Like the pyloric branch of the hepatic, the coronary artery can be ligatured without endangering the blood-supply of the stomach. It may be excised in its entire length (as is often effected in cases of carcinoma of the stomach) in removing a chain of malignant glands along the lesser curvature. The corresponding veins can be equally well ligatured, as the anastomosis between the vessels on the greater and lesser curvatures is very rich. The vessels are found along the lesser curvature between the layers of the small omentum.

Simultaneous ligature of the coronary and left gastro-epiploic may be followed by serious results, although Dr. Fricker has shown experimentally that the gastro-duodenal or the right gastro-epiploic may be ligatured at the same time as the pyloric artery without injurious effects, as a sufficient blood-supply is provided by the vessels running from left to right (*vide* No. 48).

48. Ligature of the Splenic Artery. This artery, the largest branch of the cœliac axis, is ligatured in the case of injury either of the spleen or of the trunk of the vessel, the most important indication being in cases where a deep gastric ulcer has eroded the artery and caused serious hæmorrhage.

The same applies to its branch, the left gastro-epiploic artery, as well as to the other vessels already mentioned, the right and left coronary arteries, the right gastro-epiploic and also the gastro-duodenal. The splenic artery runs transversely outwards behind the stomach along the upper border of the pancreas.

49. Provisional and Permanent Ligature of the Arteries of the Stomach, Pancreas, and Duodenum. Although this subject is considered in connection with resection of the stomach, attention must be called to the interesting researches undertaken by Fricker[2] at our suggestion, as they show how the circulation can be fully maintained along the greater and lesser curvatures by the arteries on the left side, after ligature of the coronary and gastro-duodenal arteries.

Fricker's experiments were conducted on dogs, in which the conditions are precisely similar to those in man. His observations have proved that, owing to the complete restoration of circulation, the numerous adhesions otherwise so frequently observed after operation are found to be absent, a point to which we shall return in discussing resection of the stomach.

[1] *Arch. f. klin. Chir.* Bd. 78.

[2] *Inaug. Dissert.*, Bern., 1902.

A loop of intestine and a large part of the stomach can be kept free of blood for one to one-and-a-quarter hours by means of clamps (like Doyen's in the form which we have modified), without any permanent disturbance of the circulation resulting in the case of dogs.

50. Ligature of the Superior Mesenteric Artery. Ligature of this vessel, the main artery of the small and large intestine, is not to be attempted. The artery enters the root of the mesentery below the pancreas, a point to which we call attention, as a large branch of the artery may be injured during the excision of a tumour which is adherent to the intestine or mesentery. In the event of this accident occurring, it is necessary to ascertain the vessels in the region of the mesenteric attachment to the intestine in which pulsation has disappeared, for the whole portion of intestine affected must at once be resected.

In the small intestine the rami intestini tenuis are more closely related to one another near the gut than are the main branches for the large intestine (ileo-colic, right and middle colic arteries), which are widely separated and only communicate through numerous arterial arches. In the case of the large intestine, therefore, one main trunk cannot replace another, and experience has shown that in lesions, especially of the middle colic, the left colic (branch of the inferior mesenteric) is not sufficient to maintain the nutrition of the transverse colon. It should be made an absolute rule, therefore (*vide* Resection of the Stomach), in all injuries of the colic arteries, or in operations necessitating resection of the transverse colon, to remove every portion of the bowel in the mesentery of which pulsation cannot be felt.

A further important indication for exposing the superior or inferior mesenteric arteries is to be found in thrombosis or embolism of the mesenteric vessels.

The symptoms of this condition [1] are very characteristic, comprising sudden acute colic, vomiting, and severe bleeding from the stomach and intestine, with the early signs of peritonitis.

Jackson, Porter, and Quinby [2] have collected 214 cases of embolism and thrombosis of the mesenteric vessels. The treatment consists in immediate resection of the gangrenous portion of gut.

51. Ligature of the Inferior Mesenteric Artery. Although this artery originates at a lower level than the renal and spermatic arteries we shall now give it consideration, because what has been said regarding ligature of the superior mesenteric and its branches applies equally to the ligature of the inferior mesenteric artery. It is not advisable to ligature the trunk of the vessel or its main branch, the left colic, although ligature of one of the sigmoid arteries is a less serious operation, for the reason that the latter are more numerous.

It is doubtful whether the terminal branch, the superior hæmorrhoidal artery, can be ligatured with impunity, as the descriptions given by Rehn and others of amputation of the rectum would lead us to believe. It is, of course, tied in a complete extirpation of the rectum, in which case, however, a preliminary ligature is of the greatest advantage. But it is very doubtful to what extent the branches of the hypogastric, more especially the middle hæmorrhoidal, can be relied on to maintain the circulation.

On the other hand, no risk is incurred in ligaturing one of the two branches of the superior hæmorrhoidal artery which descend close together behind the rectum, as there is an ample cross anastomosis between the two vessels.

52. Ligature of the Renal Artery. Despite the importance of the suprarenal glands, ligature of the suprarenal arteries is only undertaken in the course of other operative procedures.

Ligature of one renal artery is undertaken in excision of the kidney, the temporary application of a clamp being an effective measure in preventing loss of blood during a partial excision of the kidney, and especially in splitting the renal pelvis.

Ligature of the renal vessels has recently been recommended by Major Holt in the treatment of long-standing renal fistulæ.

[1] Cf. four observations by Körte published by Falkenberg in Langenbeck's *Archiv*, Bd. 70.

[2] *Journal of Amer. Med. Assoc.*, June 1904.

53. Ligature of the Internal Spermatic Arteries (cf. also No. 54 and Fig. 53). Ligature of these long delicate arteries running from the aorta in front of the second lumbar vertebra to the testicle is of little surgical importance. Instead of ligaturing them near the seat of their origin, a simpler method is to operate close to the testicle or to the ovary in the female.

The artery is reached by exposing the spermatic cord through our inguinal excision, and dividing the aponeurosis of the external oblique muscle over the inguinal canal. Apart from injuries, the chief indication for ligaturing the artery is to produce atrophy of the testicle and epididymis, in which case it is generally included in the whole bundle of vessels, *i.e.* spermatic veins and the artery to the vas.

The ovarian artery is ligatured along with the uterine, so as to control the hæmorrhage associated with a complete hysterectomy.

(k) Common Iliac Artery and its Branches

54. Ligature of the Common Iliac Artery [1] (Fig. 53). The common iliac artery commences at the bifurcation of the aorta opposite the fourth lumbar vertebra at the level of the umbilicus, where it lies on the inner border of the psoas. The common iliac veins are situated behind the right common iliac artery, the left vein occupying a higher and the right vein a lower level. The ureter, and, on the right side, the superior hæmorrhoidal artery (from the inferior mesenteric) cross it in front.

Ligature of the common iliac is only indicated in conditions of severe injury, for unless the collateral circulation is satisfactory, gangrene supervenes in nearly half the cases. Ligature of this artery is a necessary preliminary to interilio-abdominal disarticulation. Temporary ligature (first attempted by Travers and performed several times by Schönborn) or temporary compression (which, according to Madelung and McBurney, is best accomplished intra-peritoneally) [2] are preferable methods of operation.

An oblique incision is made, parallel to and three fingers'-breadth above Poupart's ligament, dividing skin and superficial fascia, the superficial epigastric artery being ligatured. The aponeurosis, and in the outer part of the incision the muscular fibres of the external oblique are divided parallel to the direction of the fibres. The internal oblique and transversalis are then split in the direction of their fibres, retracted, and their combined aponeurosis is further divided with the knife. The sheath of the rectus is now opened in a vertical direction, and the muscle retracted inwards. The underlying fascia transversalis and peritoneum can then be easily separated with the finger from the fascia of the abdominal muscles down to Poupart's ligament, and also off the fascia covering the ilio-psoas muscle in the internal iliac fossa, this separation being continued as far as the bifurcation of the common iliac at the edge of the psoas. The pale red ureter is here observed crossing the artery obliquely, and is raised up along with the peritoneum. In the male the spermatic vessels, which descend in front of the ureter and in front of the external iliac artery to reach the internal abdominal ring, are also elevated. In the female, the ovarian artery crosses in front of the external iliac artery to enter the suspensory ligament of the ovary.

The external cutaneous nerve and, at the crest of the ilium, the iliac branch of the ilio-lumbar artery, a branch of the internal iliac, are encountered on the fascia iliaca. The genito-crural nerve lies on the main artery, its genital branch, which enters the inguinal canal at the internal abdominal ring, being also raised up, while the crural branch pursues the course of the external iliac artery. On the left side the inferior

[1] *Vide* Kümmel 1884, and Dreist, *Deutsche Zeitschr. f. Chir.* Bd. 71.

[2] Compare the admirable compilation by Tillmann on ligature of blood-vessels of the pelvis. Tillmann calculates the mortality from ligature of the common iliac artery at 55 per cent (Dreist) even in antiseptic days. Gebson was the first to ligature the artery intra-peritoneally in 1812, and Mott extra-peritoneally in 1827.

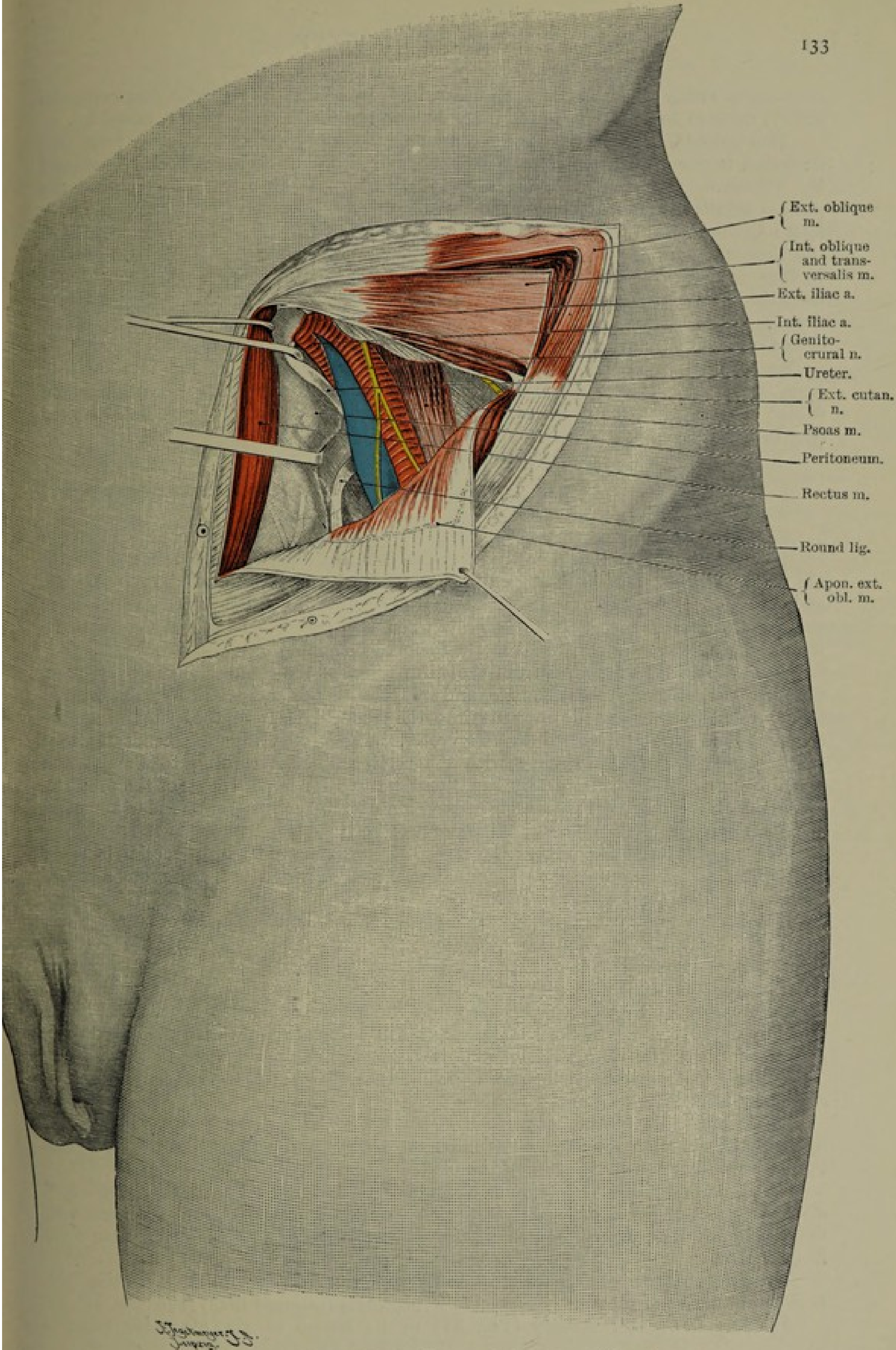


FIG. 53.—Angular incision for ligature of the common iliac artery. (Only a small part of the trunk of the artery is here represented.)

mesenteric artery or its sigmoid branches, and especially the superior hæmorrhoidal artery, cross in front of and to the inner side of the ureter, and are also raised up.

This procedure for ligaturing the common iliac artery differs essentially from that described in our 4th edition (Mott's incision), and also from all the methods mentioned by Tillmann. We regard it as a great advance on other methods, because the process entails division of neither muscles nor nerves. Further, by making a simple long oblique incision through the skin and fascia, and then an angled incision through the deeper fasciæ and muscles, we can obtain much better access without causing further injury. By splitting the deeper muscles in the line of their fibres, *i.e.* transversely, and by opening the sheath of the rectus in a vertical direction we turn down a three-cornered flap (see Fig. 53), which gives excellent access to the bifurcation of the common iliac artery and even of the aorta itself.

We would recommend this incision when a free exposure of the internal iliac fossa is desired. It should be performed in preference to the intra-peritoneal method except in cases when the peritoneum is so closely adherent that it cannot be separated (*e.g.* in Aneurysm).

(l) Hypogastric Artery and its Branches (Pelvic Arteries)

55. Internal Iliac Artery (Fig. 53). The internal iliac artery can be ligatured by the same method as that described for the common iliac, or transperitoneally with the patient in the Trendelenburg position, as has been successfully attained by Dennis and Treves. Extra-peritoneal ligature is preferable to intra-peritoneal as it is simpler and less dangerous. It is only when the vessels on both sides are to be ligatured that the intra-peritoneal method should be adopted.

The artery passes forwards from the bifurcation of the common iliac artery, upon the inner aspect of the psoas muscle, and in front of the sacro-iliac articulation. It then passes inwards and downwards into the true pelvis, from the point where the common iliac artery is crossed by the ureter. The ureter, which descends in front of the artery, is raised up along with the peritoneum. According to Baudet and Kendirdjy, the internal iliac artery has been ligatured for hypertrophy of the prostate, for inoperable cancer of the uterus, in excision of the rectum, for vascular tumours, and for aneurysm of the gluteal and sciatic arteries.

Quénu and Duval recommend the transperitoneal method with a mesial incision, the peritoneum of the posterior abdominal wall being divided over the promontory of the sacrum 3 to 5 cm. from the middle line.

Krönig has ligatured both internal iliacs for inoperable cancer of the uterus, in which cases the intra-peritoneal operation is preferable, Pfannenstiel's transverse curved incision between the umbilicus and pubis being the best, while Kosler (Niermer) places the incision (7 cm. long) 1 cm. above the line of the pubic hair. The bifurcation of the aorta is exposed and the peritoneum split longitudinally for a length of 10 cm. (4 inches), after which the bifurcation of each iliac artery is defined by blunt dissection, and both internal iliac arteries are ligatured.

Vuillet[1] has successfully ligatured the internal iliac artery intra-peritoneally, for secondary hæmorrhage from the gluteal artery.

56. There is no indication, except in the course of an operation, to isolate and ligature the *superior vesical* artery (umbilical artery in the fœtus), which traverses the pelvic wall to reach the apex of the bladder.

57. The ilio-lumbar artery runs backwards behind the psoas, and is continued along the crest of the ilium, where it lies on the iliacus muscle and anastomoses with the circumflex iliac artery. It is ligatured in operations involving the iliac fossa from behind.

The chief importance attached to this artery is that it forms an anastomosing link between branches of the aorta and of the hypogastric (internal iliac) (*vide* No. 54).

58. The Obturator Artery (Fig. 54) in its course to the obturator canal is

[1] *Arch. internat. de chirurgie*, Gand, 1904.

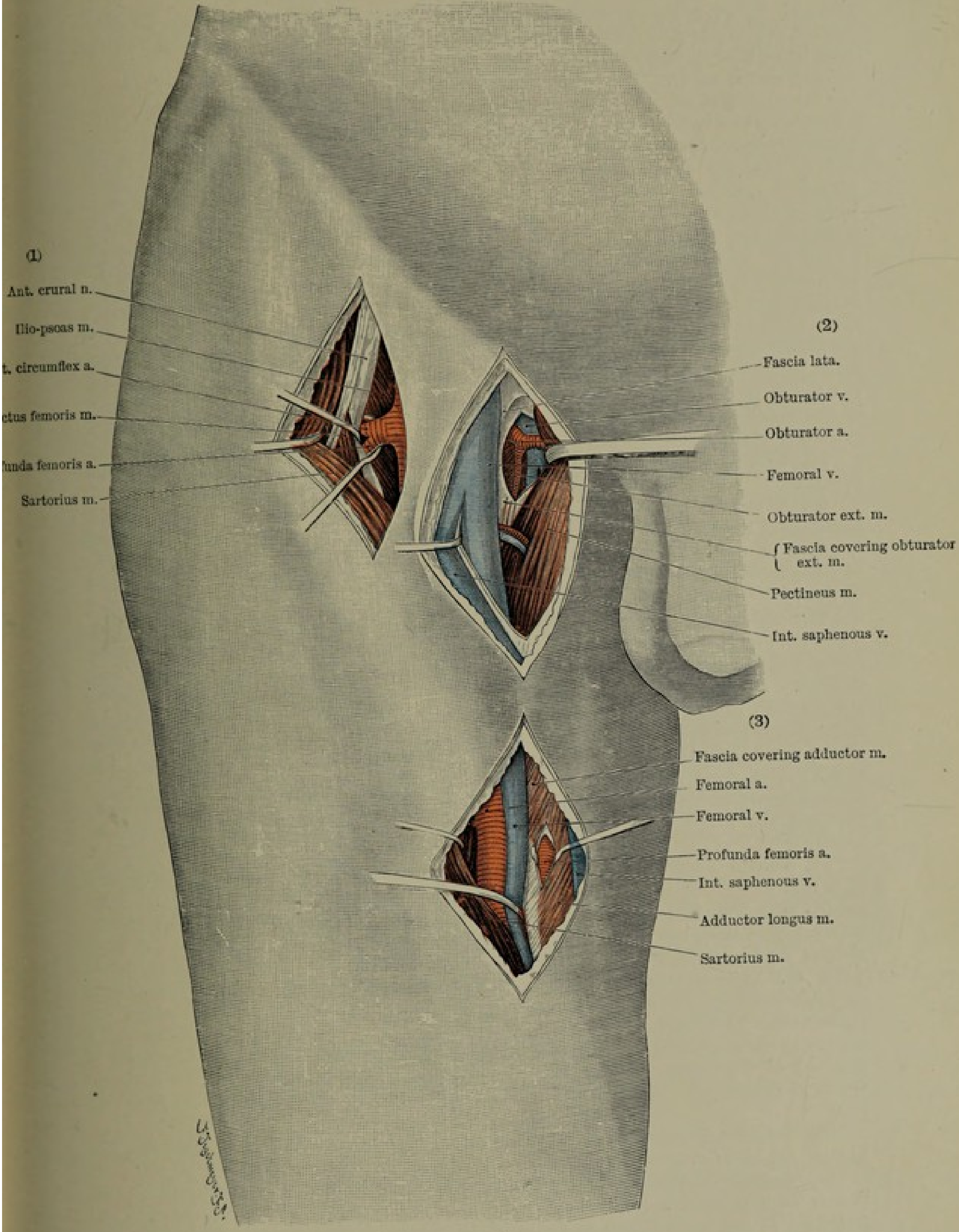


FIG. 54.—(1) Ligature of profunda femoris artery and external circumflex artery. (2) Ligature of obturator artery. (3) Ligature of profunda femoris artery.

situated between the peritoneum and the obturator internus muscle. Its pubic branch, which ascends on the back of the pubis to the inner side of the crural ring, may be injured in relieving the constriction of a femoral hernia.

(*a*) *In the pelvis.* The peritoneum is raised up in the same way as for ligature of the internal iliac artery. The artery may have to be ligatured in the pelvis when it arises abnormally from the deep epigastric, and when it is injured in the course of an operation for femoral hernia. The deep epigastric itself would then have to be tied.

(*b*) *Ligature at its exit from the obturator canal at the upper border of the obturator externus muscle* (Fig. 54). The incision—the same as for ligature of the internal circumflex branch of the profunda femoris—descends vertically from a point a finger's-breadth internal to the middle of Poupart's ligament. The skin, superficial fascia, and superficial layer of the fascia lata are divided. The internal saphenous vein, which lies upon the fascia, is drawn outwards. The strong pectineal fascia is divided just internal to the femoral vein. After the outer border of the pectineus muscle has been defined the latter is separated from the os pubis and fascia over the obturator externus, and is drawn well inwards. The strong transversely-striated fascia over the obturator externus muscle is now divided, and the finger, passed above the upper border of the muscle, feels for the under surface of the horizontal ramus of the pubis, below which the artery leaves the obturator foramen accompanied by the obturator nerve which lies above it.

59. The Lateral Sacral Artery is ligatured when divided in resection of the sacrum.

60. Gluteal Artery (Fig. 55). The place where the artery is ligatured may be ascertained through the skin by feeling for the upper edge of the great sacro-sciatic foramen, at the level of the upper end of the gluteal fissure and of the upper edge of the gluteus maximus muscle. Here the artery passes backwards from under cover of the pyriformis.

The incision corresponds to the upper two-thirds of a line extending from the posterior superior iliac spine to the upper border of the great trochanter. The skin, fascia, and thick gluteus maximus—the fibres of which run parallel to the incision—are divided. After division of the fascia over the lower border of the gluteus medius, the muscle itself is exposed and drawn upwards. On the finger being passed under it the upper margin of the great sacro-sciatic foramen is felt. Here, above the upper border of the pyriformis, the large gluteal artery passes directly backwards out of the pelvis and at once gives off large branches, the largest passing outwards. The *superior gluteal nerve* passes out of the pelvis along with the artery, and runs outwards between the gluteus medius and minimus, to end in the tensor fasciæ femoris muscle.

61. Sciatic Artery (Fig. 55). Incision corresponding to the middle two-thirds of a line extending from the posterior inferior iliac spine to the base of the great trochanter. The incision is below and parallel to that for ligature of the gluteal artery. The skin, the thick subcutaneous fat, the fascia, and the fibres of the thick gluteus maximus are divided. The lower border of the pyriformis muscle is visible under the gluteus maximus, and is clearly exposed with the finger. The artery, accompanied by the inferior gluteal nerve, appears from under the proximal end of the pyriformis. The nerve, after giving off large branches to the gluteus maximus and a branch to the small sciatic nerve, is continued vertically downwards under the fascia of the back of the thigh. The spine of the ischium and the lesser sacro-sciatic ligament which is attached to it serve as a guide to the place of exit of the artery from the pelvis.

62. Inferior Vesical Artery. This artery is ligatured *in loco* in exposing the base of the bladder.

63. Artery to the Vas Deferens. This artery is only of importance in that it acts as a substitute for the spermatic artery in maintaining the nutrition of the testicle. If necessary it can be ligatured by means of the inguinal incision over the spermatic cord, where it lies close to the vas deferens.

64. Middle Hæmorrhoidal Artery. This artery, which is ligatured in excision

of the rectum, is found closely applied to the wall of the rectum above the coccygeus and levator ani muscles and the pelvic fascia.

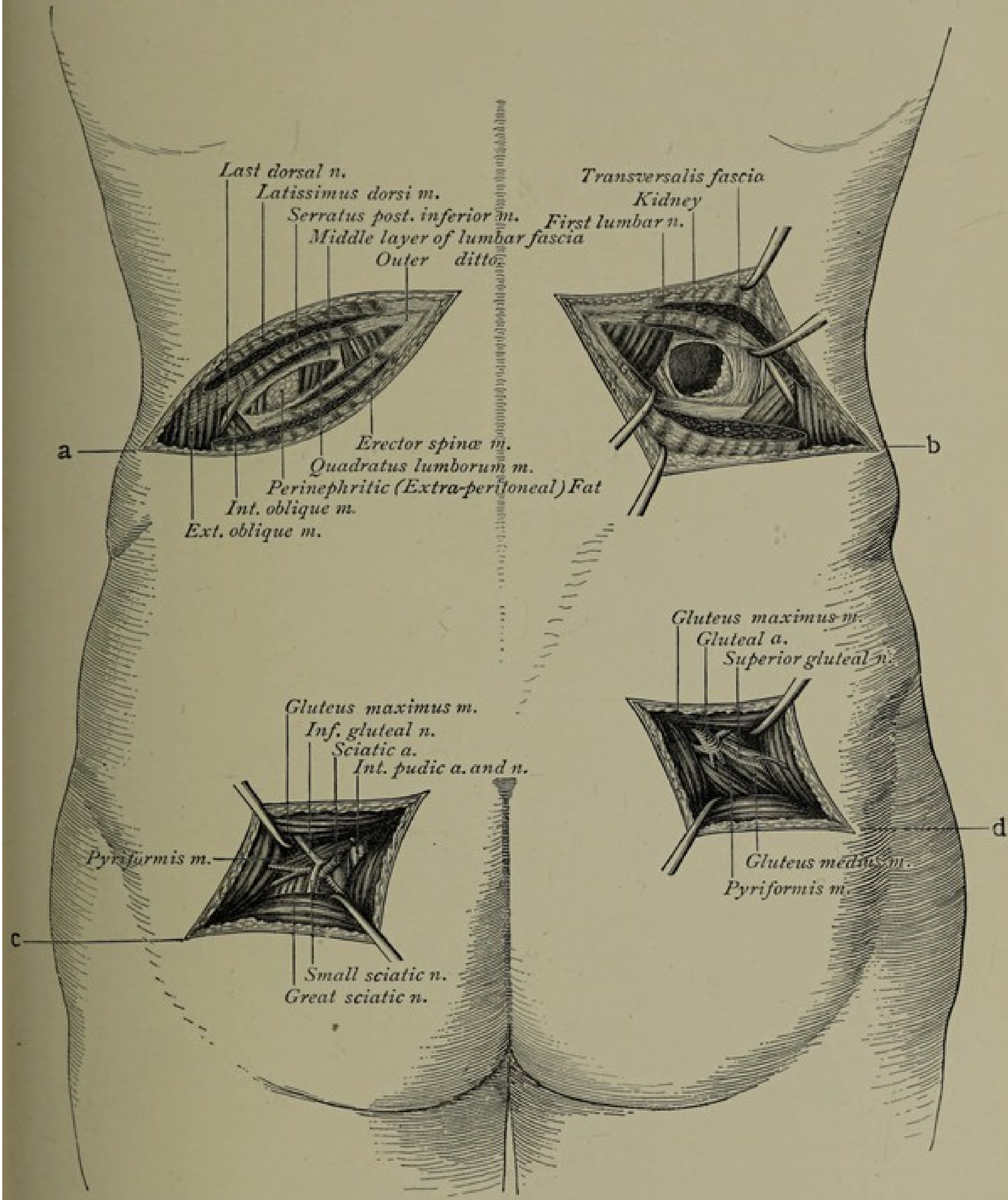


FIG. 55.—(a) and (b) Nephrotomy. (c) Ligature of the sciatic and internal pudic arteries, and exposure of the great sciatic, small sciatic, and internal pudic nerves. (d) Ligature of the gluteal artery and exposure of the superior gluteal nerve.

65. The Uterine Artery. Ligature of the uterine artery is chiefly performed as a preliminary to excision of the uterus, extirpation of large myomata, or in order to produce atrophy of uterine myomata.

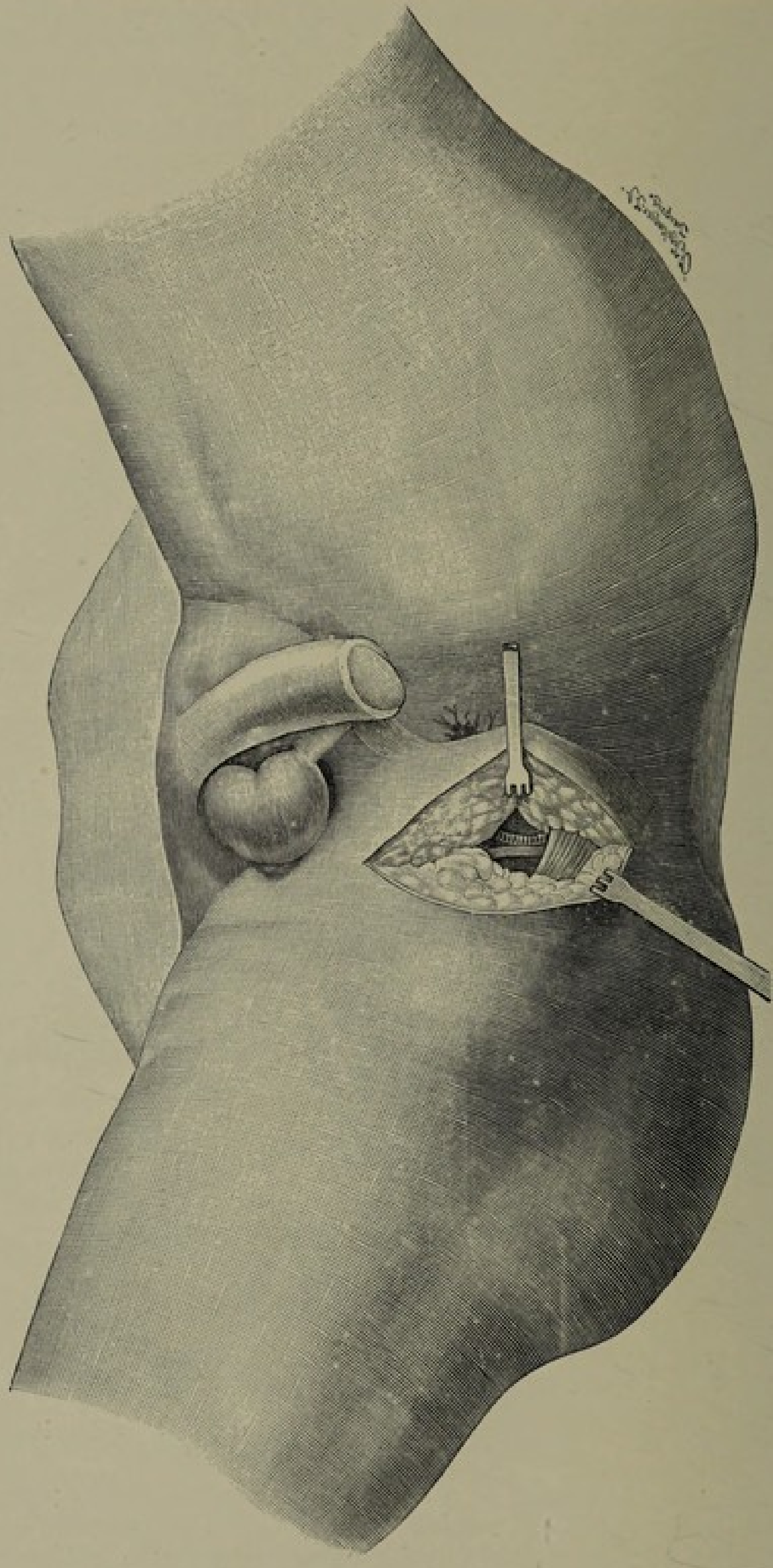


Fig. 56.—Ligature of the internal pudic artery at the ischial tuberosity.

As it is difficult to reach from the iliac fossa, the intra-peritoneal route is to be preferred, an incision being made into the broad ligament parallel to and behind the round ligament, 1 cm. from the "linea innominata" (Altoukhow). The ureter and the ovarian vein remain behind with the posterior layer of the broad ligament.

The artery can also be ligatured after it has crossed the ureter in its course to the cervix uteri. It is found close to the lateral wall of the uterus between the layers of the broad ligament, where it gives off a branch to the vagina and a branch which passes behind the uterus to anastomose with the artery of the other side.

66. Internal Pudic Artery (Fig. 55). (*a*) This vessel may be ligatured from behind through the same incision as that made for ligaturing the sciatic artery (*vide* No. 60). At its exit from the pelvis it lies below the pyriformis muscle internal to and deeper than the sciatic artery, and re-enters the pelvis by passing round the base of the ischial spine. The relation of the artery to the ischial spine can be readily determined. The internal pudic nerve lies on the artery.

(*b*) *Ligature in the perineum* (Fig. 56). Longitudinal incision at the inner edge of the tuber ischii, one-third being placed in front and two-thirds behind, through skin, thick fatty layer and perineal fascia. Anteriorly, the transversus perinei muscle is defined and retracted forwards, while the edge of the gluteus maximus and the sacro-sciatic ligament are exposed in the posterior end of the wound. After division of the fascia covering the obturator internus along the inner border of the tuberosity the artery is found deeply placed, accompanied by the pudic nerve, the latter being more superficial.

The branches of the internal pudic artery, viz. the inferior hæmorrhoidal, superficial perineal, dorsal and profunda arteries to the penis (or clitoris) and the artery to the bulb, are ligatured when divided in the course of operation.

(m) External Iliac Artery and its Branches (Arteries of the Lower Extremity)

67. Ligature of the External Iliac Artery (Fig. 57). The results of ligature of the external iliac artery are more satisfactory than those of the common iliac, as there is a free collateral anastomosis between the internal iliac and the branches of the common femoral and profunda femoris. The artery is much more easily ligatured than the internal iliac.

An incision is made close above and parallel to the middle third of Poupart's ligament, with division of the skin and well-developed superficial fascia, while the superficial epigastric artery, which ascends vertically in the fascia, must also be divided. After division of the aponeurosis of the external oblique, the internal oblique and transversalis muscles need not be similarly treated as Tillmann and Cooper propose, but are detached upwards from out of the groove of Poupart's ligament with the handle of the scalpel, and the dense transversalis fascia which closes each groove behind is divided. The artery, together with some lymphatic glands, lies beneath some fatty tissue under Poupart's ligament. Internal to it is the vein, and external to it the fascia of the psoas muscle. The *anterior crural nerve* lies deeply between this muscle and the edge of the iliacus, about 2 cm. ($\frac{3}{4}$ in.) external to the artery. Upon the artery is the slender crural branch of the genito-crural nerve, which supplies the skin of the inner half of the front of the thigh in its upper part. According to Currie,[1] who collected eight cases of ligature of the external iliac, the transperitoneal operation is necessary in dealing with an aneurysm, although it should not be regarded as the normal procedure.

The branches of the external iliac artery, namely, the *deep epigastric* and the *deep circumflex iliac* arteries, may be exposed at their origin above Poupart's ligament, below the abdominal muscles and the fascia transversalis, by the same incision as that for the external iliac artery.

68. Ligature of the Deep Epigastric Artery. This artery arises a short distance above Poupart's ligament, lying behind the fascia transversalis and running upwards and inwards along the inner side of the internal abdominal ring.

(*a*) *Ligature at its origin* (Fig. 57). The artery may have to be ligatured at its origin in wounds of the abdominal wall, or when an abnormal obturator artery

[1] *Annals of Surgery*, vol. 4, 1905.

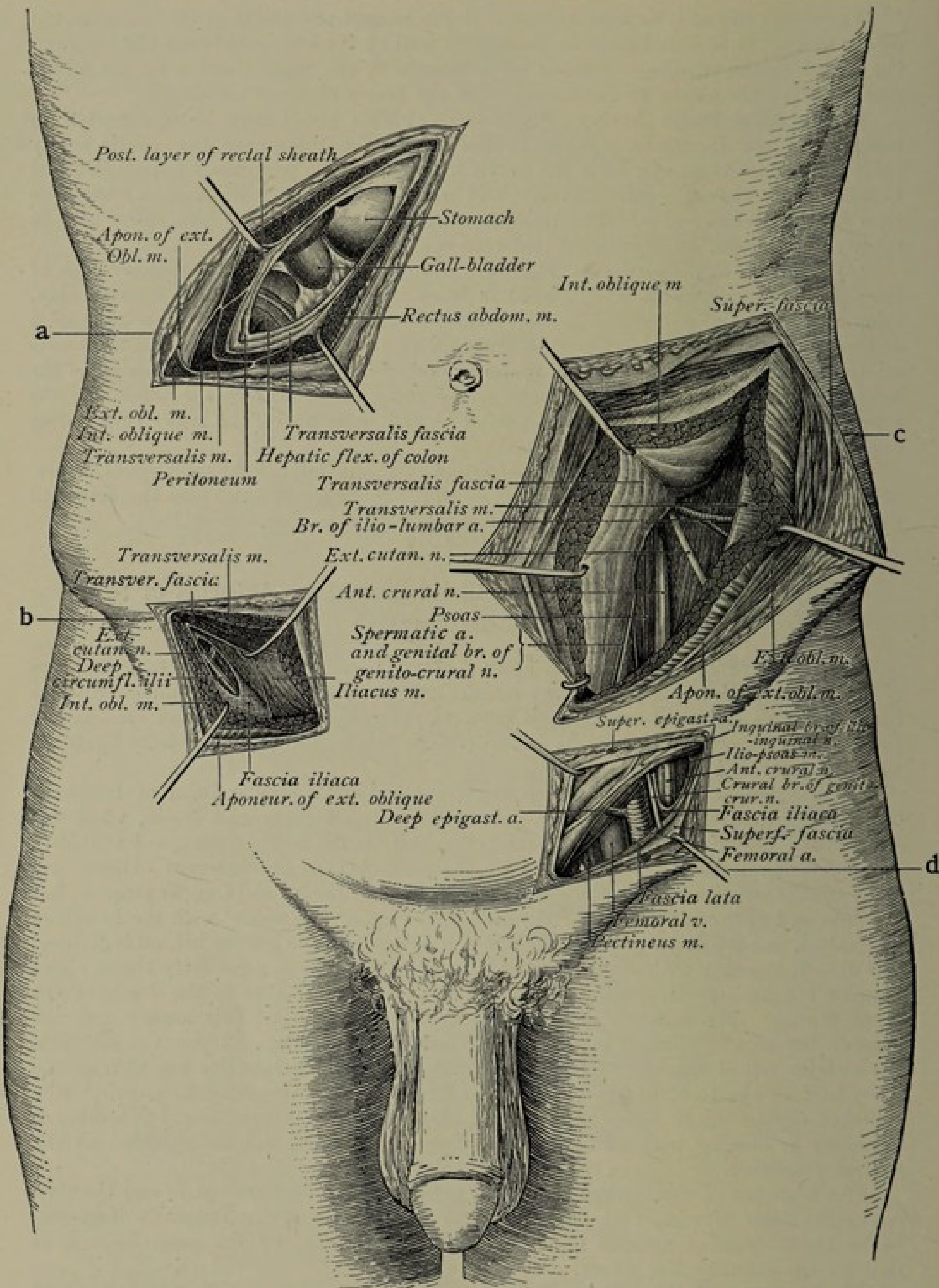


FIG. 57.—(*a*) Cholecystotomy. (*b*) Ligature of the deep circumflex iliac artery. (*c*) Ligature of the common iliac artery. (*d*) Ligature of the common femoral artery.

from the epigastric has been injured in dividing the constriction of a strangulation in femoral hernia. It is exposed in the same way as the external iliac artery. At its origin it lies in front of the external iliac vein and to the inner side of the main artery.

(*b*) *Ligature at the outer border of the rectus* (Fig. 57*a*). This is effected by an incision three fingers'-breadth above and parallel to the inner half of Poupart's ligament, the operator dividing skin, superficial fascia, the strong oblique fibres of the aponeurosis of the external oblique, and the transverse fibres of the aponeurosis of the internal oblique and transversalis muscles, which fuse together to form the anterior layer of the sheath of the rectus. The outer edge of the rectus is exposed and drawn

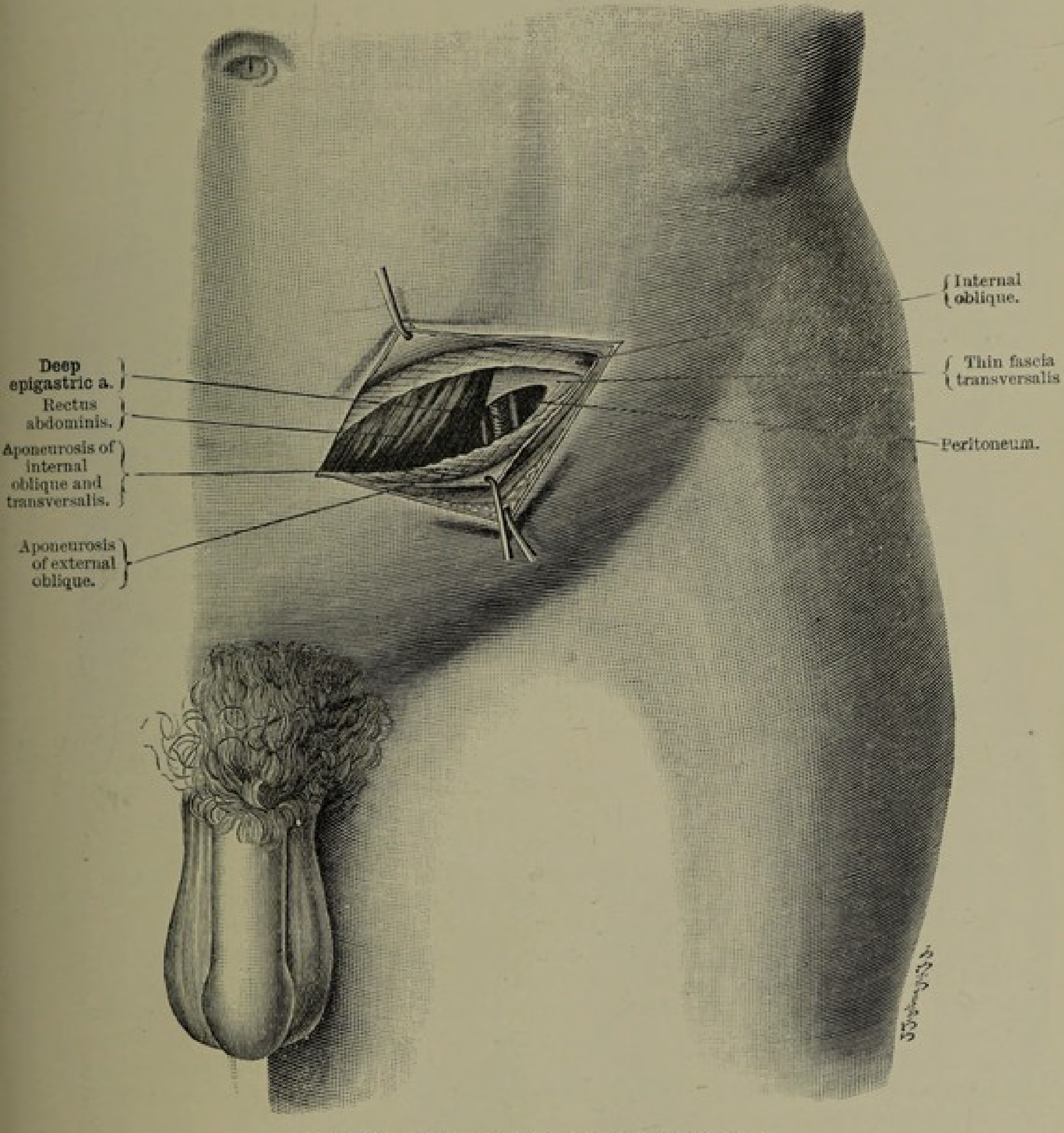


FIG. 57*a*.—Ligature of the deep epigastric artery.

inwards. Beneath it, and covered by a very thin layer of connective tissue (fascia transversalis), is the extra-peritoneal fat, and upon it the artery, ascending obliquely from below upwards and inwards under the edge of the rectus.

69. Ligature of the Deep Circumflex Iliac Artery (Fig. 58). An incision is made above the outer third of Poupart's ligament, with division of the skin, the superficial fascia, and the strong oblique fibres of the external oblique. The thick ascending fibres of the internal oblique, and the transversalis muscle are separated and pulled

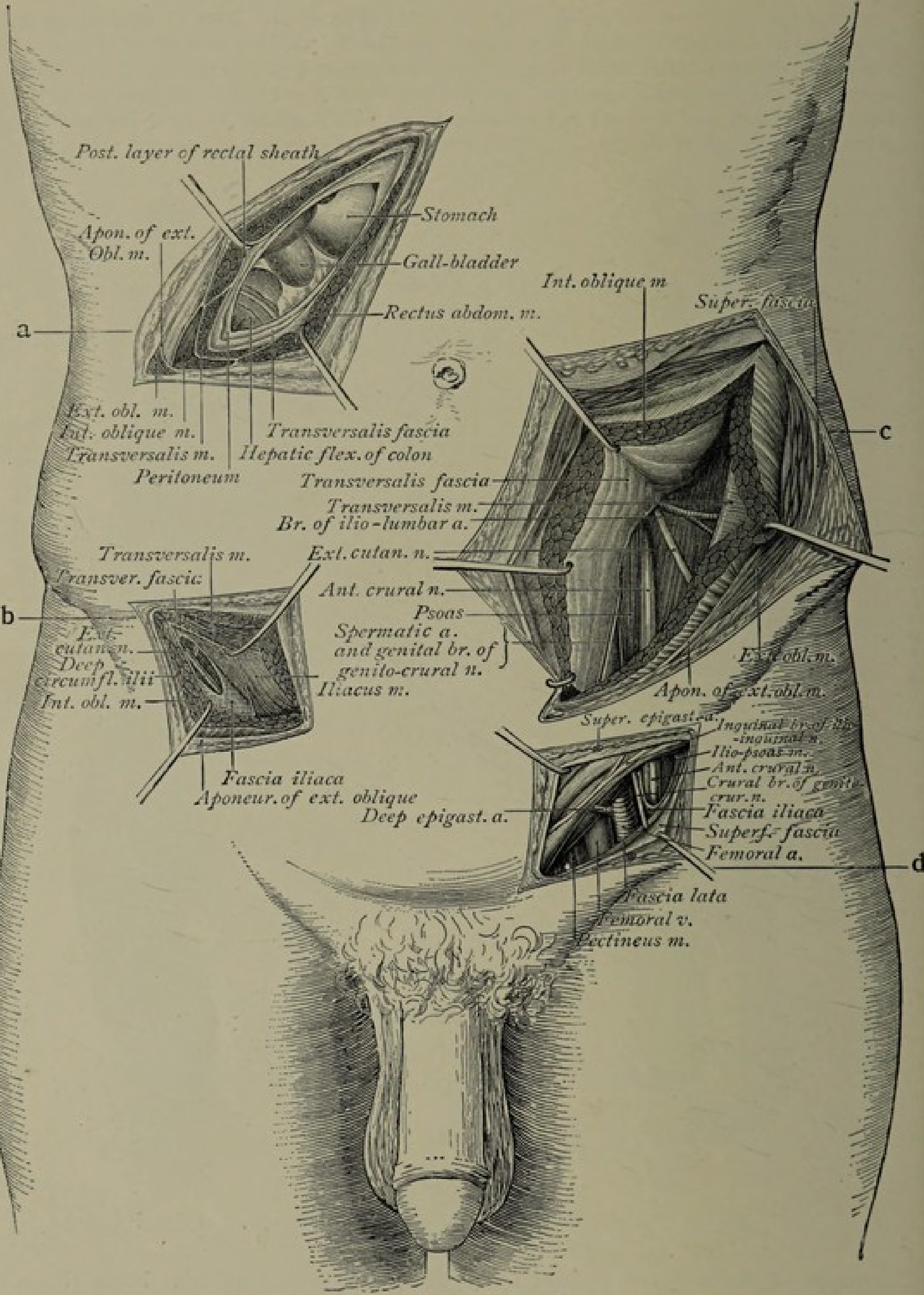


Fig. 58.—(*a*) Cholecystotomy. (*b*) Ligature of the deep circumflex iliac artery. (*c*) Ligature of the common iliac artery. (*d*) Ligature of the common femoral artery.

apart. Between the two latter muscles are some vessels and branches of the ilio-inguinal nerve. The transversalis fascia is now divided, and the peritoneum is carefully raised from the iliac fascia. After division of the iliac fascia the artery is found lying

parallel to Poupart's ligament upon the iliacus muscle. The external cutaneous nerve passes obliquely downwards behind it. It is important to know the relation of parts along this incision, as it is often employed in opening psoas abscesses. A psoas abscess lies underneath the fascia.

70. Ligature of the Femoral Artery (Fig. 59). The femoral is the direct continuation of the external iliac artery, coursing in a line from the middle of Poupart's ligament directly downwards towards the middle of the posterior aspect of the knee-joint, and passing from the inner towards the posterior surface of the femur at the junction of the middle and lower thirds of the bone. The incisions for ligaturing the artery, however, are made along a line extending from the middle of Poupart's ligament to the adductor tubercle, because in the lower part the artery is reached not from the front but from the inner aspect.

Common femoral artery in the flexure of the groin.[1] An incision is made parallel to and below the middle third of Poupart's ligament, followed by ligature of the superficial epigastric artery in the subcutaneous tissue, and division of the superficial layer of the fascia lata below Poupart's ligament. The artery, along with the origins of the deep epigastric and deep circumflex iliac arteries, appears below the middle of the ligament lying upon the pubic bone, where it may be distinctly felt. The crural branch of the genito-crural nerve lies upon the sheath of the vessel. Internal to the artery is the femoral vein : external to it the fascia covering the ilio-psoas, and beneath the fascia the trunk of the anterior crural nerve at the outer edge of the psoas.

In the upper third, at the apex of Scarpa's triangle. The skin and fascia lata (the latter forming the anterior sheath of the sartorius) are divided along the line already mentioned. The sartorius is freed and drawn outwards. Under this muscle are the sheath of the vessel and branches of the anterior crural nerve, the large internal saphenous nerve being external to the artery. The femoral vein is to its inner side. Upon the fascia, external to the incision, is the middle cutaneous nerve, while the internal saphenous vein lies internal to the incision.

Above the opening in the adductor magnus (at the lower part of Hunter's canal). Longitudinal incision is made at the junction of the middle and lower thirds of the thigh (reckoned from the anterior superior iliac spine to the lower end of the femur), along the groove which can be felt between the adductor and extensor muscles. The internal saphenous vein is avoided, and after division of the fascia, the sartorius muscle, which is recognised by its longitudinal fibres, is drawn inwards and backwards. The dissection is continued down to the fibres of the fascia covering the vastus internus, which are directed obliquely forwards. This fascia is divided at the anterior edge of the white glistening tendon of the adductor magnus, to which it is adherent. The artery lies very near the bone. Posterior and external to it is the vein, whilst the long saphenous nerve lies in front of the sheath. One must take care not to pass too far backwards—that is to say, behind the adductor tendon.

Upper part of popliteal artery—**(a) From the Inside.** Incision is made behind the prominent cord-like tendon of the adductor magnus, which is inserted into the adductor tubercle. Posteriorly lie the sartorius, the tendons of the gracilis, and semitendinosus, and under the latter the muscular substance of the semi-membranosus. The long saphenous vein is found in the subcutaneous tissue. After division of the fascia the muscular fibres of the sartorius appear. On the dissection being continued deeply between it and the tendon of the adductor magnus, the artery will be found upon the bone, behind the tendon, embedded in fat. The popliteal vein lies posteriorly, and between it and the integuments is the internal popliteal nerve. On drawing the sartorius muscle backwards the *internal saphenous nerve* is exposed, accompanied by the superficial branch of the *anastomotica magna artery,* both passing backwards across the inner edge of the tendon of the adductor magnus.

(b) From the Outside. Ligature of the popliteal artery below the opening in the adductor magnus, in the upper part of the popliteal space, is more easily effected from

[1] We regret that anatomists have not employed the term common femoral artery, as the two main sources of the blood-supply, the profunda for the thigh and the femoral proper for the leg, are still united.

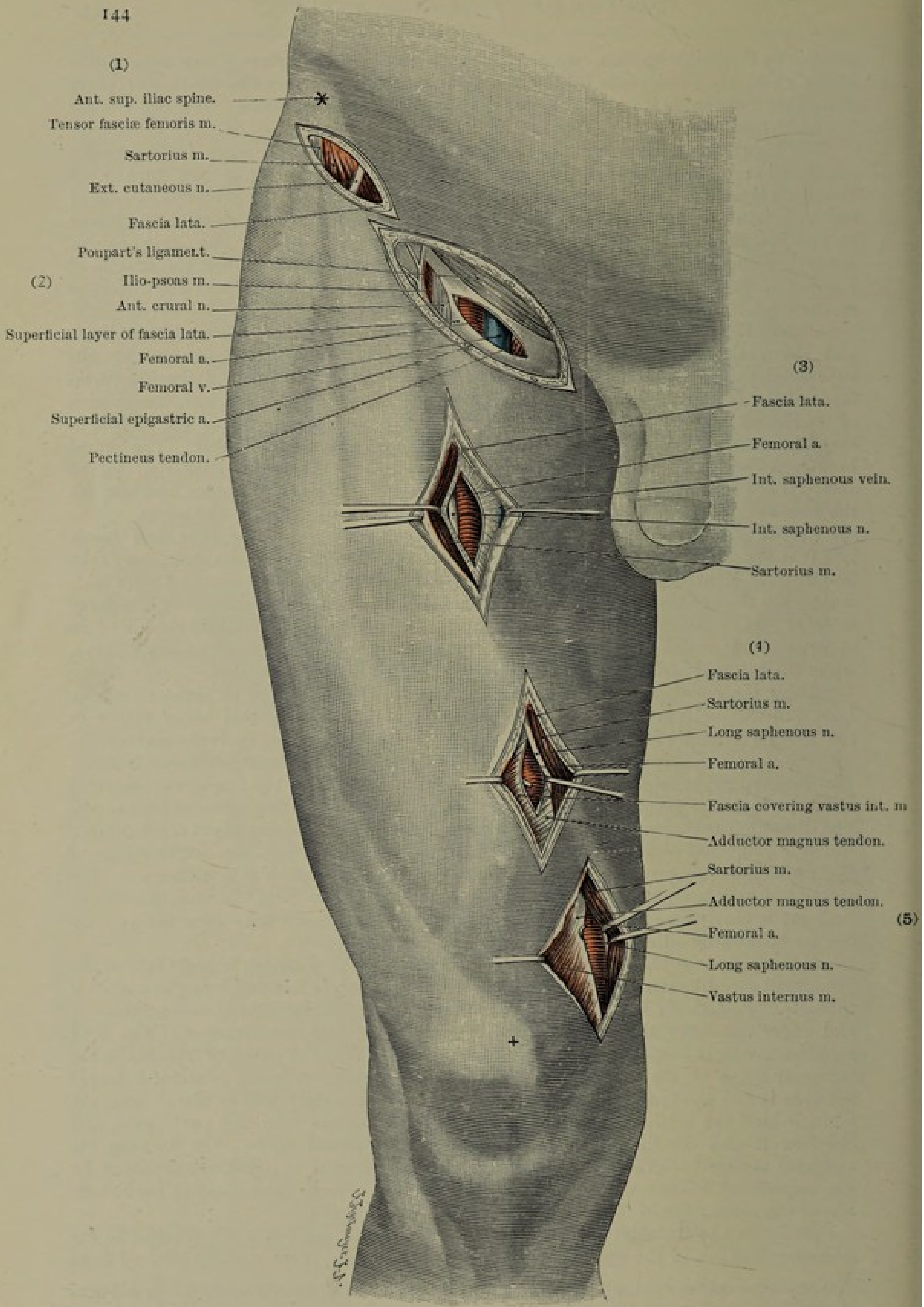


FIG. 59.—(1) External cutaneous nerve. (2) Common femoral artery. (3) Femoral artery. (4) Femoral artery at the opening in the adductor magnus. (5) Femoral artery at the lower end of the femur.

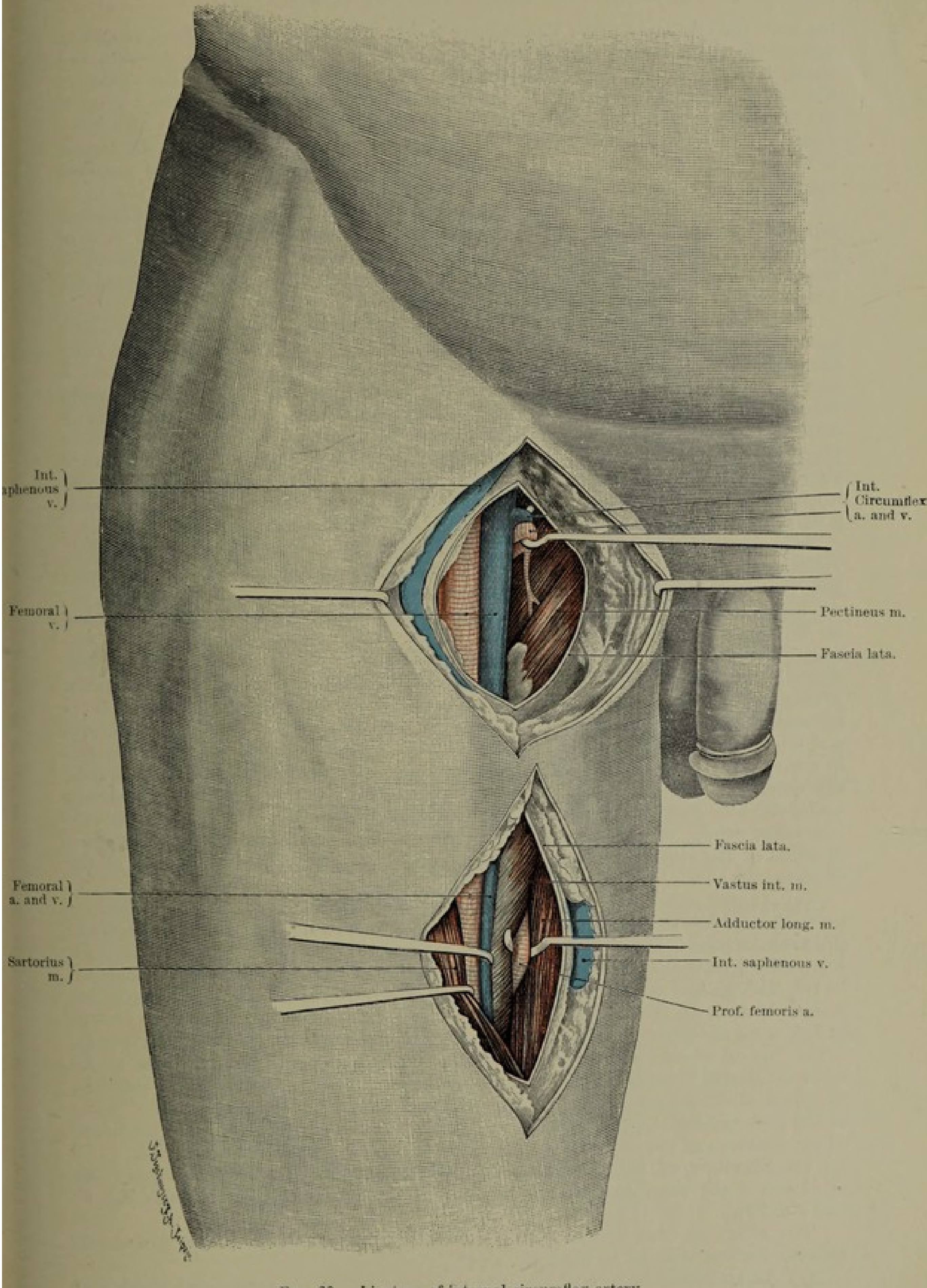


FIG. 60.—Ligature of internal circumflex artery.

the outer than the inner side. The incision is 8 to 10 cm. (3⅜ to 4 in.) long, extending upwards from the back of the external condyle of the femur through the skin and strong fascia lata. In front of the incision are the ilio-tibial band and the tendon of the vastus externus, behind which the finger is passed deeply towards the trigone of the femur, while the short head of the biceps is separated from the bone with a blunt dissector and retracted backwards. In the fat, along the inner edge of the biceps, is the popliteal nerve, superficial to which is the popliteal vein, with the popliteal artery situated more deeply and to its inner side.

The small branches of the common femoral artery, viz. the superficial epigastric, superficial circumflex iliac, and external pudic, are only ligatured in the case of accidental or operation wounds. The superficial epigastric lying in the fascia is frequently cut, and is always divided in the inguinal incision we recommend for hernia and for operations on the testicle.

71. Ligature of the Internal Circumflex Artery (Fig. 60). This artery arises as a rule from the common femoral, although in many cases it takes its origin from the profunda femoris. An incision is carried vertically downwards from a point a finger's-breadth internal to the middle of Poupart's ligament. The long saphenous vein, which is met with upon the fascia, is drawn outwards. The pectineal fascia is divided internal to the saphenous opening, so as to expose distinctly the muscular fibres of the pectineus. The artery passes above the outer border of this muscle above its insertion into the femur, and thence along the lower border of the obturator externus directly downwards and backwards to the inner aspect of the femur, where it gives off a large superficial branch which passes inwards over the pectineus muscle.

The artery is freed from the fatty tissue at the inner aspect of the femoral vein. When arising from the profunda artery it passes inwards behind the femoral vein; but when from the common femoral, it occasionally passes in front of the vein.

72. Ligature of the Profunda Femoris Artery (Fig. 61). (*a*) *At its origin from the common femoral.* An incision is carried vertically downwards from a point two fingers'-breadth below and 1 cm. external to the middle of Poupart's ligament. The centre of the incision is to be opposite the level of the base of the great trochanter. After division of the skin and the strong fascia lata the inner edge of the sartorius is exposed and drawn outwards. Under it is the inner edge of the rectus, close to which, embedded in fat, are the branches of the anterior crural nerve, which descend in front of the ilio-psoas muscle near its insertion. On drawing the nerves outwards, the outer surface of the femoral artery appears, with the profunda artery passing outwards and downwards from it; whilst arising from the latter is the external circumflex artery, which passes transversely outwards beneath the rectus. The point of origin of the vessel corresponds to the lower part of the palpable projection of the ilio-psoas muscle.

(*b*) *At the upper edge of the insertion of the adductor longus.* An incision is made through the skin and fascia at the junction of the upper and middle thirds of the femur a hand-breadth below the inner edge of the fold of the groin, in the same line as for ligature of the femoral artery—that is, in the groove where the bone can be felt between the adductors and extensors. The sartorius is drawn outwards, but instead of dividing the deep fascia over the vessels (sheath of the vessels), as is done in ligaturing the femoral artery, the fascia over the adductor longus is divided internal to the femoral vessels, and the dissection is continued deeply along the fibres of the adductor longus towards the bone, as far as the inner aspect of the vastus internus, the fibres of which pass obliquely downwards and forwards. The artery will be found at the posterior attached edge of the vastus internus immediately above the upper end of the insertion of the adductor longus, under which it is continued downwards.

73. Ligature of the External Circumflex Artery. (*a*) *At its origin*: the operation is the same as that for ligature of the profunda femoris (*vide* Fig. 61 and No. 72*a*).

The artery at once divides into a descending branch, which passes downwards beneath the rectus as far as the knee, and

(*b*) An ascending branch which runs outwards under the rectus, and which may

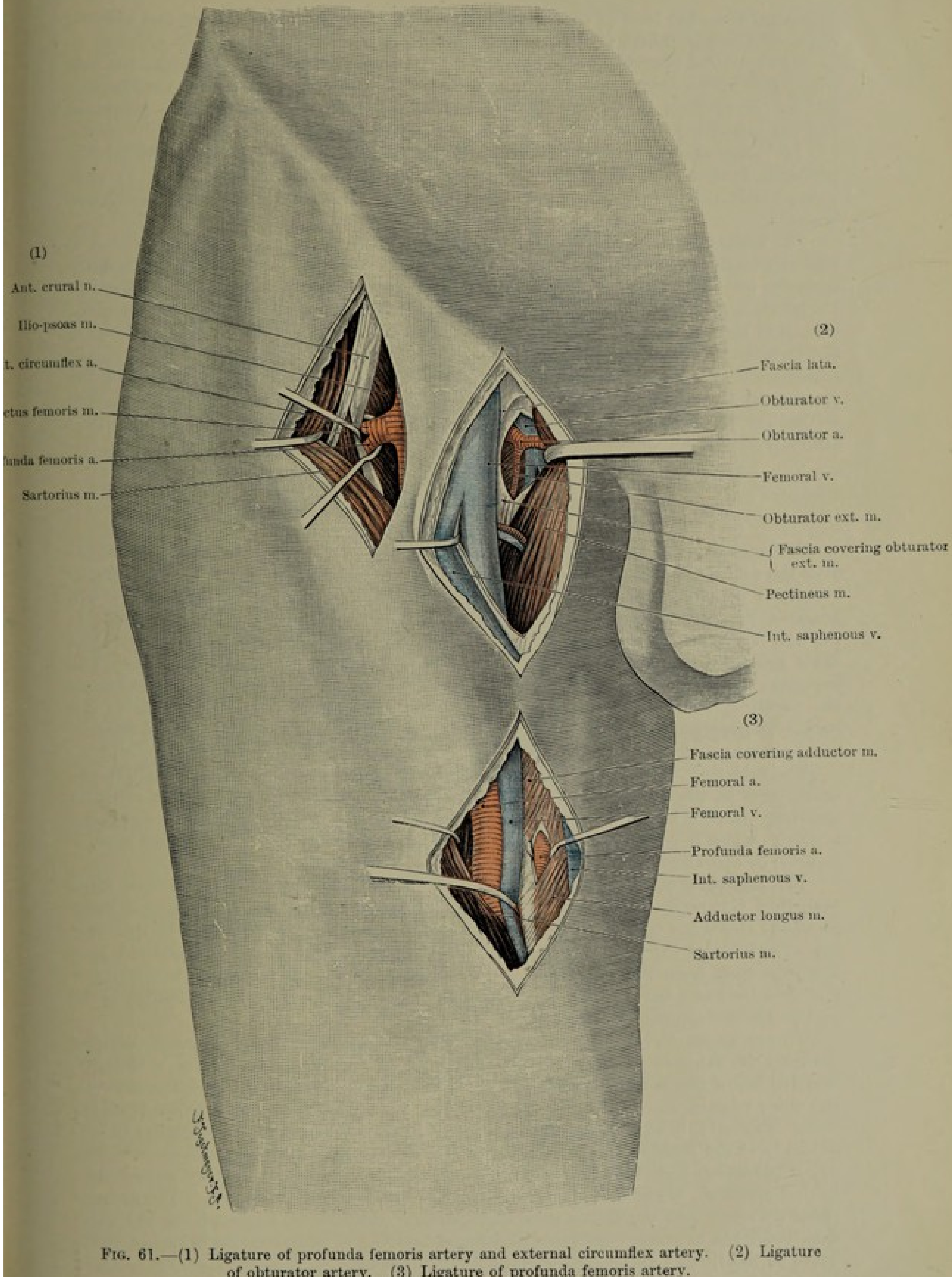


Fig. 61.—(1) Ligature of profunda femoris artery and external circumflex artery. (2) Ligature of obturator artery. (3) Ligature of profunda femoris artery.

be ligatured at the base of the great trochanter as a terminal branch of the external circumflex artery, where it is frequently injured in the course of operations.

The terminal branch may be exposed on the bone by an incision through the skin a finger's-breadth below the most prominent lateral projection of the great trochanter, and by the division of the strong fascia lata (aponeurosis of the gluteus maximus) and the glistening tendinous attachment of the vastus externus muscle.

74. Ligature of the Perforating Arteries. The terminal branches of the profunda femoris, *i.e.* the perforating arteries reach the back of the thigh in close contact with the inner side of the femur, and are occasionally ligatured in accidental wounds.

75. Ligature of the Anastomotica Magna Artery (Fig. 59). An incision is made through the skin and strong fascia along a line extending vertically upwards from the adductor tubercle of the femur. The sartorius muscle is drawn backwards. Under it, embedded in fat, is the long saphenous nerve accompanied by the superficial branch of the anastomotica magna artery. To find the deep branch, pass in front of the prominent glistening tendon of the adductor magnus towards the bone in the substance of the vastus internus. The artery arises from the femoral in front of the opening in the adductor magnus, so that it may be ligatured by the same method as that for the femoral itself. The superior internal articular branch of the popliteal artery is seen lying transversely upon the bone above the internal condyle.

(n) Popliteal Artery and its Branches

76. Ligature of the Popliteal Artery (Fig. 62). A vertical incision is made over the middle of the popliteal space opposite the knee-joint. The short saphenous vein is to be avoided at the lower part of the incision. It ascends between the two heads of the gastrocnemius and opens into the popliteal vein. To its outer side is the communicans fibularis nerve. The dissection is continued through the fat to the inner side of these structures and between the heads of the gastrocnemius. The internal popliteal nerve is the first structure to appear. When this is drawn outwards the popliteal vein comes into view, closely bound down by a strong sheath to the subjacent popliteal artery, which lies above upon the fat covering the femoral trigone, and below upon the popliteus muscle.

The muscular branches of the popliteal artery are represented by the sural arteries which end in the two heads of the gastrocnemius, while there are five articular arteries, viz. the superior and inferior external and internal, and the azygos, the latter of which is very conspicuous. These vessels are only ligatured in the case of injuries or operation wounds.

77. Ligature of the Anterior Tibial Artery (Fig. 63). This is the first large branch of the popliteal artery, and reaches the front of the leg by passing directly forwards above the upper end of the interosseous membrane. It can only be ligatured from the front of the leg. The course of the anterior tibial artery is indicated by a line extending from the projection at the anterior aspect of the outer tuberosity of the tibia (midway between the tubercle of the tibia and the head of the fibula) to the mid-point between the two malleoli.

In the upper third. An incision is carried downwards from a point midway between the tubercle of the tibia and the head of the fibula, beginning a thumb's-breadth below the outer tuberosity of the tibia. After division of the skin and fascia, the outer edge of the tendinous origin of the tibialis anticus, which arises from the outer tuberosity, is seen: it corresponds to the intermuscular space between the tibialis anticus and the extensor longus digitorum. This space is now opened up with the finger down to the interosseus membrane, through which the artery passes from behind forwards, about a finger's-breadth below the head of the fibula. The anterior tibial nerve reaches the artery somewhat farther downwards, coming from the outer side under the extensor communis digitorum muscle. The transverse branches of the nerve to the tibialis anticus are given off very high up.

In the middle third. An incision is made 3 cm. (rather more than an inch) external to the anterior edge of the tibia along the palpable and often visible furrow at the outer border of the tibialis anticus muscle. The fascia is divided along the white line corresponding to the above furrow (a second white line, somewhat farther outwards, corresponds to the intermuscular septum between the extensor longus hallucis and the extensor longus digitorum), and the finger is passed down to the interosseous membrane, upon which is the artery, under cover of the muscular fibres

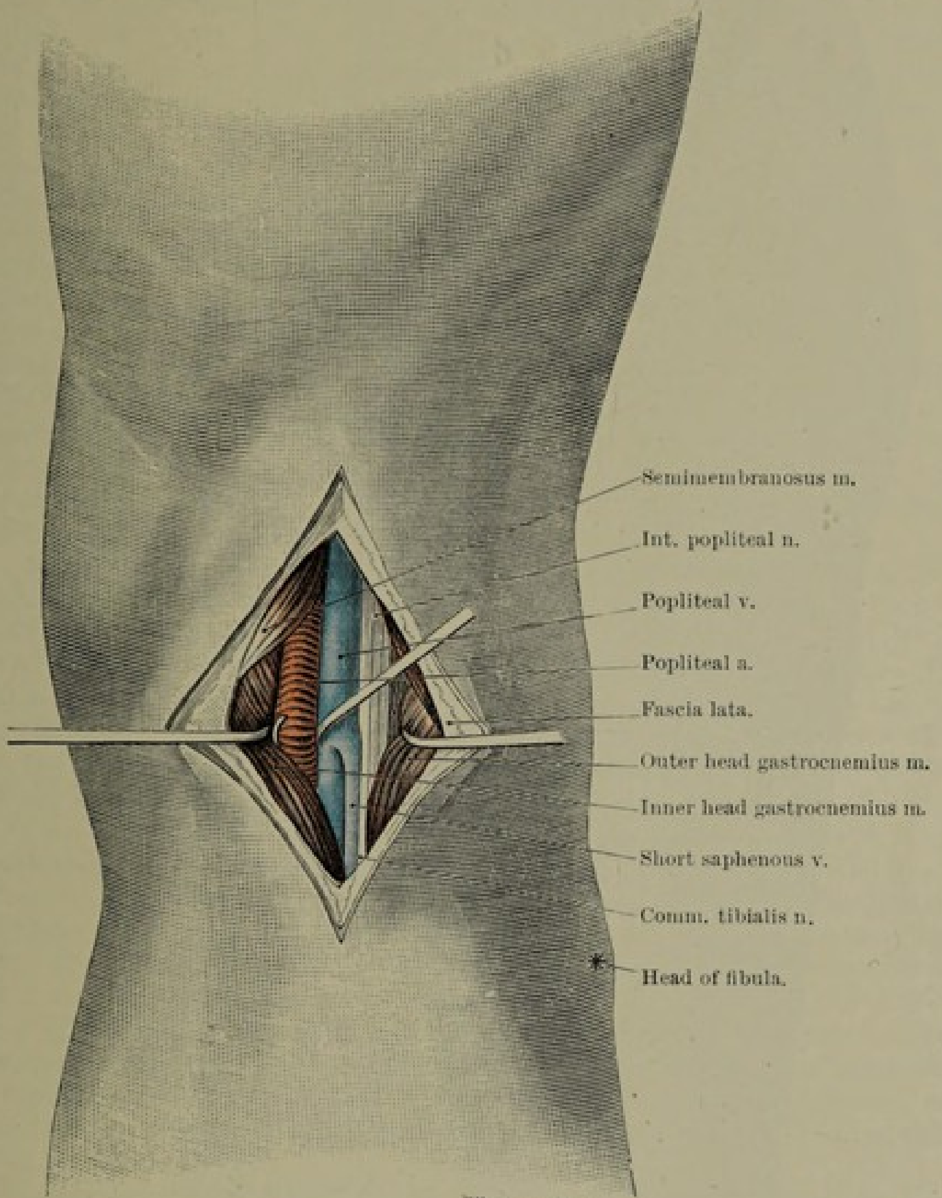


FIG. 62.—Ligature of popliteal artery.

of the tibialis anticus, between it and the extensor longus hallucis. The anterior tibial nerve lies upon the outer side of the artery.

In the lower third. An incision is made at the outer edge of the tendon of the tibialis anticus (the first large projecting tendon which lies external to the anterior border of the tibia), between it and the tendon of the extensor longus hallucis. After we have divided the skin and the strong fascia, the last-named tendon is clearly exposed and drawn outwards. The finger is now passed down towards the outer surface of the tibia. The first structure to appear external to the muscular fibres of the tibialis anticus muscle is the anterior tibial nerve, beneath which is the artery.

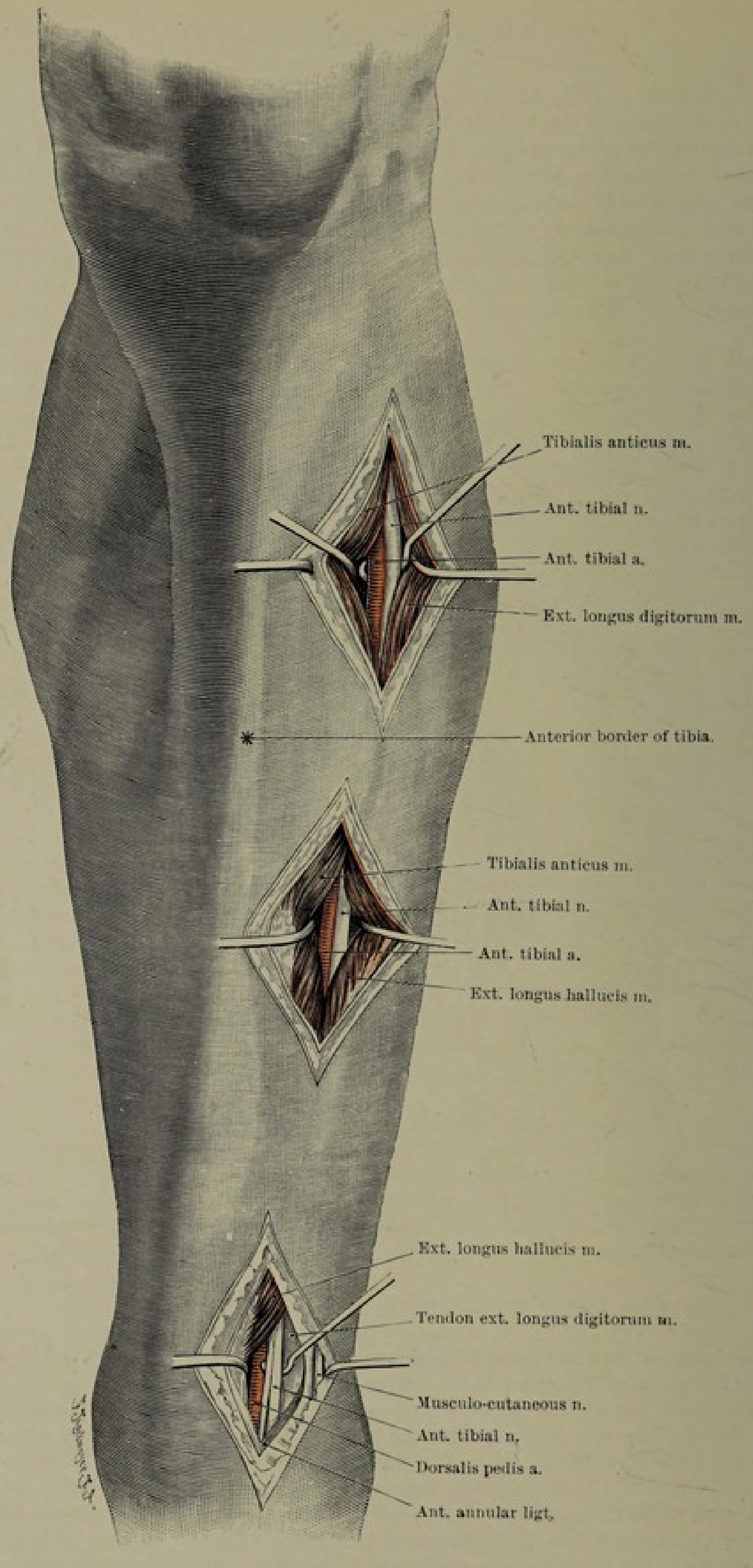


FIG. 63.—Anterior tibial artery and nerve.

As regards ligature of the small branches of the anterior tibial artery, viz. the anterior and posterior tibial recurrent and the internal and external malleolar arteries, only that of the dorsalis pedis on the dorsum of the foot requires consideration (*vide* No. 80).

78. Ligature of the Posterior Tibial Artery (Figs. 64 and 65). (*a*) *In the upper third of the leg* (*truncus tibio-peronealis*) (Fig. 64).[1] That portion of the posterior tibial artery between the origin of the anterior tibial and the peroneal artery may be conveniently referred to as the truncus tibio-peronealis. Incision is made downwards along the middle line, beginning at the level of the head of the fibula three fingers'-breadth below the popliteal crease. In division of the fascia, the short saphenous vein and communicans tibialis nerve are avoided and drawn outwards. The line of junction of the two heads of the gastrocnemius is sought for, and the tendinous raphe is freely divided. The large vessels and nerves to the heads of the gastrocnemius are drawn aside. Beneath the outer head of the gastrocnemius is the upper border of the soleus extending obliquely from above downwards and inwards; and upon it, also passing downwards and inwards, is the slender tendon of the plantaris muscle. The posterior tibial artery begins at the bifurcation of the popliteal, opposite the lower border of the popliteus and upper border of the soleus muscles. The edge of the latter muscle must be drawn downwards, or better nicked, in order to reach the posterior tibial artery, the corresponding vein and nerve being drawn outwards. The anterior tibial artery passes to the front through the interosseous membrane about $2\frac{1}{2}$ inches below the line of the knee-joint (a finger's-breadth below the lowest part of the head of the fibula). The tendinous surface of the soleus can be distinctly seen descending obliquely inwards towards the inner border of the tibia, under the inner head of the gastrocnemius.

(*b*) *In the upper half* (Fig. 65). The incisions for the posterior tibial artery lie in the direction of a line extending from the lower edge of the internal tuberosity of the tibia to a point midway between the internal malleolus and the tendo Achillis.

The incision is made half an inch behind the inner border of the tibia. The long saphenous nerve and vein (the latter in front) run in the line of the incision, and care must therefore be taken to avoid them. After division of the fascia the inner border of the gastrocnemius appears, and is drawn aside with a blunt hook. The oblique fibres of the subjacent soleus are now seen arising by a broad attachment from the tibia. They are to be divided until the strong obliquely-striated deep fascia which is attached to the posterior surface of the tibia is exposed, on dividing which the muscular fibres of the flexor longus digitorum come into view. The finger is now introduced into the wound and directed outwards between this muscle and the fascia covering it, when the artery will be felt lying upon the tibialis posticus muscle $1\frac{1}{4}$ inch beyond the inner border of the tibia. The large posterior tibial nerve is beyond the artery—that is to say, to its outer side. The tibialis posticus muscle lies upon the interosseous membrane. One must be careful not to pass between the tibia and the flexor longus digitorum. The mistake which is most frequently made is to pass in between the gastrocnemius and the soleus, instead of dividing the whole thickness of the latter muscle.

In the lower third (Fig. 65). An incision is carried downwards from the angle at the upper end of the visible and palpable furrow between the inner border of the soleus and the deep flexors (the flexor longus digitorum lying next the inner border of the tibia).

The long saphenous vein and nerve are to be avoided in dividing the skin and fascia. The free inner border of the soleus is then exposed and drawn backwards, when the tendon of the flexor longus digitorum (with its muscular fibres behind it) will be seen lying upon the tibia. On dividing the thin fascia covering the deep flexors, the artery will be found immediately under it to the outer side of the flexor longus digitorum. The posterior tibial nerve lies still more external.

Behind the internal malleolus. Incision is made midway between the posterior

[1] The portion of the artery between the origin of the anterior tibial and the peroneal artery ought to possess a distinctive name.

border of the internal malleolus and the tendo Achillis, dividing the skin, superficial fascia, and the strong transversely striated deep fascia. Between the internal malleolus and the artery are the tendons of the tibialis posticus and flexor longus

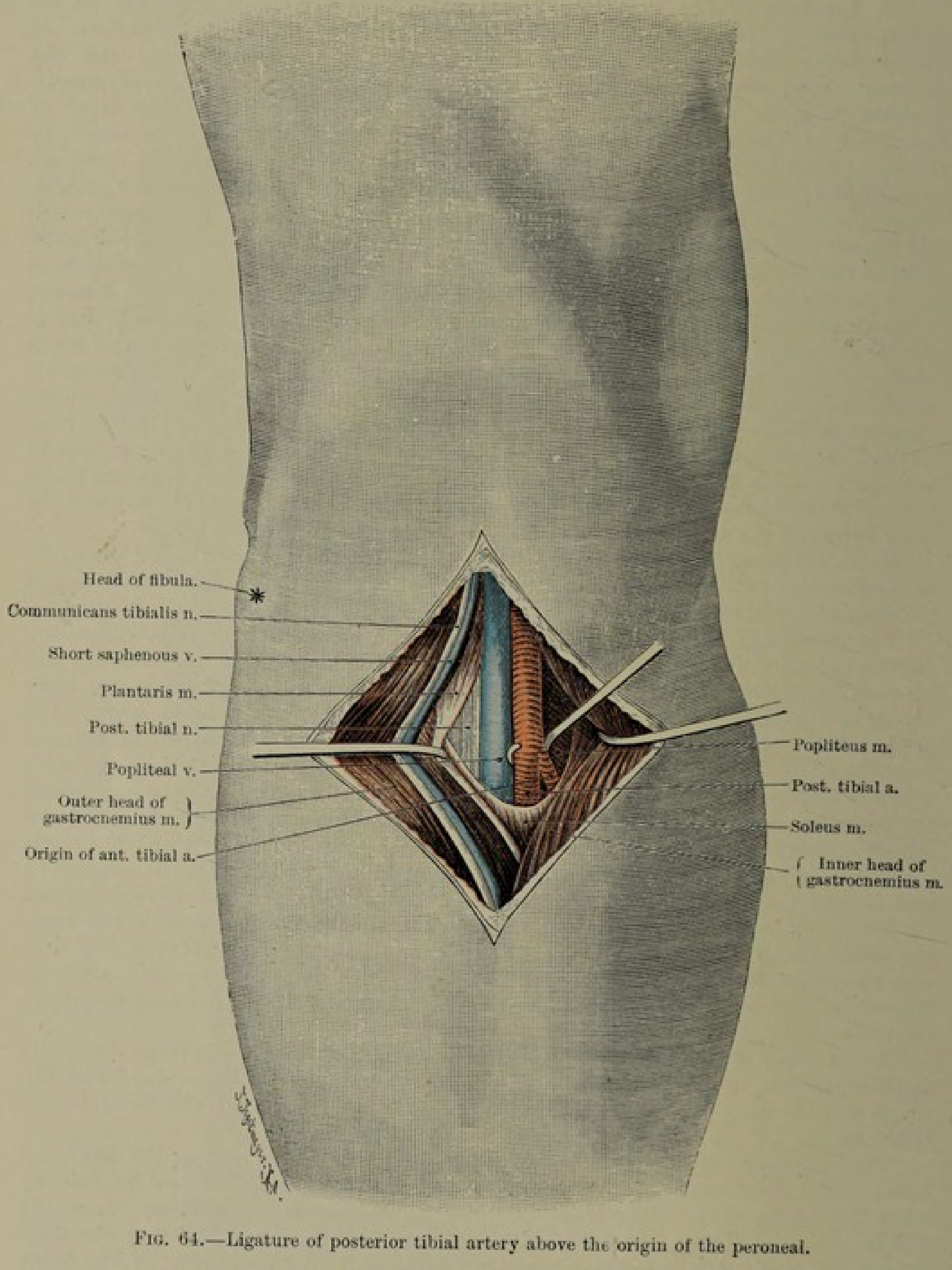


FIG. 64.—Ligature of posterior tibial artery above the origin of the peroneal.

digitorum, which lie in the order mentioned from before backwards. Behind the artery is the large posterior tibial nerve, and behind it again the tendon of the flexor longus hallucis. In this operation care must be taken not to pass in amongst the fat lying in front of the tendo Achillis.

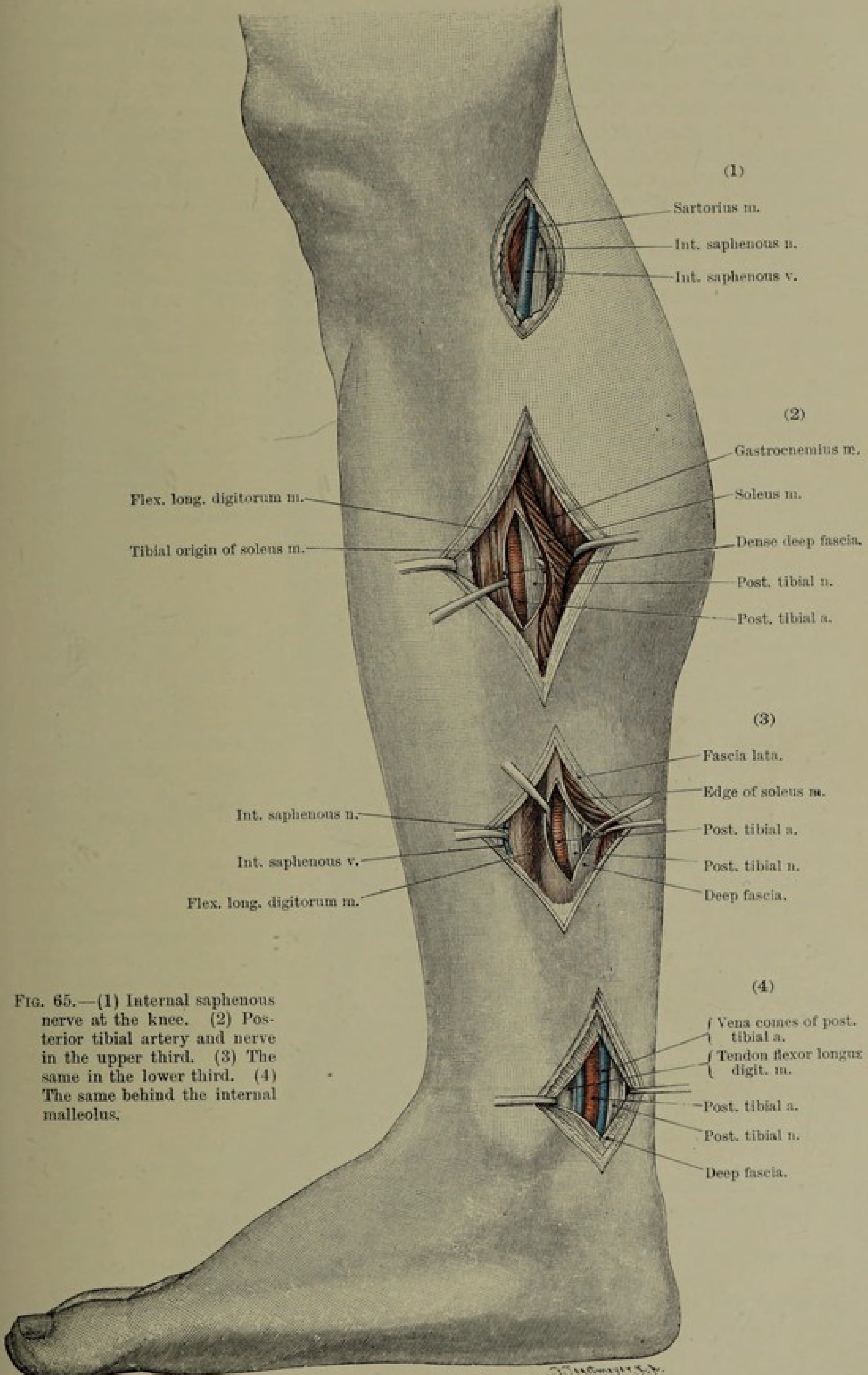


FIG. 65.—(1) Internal saphenous nerve at the knee. (2) Posterior tibial artery and nerve in the upper third. (3) The same in the lower third. (4) The same behind the internal malleolus.

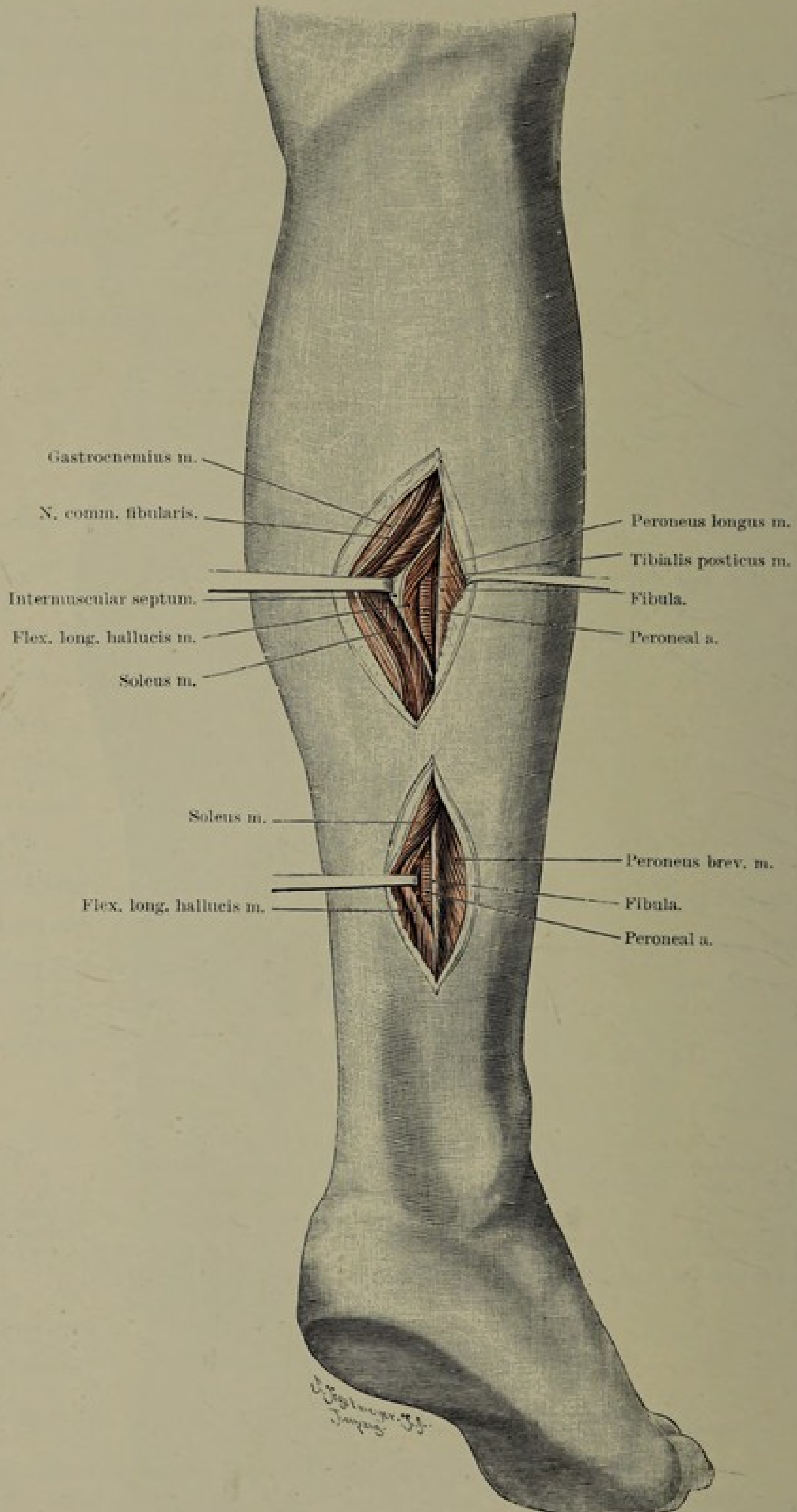


FIG. 66.—Ligature of peroneal artery in the middle and lower third of the leg (postero-external aspect).

79. Ligature of the Peroneal Artery (Fig. 66). The course of the vessel is indicated by a line continued from the popliteal artery down along the inner part of the posterior surface of the fibula. The posterior surface of the fibula may be felt through the skin along the whole length of the leg. The incisions for ligaturing the artery are made along a line drawn from the posterior border of the head of the fibula to a point midway between the external malleolus and the tendo Achillis.

(*a*) *In the upper half.* Incision is made behind the muscular projection of the peronei muscles down to the posterior surface of the fibula, which can be readily felt. The nervus communicans fibularis is observed running downwards along the outer border of the gastrocnemius, the soleus lying deeper. After division of the fascia covering the soleus the muscle is separated by blunt dissection from the posterior surface of the deep fascia (ligamentum intermusculare posticum), until the peroneus longus is exposed on the fibula external to the soleus. The deep fascia is now divided and raised from the posterior surface of the fibula along with the muscular part of the flexor longus hallucis, until the groove between the fibula and the tibialis posticus is reached. The artery runs nearly vertically downwards on the latter muscle.

(*b*) *At the junction of the middle and lower thirds.* Incision is made on the posterior surface of the fibula. The fascia between the soleus and the peroneus brevis (on the fibula) is split and the soleus retracted outwards, and after dividing the fascia (Lig. intermusculare posticum) covering the flexor longus hallucis, we dissect the latter off the posterior surface of the fibula, thus exposing the fascia which covers the tibialis posticus under which the artery has its position.

(o) Arteries of the Foot

80. Ligature of the Dorsalis Pedis Artery (Terminal Branch of the Anterior Tibial) (Fig. 67). The course of the vessel is indicated by a line extending from midway between the two malleoli to the hinder end of the first interosseous space.

At the ankle-joint. The skin is divided longitudinally midway between the two malleoli. The internal branch of the musculo-cutaneous nerve is seen running in the direction of the incision, and is drawn outwards. The fascia, along with fibres of the anterior annular ligament, is divided over the tendon of the extensor longus hallucis (here partly muscular), which is drawn inwards. The artery is now exposed, the anterior tibial nerve lying upon its outer aspect.

Below the ankle. An incision is made along the line already mentioned. The inner branch of the musculo-cutaneous nerve which lies upon the fascia is drawn outwards. Under the fascia lie internally the tendon of the extensor longus hallucis, and externally the innermost tendon and the muscular fibres of the extensor brevis digitorum, which on being drawn downwards and outwards exposes the artery which lies beneath it upon the tarsal ligaments. The anterior tibial nerve is upon the outer side of the artery.

Where it dips down into the first interosseous space. An incision is made through the skin and fascia between the bases of the first and second metatarsal bones. The internal branch of the musculo-cutaneous nerve is avoided and drawn outwards along with the internal saphenous vein. Internally is the innermost tendon of the extensor brevis digitorum, and still farther inwards the broad tendon of the extensor longus hallucis. The artery, with the cutaneous termination of the anterior tibial nerve lying upon it, appears from beneath the outer edge of the extensor brevis tendon, and gives off the large first dorsal interosseous branch.

The small branches of the dorsalis pedis, viz. the tarsal and metatarsal arteries, the latter forming an arch on the dorsum of the foot, may have to be ligatured in accidental wounds of the foot.

Of the branches to the toes only the dorsalis hallucis artery requires consideration. It is the continuation of the dorsalis pedis in the first interosseous space.

81. Ligature of the Plantar Arteries (the Terminal Branches of the Posterior Tibial Artery). (*a*) *Below the internal malleolus* (Fig. 68). The posterior tibial

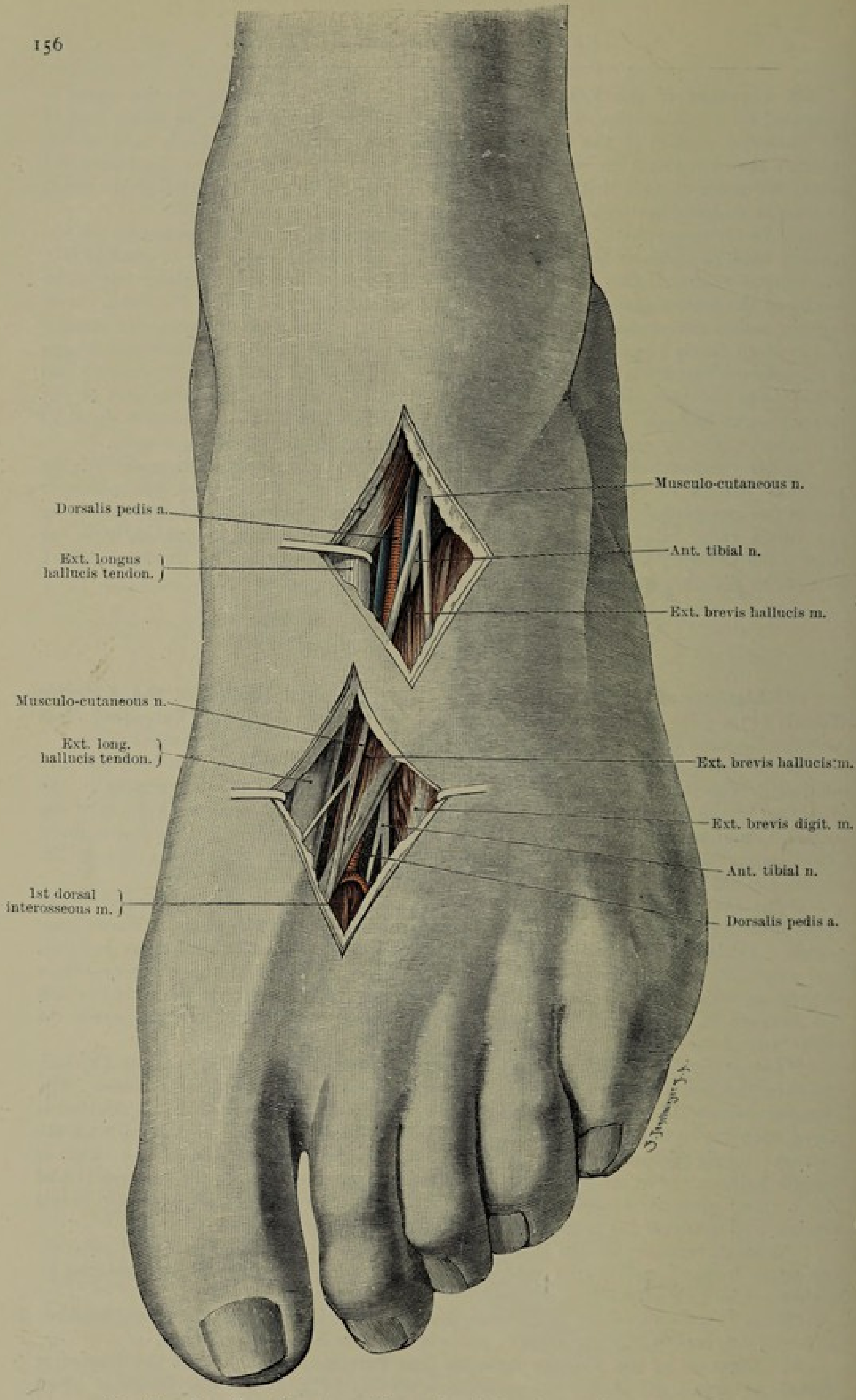


Fig. 67.—Dorsalis pedis artery, with anterior tibial and musculo-cutaneous nerves.

artery is the parent trunk of the two plantar arteries, and may be termed the arteria plantaris communis. An incision is made beginning a finger-breadth below and in front of the sustentaculum tali is carried horizontally backwards along the inner border of the foot above the prominence of the abductor hallucis muscle. After division of the skin and fascia the abductor hallucis is exposed, and separated downwards from the subjacent deep fascia. On dividing the latter we find the plantar vessels opposite a line continued downwards from the posterior border of the internal malleolus. The posterior tibial nerve lies immediately below the artery.

(*b*) *Internal plantar artery* (Fig. 69). An incision is made in a line from the point of the heel to the great toe, beginning in front of the ball of the heel and extending forwards. The skin, a thick layer of fat, and the dense longitudinal fibres

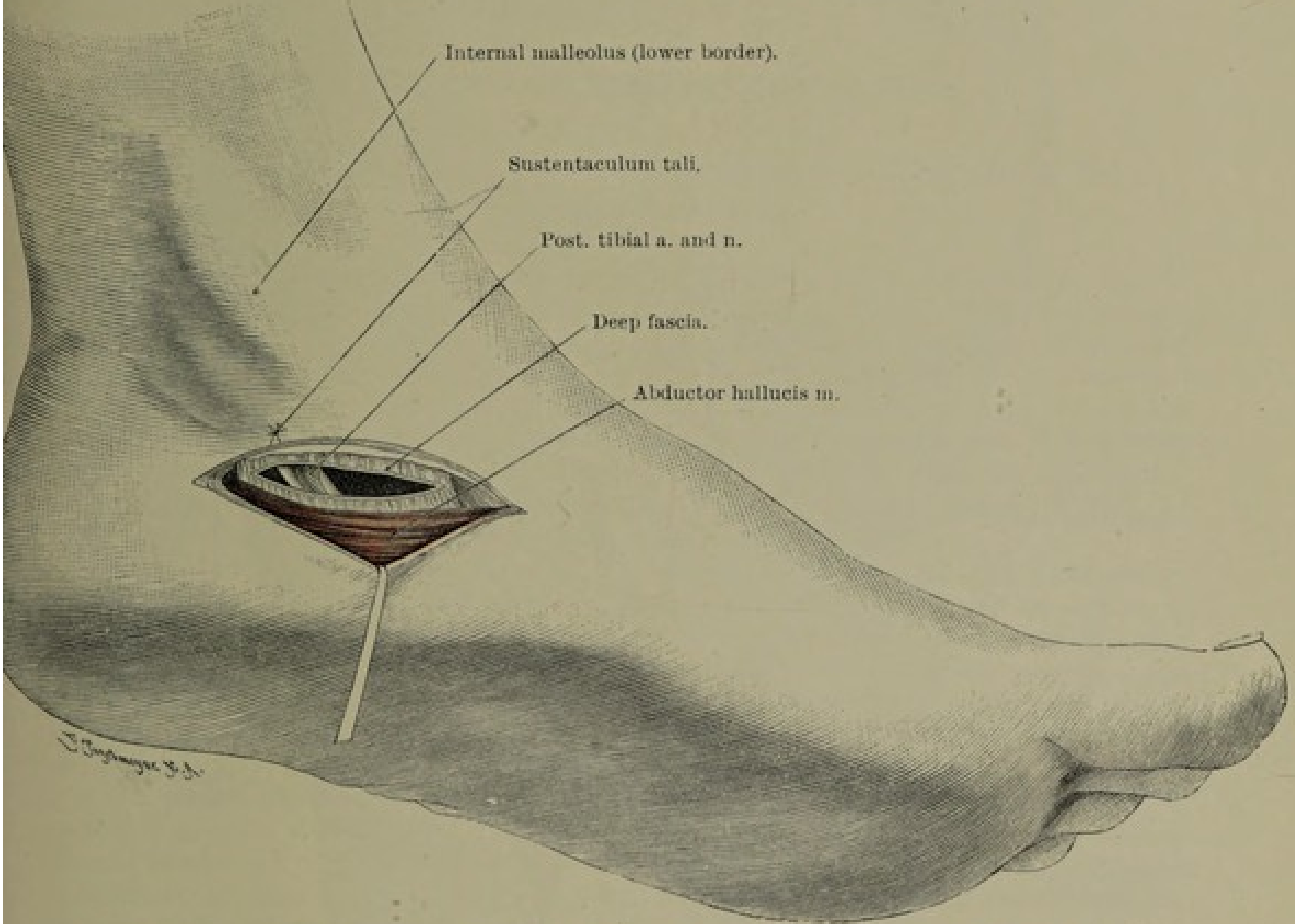


FIG. 68.—Plantar arteries at their origin from the posterior tibial artery. Posteriorly, the posterior tibial nerve.

of the plantar fascia are divided. The muscular substance of the abductor hallucis is exposed, and the artery is found passing under it into the sole. The flexor brevis digitorum lies external to the artery.

(*c*) *External plantar artery* (Fig. 69). An incision is made from immediately in front of the ball of the heel forwards in the direction of a line from the point of the heel to the fourth toe. On division of the skin, abundant fat, the strong plantar fascia, and the muscular fibres of the adjacent edges of the flexor brevis digitorum and abductor minimi digiti are exposed, with the artery lying between them.

(*d*) *The plantar arch at the first interosseous space* (Fig. 69). An incision is made backwards in the hollow outside the ball of the great toe, in the direction of a line from the second toe to the point of the heel, through skin, abundant fat, and the strong plantar fascia. Upon the inner side of the wound is the tendon of the flexor longus hallucis along with, posteriorly, the muscular fibres of the abductor hallucis,

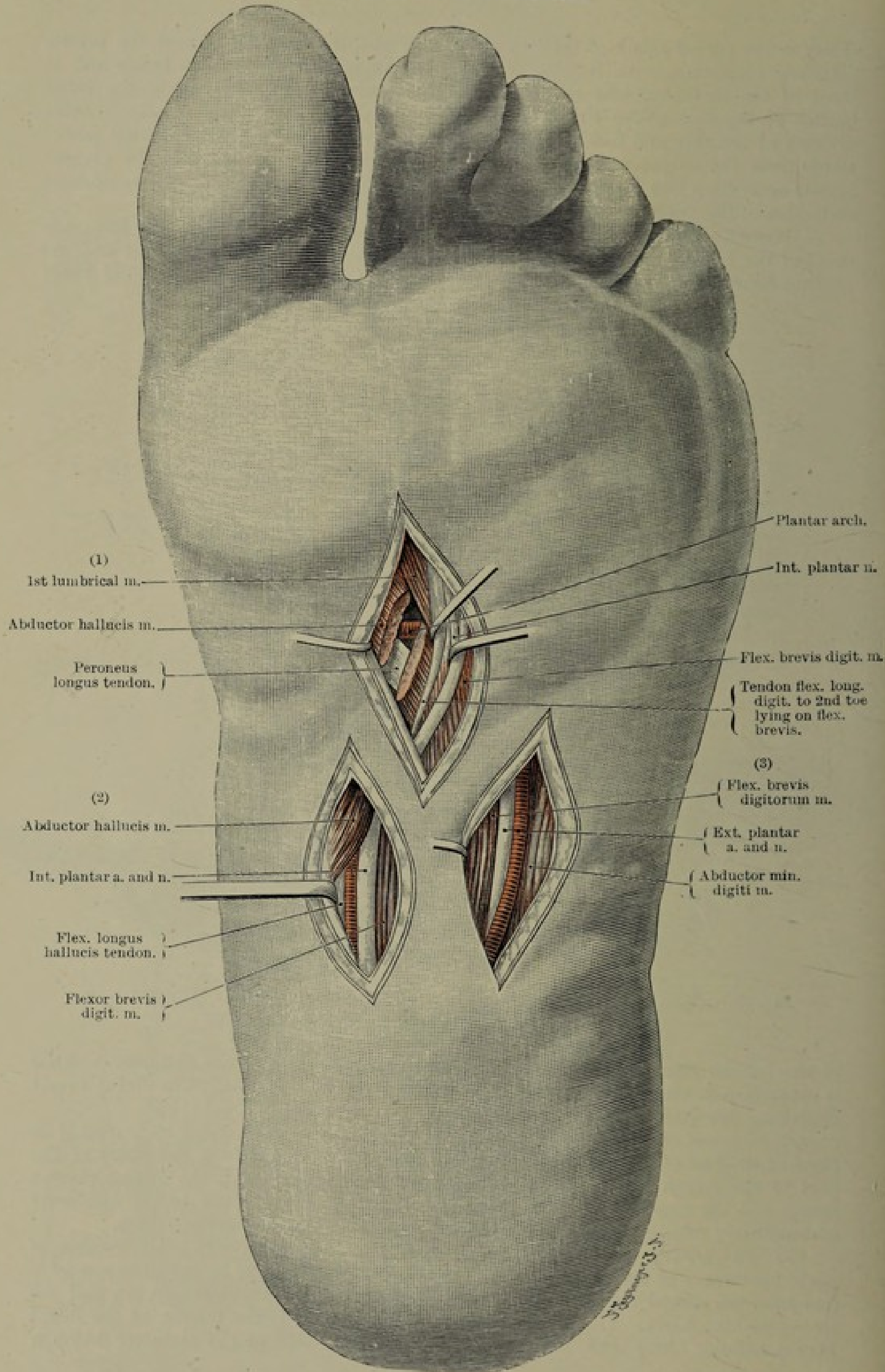


FIG. 69.—(1) Plantar arch. (2) and (3) Internal and external plantar artery and nerve.

and, anteriorly, those of the flexor brevis hallucis: these structures are drawn inwards. Upon the outer side of the wound is the large internal plantar nerve with its branches to the second and third toes: these are drawn towards the little toe. The nerve to the great toe does not come into view. The short flexor tendon of the second toe and the subjacent long flexor tendon with the first lumbrical muscle are exposed and drawn outwards, the powerful adductor hallucis muscle which lies still deeper being then exposed. After cutting through this muscle the artery will be found lying deep at the first interosseous space where it joins the dorsalis pedis artery. The artery lies upon the interosseous muscles. To the inner side of its termination is the projecting border of the first metatarsal bone, to the base of which is inserted the tendon of the peroneus longus muscle.

C. SURGERY OF THE VENOUS SYSTEM

(a) General Indications for the Exposure and Ligature of the Larger Veins

Veins are now exposed and ligatured much more frequently than was the case in former years. A vein, like an artery, has to be ligatured for the arrest of hæmorrhage, but, owing to the low blood-pressure in a vein, bleeding is much more easily arrested by pressure or plugging than is possible with an artery.

In the case of an injury to a large vein, it is often unwise, and indeed impracticable, to apply a ligature. For example, there is considerable risk in ligaturing such veins as the superior and inferior venæ cavæ, the common iliac, the innominate, or even the femoral vein, and to a less extent the subclavian and jugular veins. In these cases plugging, when properly applied, is generally sufficient.

We have on more than one occasion successfully dealt with the hæmorrhage following a wound at the junction of the jugular and subclavian veins by means of plugging. This injury is most liable to occur in the course of the removal of a malignant gland (secondary to carcinoma mammæ) situated in the angle between the two veins. Similarly, when the occasion arises, the internal jugular vein can be plugged with safety at its exit from the skull (jugular foramen), when it has to be divided in excising malignant growths which reach high up in the neck.

We have observed, however, that when plugging is adopted in cases of this nature, especially if the central end of the circulation remains open, serious complications often arise from the displacement of thrombi into the heart and lungs with the production of infarcts and gangrene. Suture should therefore be substituted for plugging whenever possible.

Injuries of all large veins on the cardiac side of the common femoral and subclavian veins should be dealt with by suture. In consequence of the low blood-pressure in the veins, wounds in the latter heal satisfactorily after suture. According to Jacobsthal,[1] Czerny was the first (1881) to adopt suture of a vein in man; while a year later Schede published a series of cases and brought the operation into general repute. We have adopted it successfully in the case of the innominate vein, at the junction of the internal jugular and subclavian veins, using for the purpose a continuous suture of fine antiseptic silk. A small wound may be dealt with by holding up the edges of the rent with forceps and passing a ligature round them. Tichow[2] has made a study of the process of repair following suture of veins.

Apart from the control of hæmorrhage, ligature of veins is chiefly undertaken to produce artificial changes in the circulation, ligature of the saphenous vein for varicose veins in the lower extremity being one of the best-known and most widely performed operations. Ligature of veins may also be undertaken for the cure of

[1] *Samml. klin. Vorträge*, 1905. [2] *Centralbl. f. Chir.*, 1895.

varices elsewhere. In the lower extremity the object of ligature is to relieve hydrostatic pressure.

The superior longitudinal sinus is ligatured for the cure of epilepsy, a method of treatment recently advanced and recommended by Delagenière.

Carrel[1] has recently shown that a portion of a vein can be utilised to replace a defect in an artery by means of a plastic operation, the former being sutured between the two ends of the artery. Carrel and Guthrie[2] have even suggested that in cases where an artery is obliterated, the circulation may be reversed and gangrene prevented by uniting the central part of the artery with the peripheral part of the vein. We here reproduce two diagrams from Carrel's work, for the use of which we are indebted to Harvey Cushing, who further states that the outer wall of the interpolated portion of vein rapidly undergoes considerable hypertrophy.

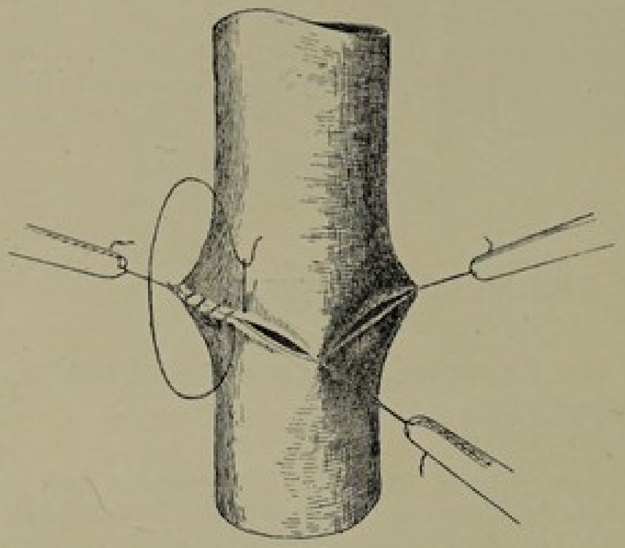


FIG. 70.—Technique of end-to-end arterial suture (Carrel). The lumen of the artery is converted into triangular shape, and the finest silk and needles are used. The cut ends are simply united with a continuous suture.

Figs. 70 and 71 show how Carrel prevents stenosis of a vein after suture. By means of three traction stitches the lumen of the vessel is opened out in a triangular form and stitched with the finest linen thread (Valenciennes lace) or 500 Alsatian cotton (Cushing) or the thinnest China silk thread on the finest needles (Kirby 13-14, Cushing 15-16). The tunica intima is not included in the case of larger arteries. Carrel has in this way successfully performed end-to-end as well as end-to-side anastomosis both in arteries and in veins, and has even been able to transplant whole organs (kidney, thyroid), and even invert the arterio-venous circulation.

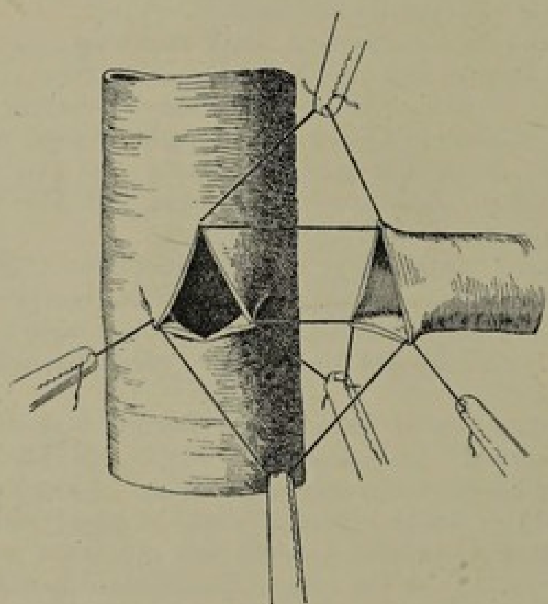


FIG. 71.—Technique of end-to-side arterial anastomosis. From a sketch by Cushing.

According to Jacobsthal, Lambert, an English surgeon, first suggested arterioraphy, while Hallowell in 1759 was the first to carry it to a successful issue. He closed a wound in the brachial artery by means of a circular stitch inserted over a steel needle. After repeating the earlier experiments of Gluck, Postemsky and Horoch, Jassinowsky has perfected the technique of arterioraphy by experiments on the aorta and carotid, while Murphy and Dorfler have proved the advisability of including the intima in the suture.

After Murphy had discovered the invagination method in the case of vessels which had been cut transversely, Payr perfected the technique of the operation by

[1] *Technique opératoire des anastomoses vasculaires*, etc., Lyon, 1902.
[2] *Annals of Surgery*, Feb. 1906.

stripping back the artery wall over a small magnesium ring slipped over the proximal end, so that the endothelium projects and can be approximated with the endothelium of the distal end (intussuscipiens), to which it is joined by suture. After circular resection of the femoral artery (Kümmel, 5 cm.), Murphy and Kümmel have obtained union of the ends of the vessels by invagination, without interfering with the lumen of the vessel. Permanent arrest of hæmorrhage was secured in 33 out of 35 cases of lateral arterial suture.

Apart from injuries, thrombosis is an equally important indication for operation. Two classes of cases must be recognised. In the first the chief indication is to restore the circulation by removal of the clot, *i.e.* by incision of the vein, and removal of the thrombus with subsequent suture.

In the second class, which is even more important, the object is an urgent one, and consists in the immediate removal of the thrombus in order to prevent its displacement, with subsequent ligature or suture of the vein. The majority of surgeons are, as a rule, too supine with regard to this class of case, for whenever thrombosis occurs in a vein (most commonly in the lower extremity) there is always the extreme danger of the clot becoming suddenly detached, with the production of embolism in the pulmonary arteries.

Whenever, therefore, a large vein becomes thrombosed, there is always the attendant risk of this catastrophe, which may occur unexpectedly and prove suddenly fatal, and the question of arresting it by cutting down and removing the thrombus must always be borne in mind.

The removal of infective thrombi is quite as important as that of an aseptic one, which is only dangerous on mechanical grounds. At the present time, their removal is mainly practised in connection with otitis media. It is the lateral sinus and the internal jugular vein which are most commonly explored and ligatured or plugged when they have been attacked by infective inflammatory processes. Hitherto surgeons have been too timid in the early treatment of infective thrombosis in the veins of the extremities and trunk. Such conditions require drastic measures. The results of ligature of the pelvic veins in puerperal conditions (Bumm) are so satisfactory that even here the evil consequences of infection can be prevented by active measures.

(b) Exposure, Suture, and Ligature of Individual Veins

82. Exposure of the Superior Vena Cava. Suture of the superior vena cava may have to be considered in the case of wounds involving the first two right intercostal spaces. In its upper portion the vena cava is covered on the right by the pleura, while lower down it lies within the pericardium. It can be reached by resecting the second costal cartilage in the manner described under exposure of the heart. The sternum must be turned back as a flap, however, if good access is to be obtained to the vena cava and both innominate veins.

Figs. 72, 73, and 74 show the method of osteoplastic resection of the manubrium sterni necessary to expose the upper part of the anterior mediastinum. Even in the event of closure of the superior vena cava an anastomosis would be established through the connections of the innominate, jugular and subclavian veins. Closure of the superior vena cava has in fact been observed on several occasions (Houzel).

Resection of the manubrium sterni for suture or ligature of the superior vena cava is performed as follows: A transverse incision (Fig. 72) is made down to the bone along the episternal notch crossing both sternal ends of the clavicles. The periosteum is freed, the communicating arch between the anterior jugular veins being avoided, and the sterno-clavicular joints are opened, after which the left pectoralis major is detached from the sternum along with the periosteum, for the latter manœuvre a vertical incision being carried downwards over the first and second left costal cartilages.

A transverse incision is then made at the level of the second costal cartilage, and the first and second costal cartilages are separated from the perichondrium and

divided. The bone having been raised with a strong hook, the capsule of the left sterno-clavicular joint is cut through posteriorly, after which the periosteum is detached from the posterior surface of the manubrium with a raspatory, so that the latter can be divided at the junction of the manubrium and body without injuring the pleura and internal mammary vessels (Fig. 73).

The portion of the sternum is then raised with a hook and turned over to the other side (Fig. 74). By this procedure the first and second right costal cartilages break at the junction with the bone.

The periosteum on the posterior surface of the manubrium is now carefully opened in the middle line, by which means we expose on the right and left of the sternum, the internal mammary vessels descending on the pleura and surrounded by some fatty tissue and small glands.

If proper care is exercised, the two layers of pleura can be pushed to either side. The remnant of the thymus gland is seen occupying the middle line and resembling a mass of fat accompanied by veins. Below it, the ascending arch of the aorta is observed. Above the latter and at the level of the first rib the left innominate vein passes transversely outwards, while to the right near the aorta a portion of the superior vena cava is noticed. A large thyroidea ima vein enters the left innominate from above. The retracted pleura forms the vertical boundaries, right and left, of this anterior part of the superior mediastinum.

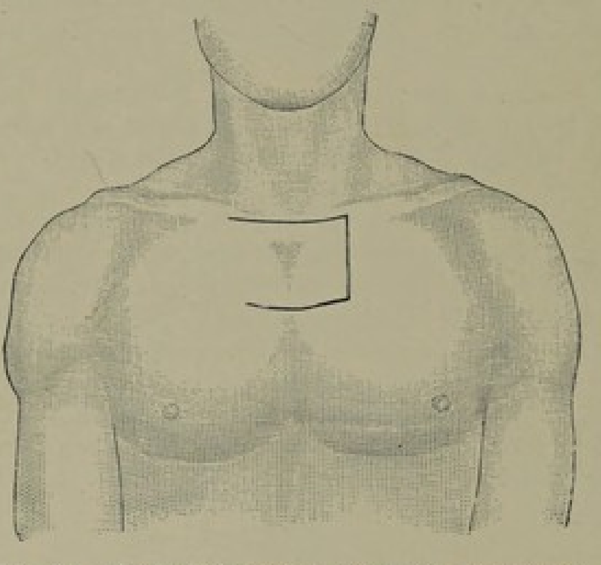


FIG. 72.—Osteoplastic resection of the manubrium sterni. The sterno-mastoids are detached from the sternum and turned upwards, the sterno-clavicular joints opened, and the capsule on the left side is detached from the sternum. The first and second costal cartilages are then divided close to the sternum, and the sternum is cut across with a chisel below the level of the second cartilage.

83. Ligature and Suture of the Inferior Vena Cava.[1] Goldmann[2] has recently made careful investigations regarding ligature of the inferior vena cava in connection with special cases. The vein is most likely to be torn in separating tumours of the right kidney (Lindner). Occasionally the rent in the vein has been stitched (v. Schede, v. Zoege, Busse, Grobe, Garrè). In Schede's case the right renal vein was cut too short in the excision of a malignant kidney. He, however, closed the opening in the side of the vena cava with fine catgut, the wound becoming completely cicatrised in four weeks without any thrombosis and with only slight narrowing of the lumen. In v. Zoege's case (nephrectomy for malignant disease of the kidney) a rent in the inferior vena cava 9 cm. long and $2\frac{1}{2}$ cm. broad, was successfully closed by suture.

Whenever one has to deal with tumours of the kidney which are at all adherent, the incision should always be made sufficiently large to allow of the vena cava being sutured, *i.e.* the peritoneum should be freely opened and the relations of the growth to the vena cava determined, as Heresco and v. Zoege advise. Notwithstanding this precaution, it is not always possible to suture the vein, and ligature may have to be employed. Goldmann refers to the excellent results which Houzel, Heresco, Albarran, Bottini and Hartmann have obtained by this means. Lindner, indeed, regards the vena cava in the same light as all other large veins in the body, *i.e.* not only can it be ligatured, but it can also be excised when adherent to tumours or thrombosed.

[1] Cf. Niebergall, *Deutsche Zeitschr. f. Chir.*, 1892, Bd. 33. Schede, Langenbeck's *Archiv*, Bd. 43, 1892. Houzel, *Revue de Chir.* Bd. 23.

[2] *Beiträge zur klin. Chir.* Bd. 47, 1905.

It must be pointed out, however, that the above remarks only apply to the vena cava below the entrance of the renal veins, as ligature above this point is fatal. According to Goldmann, this has been proved by Gosset and Lécène, while Purpura has found experimentally that death need not occur, if, from an already existing stenosis of the vena cava, a collateral circulation has been established.

FIG. 73.—Incision for osteoplastic resection of the manubrium sterni.

Goldmann quotes 112 cases of thrombosis of the vena cava observed by Vimont. In these the congestion was more marked (œdema and ascites) than after ligature and closure of the vena cava. In the latter the symptoms of congestion may be absent. Injection experiments by Lappe, Poirier, Goldmann, and others, have shown that after ligature of the inferior vena cava the blood is returned to the heart

without difficulty and, that of the numerous auxiliary anastomoses in existence, the veins in and about the spinal canal, in the groin and the azygos veins, are the principal channels by which it is effected.

It would seem, therefore, quite legitimate to ligature the vena cava below the renal veins, and even to resect a portion of its length. A case has recently been

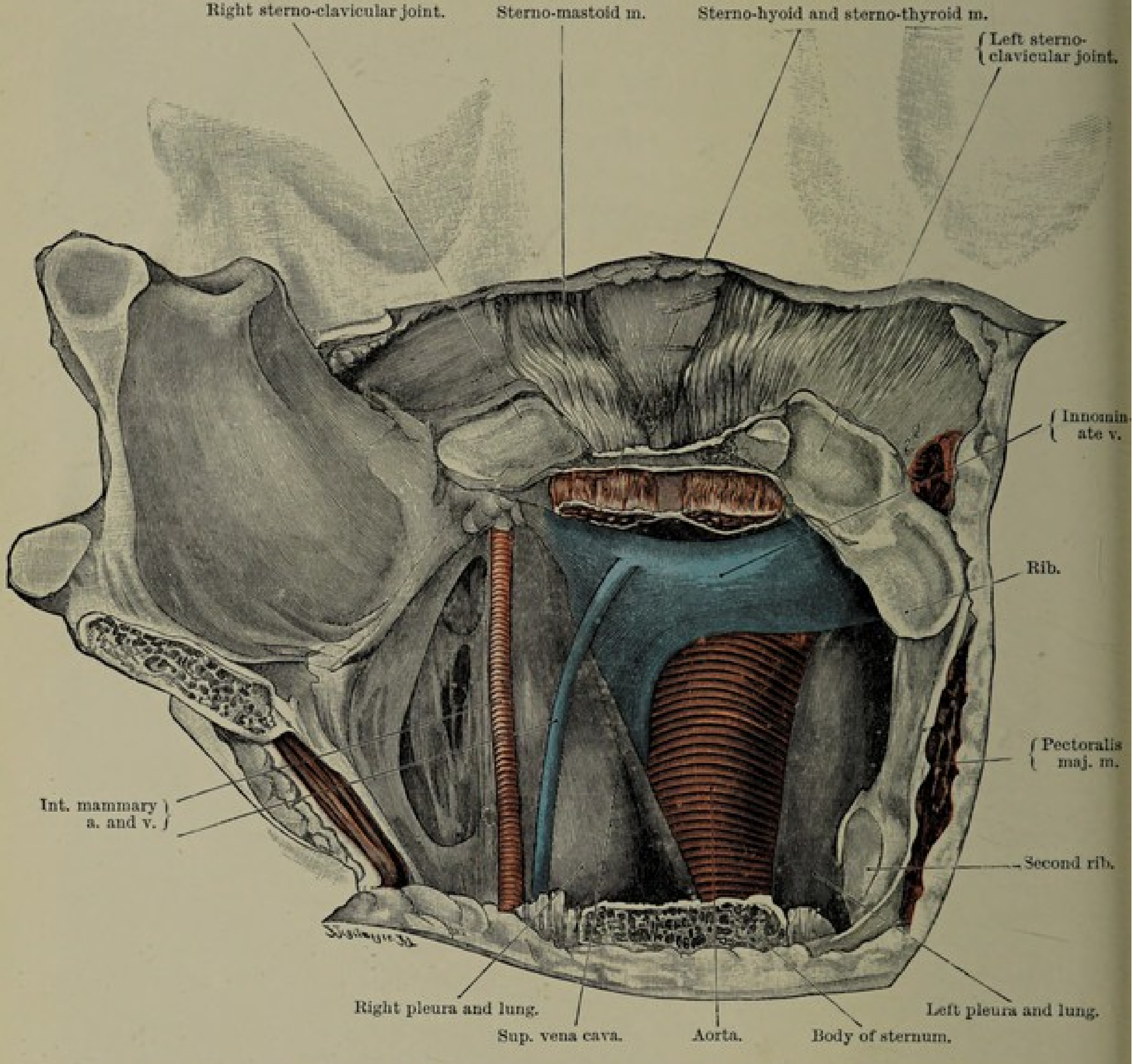


FIG. 74.—Osteoplastic resection of manubrium sterni. The sternum is turned over to the right side. The depressors of the larynx are seen detached from the back of the manubrium. The right and left pleuræ and lungs are exposed bounding the anterior mediastinum.

described by Houzel in which the initial disturbance in the circulation was perfectly compensated.

84. Ligature and Suture of the Innominate Veins. During the removal of deep-seated tumours in the neck, especially in intrathoracic "struma," severe hæmorrhage is often encountered from the tearing of deep veins (thyroidea inferior and ima). The bleeding from these veins can be temporarily arrested by pressing the bleeding-point, or the left innominate vein, against the posterior surface of the sternum, while it can be permanently controlled by plugging, where ligature is not possible.

Jordan reports two cases of wounds of the innominate vein in which recovery occurred. Ricard also reports a case in which a wound in the right innominate vein, accidentally produced during the removal of malignant glands, was successfully treated by lateral suture, while a case of Brohl's in which the left innominate vein was ligatured (excision of sarcoma) also proved successful, in the latter case temporary resection of the clavicle being performed.

If we take into account that even thrombosis of the vena cava superior is tolerated, provided it develops slowly, it is not so surprising that unilateral ligature or even excision of one innominate vein is possible owing to the large cross anastomosis between the veins of the neck. In Brohl's case, not the smallest disturbance was noted after excision of the innominate, internal jugular and subclavian veins and the thoracic duct.

Occlusion of the innominate vein by ligature is well tolerated even when there has been no preliminary stenosis to establish a collateral circulation. Goldmann refers to two cases (Heinecke and Bardenheuer) reported by Ziegler, and also one of his own, in which (like a case reported by Plucker) ligature (or resection) was undertaken owing to the spread of a tuberculous process to the wall of the vein. Both cases recovered.

It is of great importance to know that recovery can occur in these circumstances, for, in dealing with glands and other tumours ("struma") situated at the inlet of the thorax the surgeon is very often in grave doubt as to whether operation is justifiable. There is one gland in particular, the removal of which we have several times found very troublesome on account of bleeding. It is situated in the angle between the jugular and the subclavian vein at the point where the external jugular, and on the left side the thoracic duct enter. In such cases it is satisfactory to know that when the hæmorrhage can be arrested by plugging, one may proceed to ligature the innominate together with its tributary veins.

Ligature of the innominate vein is, however, in the presence of adhesions not always possible without a preliminary division of, or an osteoplastic operation on, the clavicle, the first and second costal cartilages, or the manubrium sterni. The large projecting sternal end of the clavicle is a troublesome impediment. An incision similar to that for excision of the manubrium sterni is made in the suprasternal notch, and prolonged along the clavicle on one side only. The sterno-clavicular attachment of the sterno-mastoid muscle is divided, the joint capsule opened, the articular end of the clavicle raised up, the costo-clavicular ligament divided, and the clavicle pulled forcibly downwards. If this fails to give sufficient access, the first costal cartilage must be divided and pulled downwards and outwards. If still further room is required, the second costal cartilage and the junction of the manubrium with the body of the sternum must be divided and a flap turned back similar to that for ligature of the vena cava.

Tributaries of the Innominate Vein

85. Ligature of the Thyroidea Ima Vein. Of the smaller branches of the innominate vein, especially those from the anterior mediastinum, the vertebral, deep cervical, internal mammary, superior intercostal, and thyroidea ima veins, only the latter have any practical significance as regards ligature. The thyroidea ima vein is often ligatured in goitre operations and the performance of low tracheotomy.

In opposition to anatomical descriptions, we consider "venæ thyroideæ imæ" and not "inferiores" the only proper designation for the veins which descend from the isthmus and lower pole of the thyroid gland, as their course closely corresponds to that of the thyroidea ima artery, while the inferior thyroid artery is accompanied by an exceedingly small inferior thyroid vein.

The thyroidea imæ veins anastomose freely with one another and form a plexus (Plexus, thyr. impar.). One or two main trunks can, however, be readily isolated on one or other side of the middle line, for the control of hæmorrhage. To expose

them an incision is made above the sternum (longitudinal or transverse) dividing the skin and the fascia connecting the sternothyroid muscles in the middle line.

86. Ligature of the "Common" Jugular Vein. In surgical nomenclature the internal jugular vein of the anatomists is called the common jugular vein, in order to distinguish it from that portion of the internal jugular vein above the entrance of the common facial vein, and we do not see why this nomenclature (proposed by Krause) should not be adopted by anatomists.

Ligature of the "common" jugular vein is one of the most important in the chapter on ligature of veins, not merely because it is very frequently wounded, *e.g.* in the excision of malignant tumours, but also because it has often to be ligatured in dealing with infective conditions in its tributary areas, especially in connection with certain complications of otitis media. The "common" jugular is more easily ligatured than the internal jugular vein; but in order to avoid the risk of embolism, it is only adopted when the thrombus already extends farther down, otherwise the internal jugular above the entrance of the common facial vein is to be ligatured.

As a rule, the "common" jugular vein can be tied on one side without any fear of serious congestion. Fatal disturbances of the cerebral circulation occur only in exceptional cases.

In only one out of 91 cases collected by Rohrbach[1] did death result from softening of the brain, the case being one in which the lateral sinus was most abnormal. It was of a diminutive size, while the jugular vein of the opposite side was also so small that the escape of the venous blood from the cranium was considerably interfered with. Cases have also been recorded by Linser[2] (from Brun's clinic) and Kümmel. From an examination of a number of skulls, Linser found a very small jugular foramen present in 3 per cent (generally on the left side).

It seems indicated that special consideration should be paid to the "common" jugular vein, especially the right, so that lateral suture may be substituted for ligature where practicable. It is admitted that this cannot be done in cases of resection for malignant disease. Schede's experiences show that lateral suture of these veins is a very safe operation. Sometimes the vein may even be opened to remove an infective or malignant thrombus and then be stitched up again. Jacobsthal collected 10 cases of suture of the jugular vein.

The common jugular vein is exposed in the same way as the common carotid (*vide* No. 3, Fig. 28). It lies to the outer side of the common carotid artery, According to Goldmann, Dangel has reported a case of bilateral ligature of the "common" jugular vein with only temporary disturbance of the circulation.

Tributaries of the "Common" Jugular Vein

87. Superior Longitudinal Sinus of the Dura Mater. Bleeding from wounds of this sinus may be controlled by plugging, which is often the only method possible. This also applies to the cavernous sinus (*e.g.* wounds during extirpation of Gasserian ganglion).

Bleeding from the superficially situated sinuses can be dealt with by ligature, *e.g.* the superior longitudinal, the lateral (on one side) and the occipital sinus. Ligature of the superior longitudinal sinus has further been recommended by Delageniere as a cure for epilepsy, a fact which also proves that no risk is attached to the operation. For the method of performing the operation, we refer to the chapter on trephining.

88. Ligature of the Lateral Sinus. Of the intracranial vessels, the lateral sinus, next to the middle meningeal artery, is most frequently the object of surgical interference. The sinus on one side is often divided and ligatured in exposing cerebellar tumours, particularly those situated in the angle near the pons.

The sigmoid portion of the sinus is opened in inflammatory conditions of the tympanic cavity and mastoid cells when the wall of the sinus has been involved, and infective thrombosis and pyæmia are threatened.

[1] *Bruns Beiträge*, Bd. 17. [2] *Ibid.* Bd. 28.

The sinus is reached by trephining over it, when it is incised, cleared out, and plugged. (See chapter on trephining.)

89. Ligature of the Occipital Sinus. The small mesial occipital sinus which extends from the Torcular Herophili to the foramen magnum is ligatured in extirpating cerebellar tumours (*vide* chapter on trephining the cerebellum).

90. Ligature of the Spheno-parietal Sinus. This sinus, which occupies a groove in the bone behind the coronary suture, and which opens into the cavernous sinus, may give rise to troublesome bleeding if wounded in trephining over the temporal region. It may require double ligature.

91. Diploic Veins. Occasionally in the course of trephining, severe venous hæmorrhage may arise from injury to a larger diploic vein, in which case the bleeding can only be controlled by plugging. The veins of the diploë are devoid of valves, and communicate by emissary veins with the sinuses of the dura mater and with veins outside the cranium.

92. Ligature of the Superior and Inferior Ophthalmic Veins. When the orbit is opened from without on account of orbital cellulitis, the question of ligaturing the veins in the orbit, which empty mainly into the cavernous sinus, and to a slight extent into the pterygoid plexus, may arise in order to prevent the backward extension of an infective thrombus, above all to the sinus.

93. Ligature of the Internal Jugular Veins. The internal jugular vein is ligatured during the extirpation of tumours situated high up in the neck, more especially carcinomatous and sarcomatous glands. As a rule, a ligature can be applied at the base of the skull, *i.e.* just below the jugular foramen, without any evil effects.

Occasionally, however, the tumour reaches so near the base of the skull that plugging alone is possible. Plugging is in these cases quite reliable, owing to the presence of the bone, and secondary hæmorrhage seldom occurs.

Madelung in a dissertation [1] collected 11 cases of ligature of the internal jugular vein, in none of which bad results were observed. It is better, however, to follow Schede's advice, and close the vein by lateral suture if possible, when it has only been cut into or partly resected. Schede's results from this operation have been uniformly good.

Ligature of the internal jugular vein plays a very important part in connection with the treatment of complications of otitis media, more especially thrombosis of the lateral sinus. Its object is to prevent the production of embolism from the detachment of an infective clot.[2] It is definitely indicated whenever trephining the mastoid process and clearing out the sinus do not suffice to dispel the signs of general infection.

The operation is performed according to the rules given for ligature of the external carotid (*vide* No. 5 and Fig. 29). The common facial vein is exposed and the ligature is applied at a higher level, provided no thrombus has already extended into the common jugular vein. The common facial or its two tributaries, the anterior and posterior facial veins, seldom call for separate ligature.

94. Ligature of the External Jugular Vein. There is one important point in connection with ligature of the external jugular vein. The vein opens in the angle between the common jugular and subclavian veins (*i.e.* into the innominate vein). Injuries in this situation are apt to be followed by aspiration of air as the mouth of the vein is kept open by the cervical fascia.

Ligature of the vein low down is therefore a necessary precaution, when division higher up cannot be avoided in the course of an operation. The position of the orifice of the vein corresponds closely to the origin of the sterno-mastoid muscle from the clavicle, behind which it lies.

The vein is always divided in operations on the neck in which our normal incision is used (*i.e.* from the mastoid process to the hyoid bone). Accompanied by the great auricular nerve, the vein runs vertically downwards on the outer surface of the sterno-mastoid muscle (*vide* Fig. 29).

[1] Schewen, Rostock, 1887.

[2] Cf. Heine, *Operationen am Ohr*, Berlin, 1904.

95. Ligature of the Anterior Jugular Vein. This vessel, which terminates in the external jugular vein, must be remembered when dividing the sterno-mastoid muscle at its origin. The vein lies behind the muscle.

The anterior jugular vein is much more frequently ligatured in the course of operations in the middle line of the neck where it lies under cover of the platysma. It is systematically tied in goitre operations in which the transverse curved incision is employed (*q.v.*).

96. Ligature of the Subclavian Vein. Next to the "common" jugular, the largest tributary of the innominate is the subclavian vein.

Suture of the subclavian vein should always be preferred to ligature. Schede mentions two cases in which suture was successfully performed, and not long ago we employed a lateral suture in a case where the vein was accidentally torn in the course of the removal of malignant glands. Plugging may also be employed, but it is not to be advised on account of the risk of a clot becoming detached and giving rise to pulmonary embolism.

The vein has, however, been successfully ligatured. A description of the procedure is given in No. 17 and Fig. 36. It must be remembered that the subclavian vein crosses the first rib in front of the scalenus anticus, while the artery passes behind the latter. This makes ligature more difficult on account of the clavicle, especially somewhat externally.

97. Ligature of the Axillary Vein (*vide* Figs. 42-44). The axillary vein is frequently ligatured, *e.g.* in excision of malignant glands adherent to it. The vein lies in front of and to the inner side of the artery. (For its exposure, see the method illustrated in Figs. 42-44.)

98. Ligature of the Veins of the Arm. It is unnecessary to give a special description of the technique for ligature of the veins of the arm, as they pursue a course similar to that of the arteries, with the exception of the cephalic, basilic, and median veins. They, however, rarely require to be ligatured specially, though, perhaps, insufficient attention is paid to the indications for preventing displacement of clot in severe infective conditions of the arm. Their superficial position renders their recognition easy in the forearm or elbow for bleeding or transfusion. The median vein is most frequently selected for this purpose (cf. No. 31 and Fig. 4).

Branches of the Inferior Vena Cava

99. Ligature and Suture of the Common Iliac Vein. Ligature of the common iliac vein is only employed in cases of extreme necessity or where, in consequence of long-continued pressure on the vein, a collateral circulation has been already established. All circumscribed injuries to the vein should be closed by suture.

The vein is exposed by a similar procedure to that for the corresponding artery (*vide* No. 53 and Fig. 53). The left vein lies behind and on the inner side of the artery, while the right vein lies behind the right artery.

100. Ligature of the Hypogastric Vein (Internal Iliac). Ligature of the internal iliac vein is not so serious an operation as is that of the common iliac vein. It is undertaken to prevent the development of puerperal pyæmia in cases where the uterine venous plexuses are thrombosed. Bumm[1] successfully ligatured both internal iliac and ovarian veins in a case of this description, while Trendelenburg had previously carried Freund's suggestion into practice. Bumm's operation was performed intraperitoneally, a method which allowed him to determine exactly the position and extent of the thrombosis. For the technique of ligature of the hypogastric vein, see Internal Iliac Artery (No. 54, Fig. 53).

101. Ligature of the Common Femoral Vein. As a result of Braun's observations,[2] which showed that the femoral vein was almost the only outlet for the blood from the lower extremity, ligature was for a long time carefully avoided. The researches of Kammerer, Niebergall, and Jordan, however, agree with v. Bergmann's

[1] *Ges. f. Geburtsh.*, Berlin, Nov. 1904. [2] *Die Oberschenkelvene*, etc., Leipzig, 1871.

experimental investigations in showing that the risk of gangrene is very slight (only three cases are known), although it is, of course, much greater if the common femoral artery is also tied.

When both the artery and vein are wounded, an attempt must be made to close the vessels by suture, as has been done successfully by Schede. When the vein only is wounded, no ill effects are, as a rule, to be expected from ligature, although suture is a safer method.

102. Ligature of Tributaries of the Femoral and Internal Iliac Veins. There is no particular interest attached to the exposure and ligature of the veins of the lower extremity and gluteal region, as each vein is exposed in the same way as for the corresponding artery. In the case of infective thrombosis and thrombo-

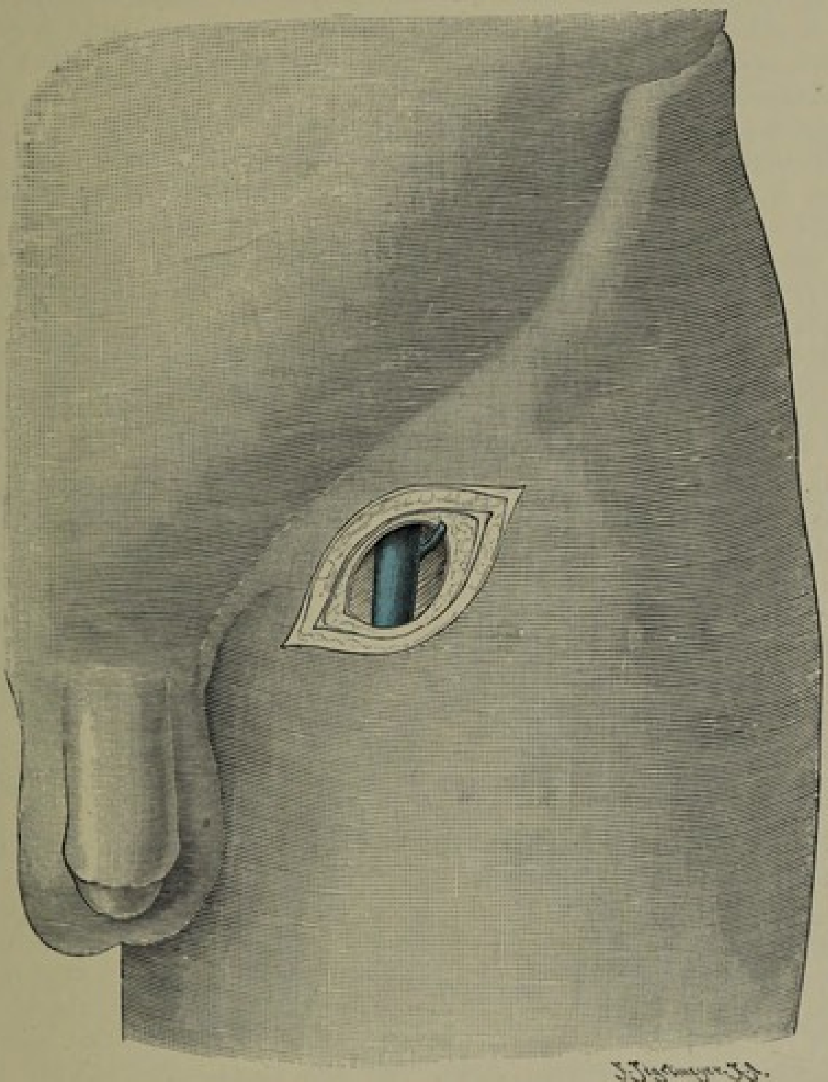


FIG. 75.—Ligature of the long saphenous vein, below where it opens into the femoral vein.

phlebitis, which is so often met with in the deep veins of the calf, more attention should be given to the question of ligaturing the vein high up (*e.g.* the popliteal vein) so as to prevent infective embolism. The long saphenous, and to a less extent the short saphenous vein differs from the other veins in the lower extremity in that it is superficial and does not accompany any artery.

103. Ligature of the Long Saphenous Vein. Of all the veins, the long saphenous is the one most frequently ligatured at the present time. Ligature is undertaken for varix, as a result of the results published by Trendelenburg in 1891.

In the milder forms of varicose veins a complete cure can be obtained by ligature, although in very advanced cases this is not possible. Goerlich [1] obtained permanent

[1] *Beitr. z. klin. Chir.* Bd. 44.

cure in only 27 per cent of his cases; while in 79 per cent improvement or disappearance of the symptoms was noticed.

In the more aggravated cases total excision of the varicose veins (Madelung) gives excellent results. Partial excision of the main convolution, an operation we have performed several times, is also satisfactory. According to Stein, Müller obtained only 50 per cent of good results with Trendelenburg's operation, but 86 per cent with Madelung's.

In very aggravated cases, Tavel[1] has secured satisfactory effects by producing artificial thrombosis in the veins after ligature by means of injections of 5 per cent carbolic (from 1 to 39 injections).

The risk of thrombosis and embolism must never be forgotten, and the operation must be avoided in patients who are the subject of other diseases, or who are debilitated or elderly. We have known a patient to die suddenly from pulmonary embolism the day he was allowed out of bed three weeks after partial excision of a bunch of veins and ligation of the vein above.

The long saphenous vein may with advantage be ligatured for the cure of phlebitis, the upward extension of the thrombosis being thus prevented.

The vein is ligatured immediately above the thrombosed part, when it is opened and the clot removed. Muller of Rostock[2] has reported 20 cases of this description.

In the case of a varix, on the other hand, the operation aims at relieving the hydrostatic pressure. The indication here is to ligature the vein high up, in order to prevent the transmission of the pressure by side branches.

Procedure. (*a*) *Above.* The position of the common femoral artery having been determined by its pulsation, the femoral vein is found, lying to its inner side. An incision is made over the vein parallel to the inner part of Poupart's ligament (Fig. 75). The long saphenous vein pierces the thin cribriform fascia, covering the saphenous opening, to open into the common femoral vein. The lower falciform edge of the fascia lata over which the vein runs should be defined. Care must be taken to see whether the vein is not double, in which case a second ligature is required.

The old operation of percutaneous or subcutaneous ligature is unsatisfactory, for one cannot then tell if the vein is not double, and the ligature cannot also be applied sufficiently high.

(*b*) *At the knee* (see Fig. 65). To expose the vein an oblique incision is made below the internal tuberosity of the tibia on the antero-internal aspect of the limb. The saphenous nerve accompanies the vein. As the position of the vein is not always constant, an oblique incision is more advisable than the longitudinal one shown in Fig. 65.

104. Ligature of the Short Saphenous Vein. Where there are communicating branches between the short saphenous and the long saphenous veins, the former may have to be tied immediately below the point at which it enters the popliteal vein. It is also ligatured in acute infective conditions of the area which it drains.

A vertical incision is made in the popliteal space similar to that for ligature of the popliteal artery (Fig. 62). The vein is found lying on the fascia between the two heads of the gastrocnemius accompanied by the communicans tibialis nerve.

105. Ligature in the Portal Area. As the portal vein is only ligatured for wounds during the course of a laparotomy, no special description of the technique need be given here. Whether more active measures than have hitherto been taken should be adopted in cases of thrombosis, and above all of infective thrombosis, further experience alone can tell.

Ligature of the portal vein is, according to Ito and Omi, fatal, unless a collateral circulation has been previously provided by such measures as omentofixation or Eck's fistula, in which an anastomosis is made with the inferior vena cava. Ligature of the portal vein gives rise to degenerative processes in the liver, which are, of course, capable of compensation.

106. Ligature of the Superior Mesenteric Vein. Mayo Robson (according to Goldmann) has successfully ligatured the superior mesenteric vein for injury. As a rule, however, serious disturbances in the intestinal area follow ligature of the vein.

[1] Dissertation by Stein, 1902. [2] *Ibid.*

SECTION III

SURGERY OF THE NERVOUS SYSTEM

Introduction

THE surgery of the nervous system has now become to a large extent the work of specialists, and requires a long course of careful study. There are, however, certain operations with which every practitioner, not to say every surgeon, ought to be thoroughly familiar, and it is the duty of a text-book on surgery such as this to deal with the technique necessary for such cases.

In a recent article by Harvey Cushing,[1] the present position of the surgery of the nervous system was made the subject of review, and it was shown that the pessimistic attitude adopted by many neurologists towards the surgical treatment of nervous diseases no longer holds good. It is quite unjustifiable nowadays that a patient, who is suffering from increased cerebral pressure with headache, vomiting, and initial blindness, should be left to his miserable fate merely because the physician cannot assure himself regarding the localisation of the original lesion. The effect of intracranial tension must be relieved by operative measures before the stage of blindness commences, if the patient's lot is to be appreciably ameliorated.

A special protest must be lodged against the old routine method of treating every case in which the question of syphilis arose with a prolonged course of iodides, as by this procedure valuable time is only wasted. Cushing recounts the case of a patient who died suddenly under this treatment, and in whom the cause of death was found to be an easily accessible gumma in the situation in which it had been originally diagnosed.

The worst symptoms of disease of the central nervous system are attributable purely to physical and mechanical conditions, as increased tension within the rigid walls of the cranial cavity exerts an injurious and paralysing effect on the central nerve apparatus. Surgery is able, however, to interfere in various ways and reduce this so-called cerebral pressure. It is reprehensible, therefore, not to avail oneself of operative measures immediately the symptoms of pressure make their appearance. Increase of intracranial pressure is readily recognised, and is described in detail in every text-book, both in its chronic and acute form, while every practitioner ought to be familiar with its symptoms. It can be demonstrated by means of puncture, and Albert Kocher has described the very simple procedure that is used in our clinic for this purpose. Quincke has further proved the great advantages of lumbar puncture in regard to the diagnosis and treatment of cerebro-spinal diseases.

In the following pages we shall consider the methods of operating for the relief of tension in the brain and spinal cord.

[1] "The Special Field of Neurological Surgery," March 1905, *Bulletin of Johns Hopkins Hospital, Baltimore.*

A. METHODS OF EXPLORATION AND RELIEF OF CEREBRAL TENSION

1. Puncture of the Skull and Brain. (*a*) *General Remarks.* Neisser and Pollack[1] deserve great credit for their excellent work on puncture of the brain in the diagnosis and treatment of nervous conditions. The authors have drawn attention to the insufficient notice that is taken of these important diagnostic aids in text-books on medicine and neuropathology. House physicians, on the other hand, make extensive use of the procedure, and we know of one medical teacher who systematically punctures with a needle every abdominal effusion, and recommends the advisability of the method to his students. Puncture of the abdomen is, however, much more dangerous than puncture of the brain, as in the former there is the risk of the operator wounding the intestines or other viscera, whereas in the latter there is little fear of him producing any injury if the operation is properly performed.

It is advantageous to adopt a correct method of procedure. Neisser and Pollack attribute the introduction of cerebral puncture for collections of fluid, to Middeldorpf and Maas. Middeldorpf published his investigations on the subject in 1856, and Maas advocated puncture, especially in cases of abscess, as a preliminary to further operative measures. Gibier and Spitzka were the first to make injections into the brain through drill-holes in the skull, while Souchon[2] as a result of numerous experiments laid down the technique in 1899. Schmidt,[3] as a neurologist, deserves the credit for having called attention to the advantages to be derived from surgical exploration, especially in connection with cerebral abscesses originating in otitis media. Schmidt regards the dangers of exploratory puncture as of the slightest description. On the other hand, v. Bergmann has issued a warning as to the risk of puncture with aspiration, while Payr,[4] again, pins his faith to the use of large instruments to puncture with in cases of tumour. It is obvious, therefore, from this discrepancy of opinion that definite restrictions must be established. We shall first, however, consider the technique of exploratory puncture.

Albert Kocher[5] has described the method usually employed in our clinic. The patient is prepared as if for trephining, the scalp being shaved, and thoroughly purified with soap and hot water, and afterwards with ether and alcohol. Fifteen to thirty minims of a 1 per cent solution of novocain, to which two drops of a solution of adrenalin have been added, are injected underneath the epicranial aponeurosis down to the bone, and a sterilised drill is then applied at the desired point, which has been previously determined by a craniometer or by other landmarks, and is driven through the skin down to the bone. The bone is then gently bored through, the operator employing less force according to the depth reached by the instrument. In this way there is no risk of the drill being plunged into the dura after the inner table of the skull has been penetrated.

Once the drill has been applied, it must be kept strictly in the line in which the needle is to be inserted. It must also be withdrawn in the same direction as it was introduced, so that the skin will not occlude the opening. The needle of an exploring syringe, 7 cm. long, is then pushed through the dura in a similar direction. The best instrument to employ is a sterilised "record" syringe fitted with a metal piston, and holding 15 or at most 30 minims. If Schimmelbusch's metal syringe is used, a glass connection must be attached to it in front in order to ascertain if the fluid escapes.

Pignaud's case, which is quoted by v. Beck and instanced as a warning by v. Bergmann, has demonstrated that the fluid must never be forcibly withdrawn, as otherwise dangerous bleeding may result. The object of exploratory puncture is simply to prove the presence of fluid; and only the smallest amount should be

[1] "Die Hirnpunktion," *Grenzgebiete der Medizin u. Chirurgie*, Bd. 13, 1904.
[2] Souchon, *New Orleans Med. and Surg. Journal.*
[3] Schmidt, *Arch. f. klin. Chir.* Bd. 45, 1893.
[4] *Centralbl. f. Chir.*, 1896, No. 31.
[5] *Centralbl. f. Chir.*, 1899, No. 22.

withdrawn. Absolute asepsis is also essential, while the needle must be fine and the syringe well fitting, forcible or excessive aspiration being avoided, if puncture is to be free from danger.

Neisser and Pollack employ an electric drill which they also use for boring through the soft parts, finding that it is no more dangerous than the hand-drill in regard to injury of the dura, and post-mortems on cases which they treated have revealed as little injury as we have found in those which came under our own observation. There is certainly nothing to contraindicate the use of a drill driven by an electromotor, although the fact that Neisser found splinters on the cortex of the brain in three cases would seem to defend the employment of the less rapidly acting hand-drill. The latter has the advantage of being always available, and with a little care the risk of its sudden penetration of the brain can be entirely avoided.

The limit to which exploratory puncture can be carried will be observed from the following brief description of the technique. If the nature of the case cannot be determined by the withdrawal of ½-1 c.cm. of fluid through a fine needle, a larger opening in the skull must be obtained. It is only after exposure of the surface of the brain that large exploring instruments can be safely employed, or that an injury can be immediately rectified if it occurs deep down in the wound. Trephining is so safe and so simple an operation, if a small trephine or Doyen's burr is used, that it is only the greater inconvenience entailed on the patient by the preliminary preparation, and the fact that an anæsthetic is required, that influences an operator in favour of the boring operation we have described. Those who are not satisfied unless large scoops, exploring needles, or spoons are used, must take advantage of a larger drill-hole.

Our method of procedure is eminently suitable, and does not necessitate an incision, when it is desired to make an injection into the brain or lateral ventricles, as, for instance, in the Roux-Borrell treatment of tetanus, in which anti-tetanic serum is injected directly into the brain. A fine needle is required, as the injection must be given as slowly as possible.

(*b*) *Special Indications for, and Technique of, Puncture of the Brain.* A surgeon who has once had the experience in the post-mortem room of finding that his patient succumbed from a collection of blood, pus, or other fluid in a perfectly accessible part of the skull, will never again fail to puncture the brain if there is the slightest suspicion of the conditions we have referred to being present, no matter whether the symptoms are localising or merely those of general cerebral pressure (acting at a distance on vital centres). Paresis, fits, disturbances of sensation, with irritability or apathy, slow or irregular and accelerated pulse, respiratory disturbances of the Cheynes-Stoke or of some similar type, and choked disc with or without symptoms of a definite focus, are all signs which suggest a collection of fluid and which render it imperative to employ cerebral puncture for diagnostic purposes.

Neisser and Pollack refer to their own experiences in a dozen cases, in some of which an unexpected diagnosis of extra- and intra-dural hæmorrhage was arrived at, while in others great relief was obtained by simple puncture followed by aspiration. Further, it is in patients in the advanced stage of cerebral compression, who have severe pressure symptoms, that puncture is especially indicated, for in their case the ordinary trephining operation is too severe, and at the same time relief may be so urgently called for that the delay necessary for the preparation for a larger operation might prove fatal. An operator need then have no hesitation in deciding to perform cerebral puncture, which can be completed in the course of a few minutes with a drill and exploring syringe.

In such cases the exploratory opening of the skull may be undertaken with Doyen's burrs, or in the simple form suggested by us and practised by Neisser and Pollack. As we have already pointed out, whenever there is a risk of puncturing large vessels or where more information is required than mere confirmation of the presence of fluid, a large instrument must be employed for opening the skull. The drill is the classical instrument for this purpose. It never fails, causes no concussion, and enables one to rapidly remove bone, to open the dura, and to examine the surface

of the brain. If it is necessary, the opening can be rapidly enlarged with cutting forceps.

Hæmorrhage from the edges of the bone can always be controlled by means of plugging with wax. The opening itself causes no harm, as, if it is aseptic, it readily closes.

Doyen's drills are well constructed and very serviceable instruments for boring a small hole down to the inner table, after which the opening can be rapidly enlarged with the spherical burr depicted in Fig. 77 (the point of which is blunt) without risk of injury to the vessels in the dura. With a small spoon, sharp only at the sides, the opening in the inner table can be enlarged to the same size as that in the outer table.

Fig. 76.

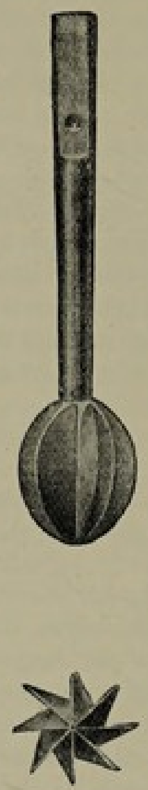


Fig. 77.

Doyen's burrs. That represented in Fig. 76 is used for drilling the hole into the vitreous, while the opening is enlarged with the instrument shown in Fig. 77.

Having removed sufficient bone, if no extra-dural lesion is found, the operator picks up the dura with fine, sharp hooks and a crucial opening is made in it with the knife. The surface of the brain can then be investigated, or, if necessary, examined more deeply with a large exploring needle or grooved director, without danger to the large vessels. In this way it is easy to prevent the occurrence of small extravasations (size of a hazel nut) which Neisser and Pollack observed occasionally after simple puncture. The advantages of the simple operation, in which the drill is inserted through the thicker tissues, are undoubted, *e.g.* in puncture of the posterior cerebral fossa, a procedure which has proved thoroughly successful in the hands of Neisser.

On the other hand, if there is reason to suspect the presence of a tumour, the second operation is more advisable, although Neisser and Pollack localised a frontal tumour by simple puncture, the diagnosis of which would otherwise have been impossible. It must be admitted that if simple puncture or the modification which we recommend for tumours is sufficient to establish the nature of the case, either is of a trifling description in comparison with the osteoplastic operation, and further the truth of Neisser and Pollack's views will be confirmed that even repeated puncture is justified if the approximate position of the tumour can thereby be determined. In Neisser's historic case puncture was performed nine times, in the course of which the tumour was disclosed twice.

To avoid repetition, the reader is referred to the chapter on cranial topography, in which the correct points for puncturing the brain for suspected collections of blood and pus are considered. In the diagram which will be found on page 201, the points recommended by Neisser and Pollack for accurate puncture are depicted. They vary to a certain extent, however, in different individuals, just as the treatment does in certain cysts.

On the other hand, the points at which the needle should be inserted in order to reach collections of fluid in the ventricles are quite definite. It is specially useful to ascertain at what points the lateral ventricle can be reached without the necessity of performing an extensive preliminary operation.

When there is an accumulation of fluid under increased pressure in the ventricle, the withdrawal of this is an established procedure, and some striking results have been recorded from simple puncture of the ventricle. The methods of penetrating the ventricle are very differently described. This may arise from the fact that the puncture of a sound ventricle with its minimum contents is very difficult, because the needle may easily wound the walls, so that it is not easy under normal conditions to establish experimentally the best method. It is easy, however, to enter the

ventricle from various places when it contains a collection of fluid. Authorities are agreed that puncture from the lateral aspect should be performed by passing in from behind and above the ear, over a point corresponding to the posterior end of the temporal line, by which route the floor of the ventricle can be readily reached. In this situation (about 3 cm. behind and above the external auditory meatus) Keen, at a depth of 5 cm., could not merely puncture the ventricle but, by an opening on both sides, could even wash it out. He pierces directly towards the summit of the opposite auricle. Mayo Robson, following Frazier, punctures at the posterior part of the first temporal convolution. In a case on which we operated, in June 1891, we made a puncture directly inwards from the posterior extremity of the temporal crest. We were able to withdraw a drachm of bloody serous fluid, but we did not afterwards succeed in introducing a drainage tube, although the needle was very exactly introduced behind the posterior end of the corpus striatum, above the floor of the lateral ventricle, the evacuation of the ventricle being so complete that the walls had fallen together. It appeared to us, therefore, desirable to puncture parallel to the direction of the sagittal diameter of the ventricle, because when the ventricle contains very little fluid the risk is not run of puncturing the opposite wall, as is the case when the puncture is directed transversely. The ventricle in the sagittal direction is of considerable extent. One can puncture in the sagittal plane, which corresponds with the main portion of the ventricle, from the front, from above, and from behind; but in order to avoid the centres of known function, it is best to pass in obliquely from above and in front, or from above and behind.

Puncture of the ventricle from above. We have as a rule made the puncture in a direction downwards and backwards, somewhat in front of the bregma, 2 cm. from the middle line. The needle must penetrate for a depth of from 5 cm. (2 ins.) before it reaches the ventricle, which it will certainly enter if the latter be distended with fluid. In our experience, too, the drainage from above has proved satisfactory, as the drain in this direction runs the least risk of injuring the opposite wall of the ventricle, so long as it is allowed merely to enter the upper portion of the ventricle, its further entrance being prevented by a ring or flange on the surface of the skull.

Neisser and Pollack also speak favourably of the results of puncture at Kocher's point, and have been able on many occasions to reach the ventricle with accuracy where the latter has been either full or empty.

The points Neisser and Pollack recommend for reaching special parts of the brain are considered in the section dealing with cerebral topography.

2. Trephining for Exploration and for Relief of Cranial Tension (Decompression). These two indications for opening the skull are best considered in conjunction, as they both require a similar exposure of the brain. The method of using the simple burr, by which an opening 1 cm. in diameter can be obtained, has already been considered under cerebral puncture, of which the technique practically is similar. Here we refer only to the formation of larger openings such as were exclusively made in former days even for exploration.

Opening into the cranial cavity is one of the oldest of operations, and fairly correct notions as to the indications for it were entertained at an early date, though associated with fantastic ideas. From history we learn that these indications were at one time regarded as very frequent and at another as very rare. To explain why it was thought at certain periods that trephining could not be done too often, while at others it was believed that a surgeon must himself be "off his head" to trephine a head injury, one has simply to refer to the methods of wound treatment. At the time when infection was prevented, though unconsciously, by all sorts of antiseptic balsams and alcoholic dressings there was as much enthusiasm over the success of trephining as there was despair at other times over the unfortunate result of every injury to the brain and its membranes when wound infection was a daily occurrence. Since the introduction of the recognised anti-bacterial wound treatment, and since its complete development in the form of asepsis, trephining, so far as the danger of infection is concerned, has become just as safe as any other form of operation. Trephining, as performed in the old accepted sense, is now regarded as an operation

free from danger; but when the conception of trephining becomes widened to that of craniotomy and craniectomy we are no longer justified in speaking so confidently.

The diploë of the skull bones differs from other bone marrow in the great number of its blood-vessels. There is a copious supply from the abundant small arterial vessels from without and from within, and a still fuller one through the communications between the external and internal veins, which unite with wide and sometimes sinus-like venous spaces in the bone itself. The diploic veins possess even a less degree of contractility than in other bones. Cushing has shown that the diploë can readily be filled by injections introduced into the sinuses of the dura mater. The diploic veins can, on this account, give rise to very severe loss of blood, especially when there is any increased pressure inside the skull which leads to their increased distension with blood.

It can be confidently asserted that, provided asepsis is guaranteed, there should never be any hesitation about trephining in any case of cerebral pressure. We have regretted many sins of omission in this respect, but very seldom have we had occasion to repent the performance of an operation. Every precaution must, however, be taken to prevent severe hæmorrhage and consequent shock.

(*a*) *Arrest of Hæmorrhage during Trephining.* The arrest of hæmorrhage is influenced to a considerable extent by the selection of the anæsthetic. In excitable and restless patients the venous bleeding is increased by forcible expiration. A suitable local anæsthetic has therefore advantages when dealing with intelligent patients, and when only a limited operation is proposed. Otherwise, one must procure deep narcosis with a general anæsthetic.

Braun, in his excellent work,[1] describes a case in which a recurrent tumour of the brain was removed under local anæsthesia only. According to his testimony, even the dura can be rendered insensitive, by infiltrating the tissues down to the bone (Hackenbruch's method). Heidenhain supports the statement that even the bone and dura become quite insensitive within half an hour after the injection of Braun's solution under the epicranium. He has also removed a cerebral tumour painlessly under local anæsthesia.

In small trephining operations we have always found the dura to be insensitive after local infiltration, while the bleeding from the soft parts as well as from the bone is also diminished.

In this connection Braun has demonstrated that when cocain and suprarenin are employed, the hæmostatic effects of the latter constituent are very considerable, although not, however, sufficient in the case of an extensive operation.

Where local anæsthesia cannot be employed, most surgeons of experience regard chloroform-morphia narcosis as the most advantageous, Horsley in particular drawing attention to the disadvantages of ether. As described elsewhere, a cup of hot tea with brandy and sugar is given an hour before operation, a precaution against post-operative collapse and pneumonia which Heidenhain regards as of great importance. Half an hour before operation $\frac{1}{6}$ to $\frac{1}{4}$ gr. of morphia is injected hypodermically, while subsequently the minimum of chloroform is given by the drop method. Cocain or novocain and suprarenin injected at the site of operation accelerates the anæsthesia. They are administered most effectively ten minutes after the injection of morphia. It must also be remembered that chloroform diminishes the hæmorrhage by reducing the blood-pressure, and that there is therefore always the danger of collapse, to avoid which risk ether may be employed, as recommended by Cushing.

Hæmorrhage from the soft parts can be readily controlled, and it is surprising that the simple and effective measures which can be employed for its arrest are not taken advantage of more regularly.

Heidenhain[2] and v. Hacker[3] insert deep overlapping loop sutures through the entire thickness of the divided scalp. But although this checks the hæmorrhage very effectively, it is a method which is by no means easy to adopt. Strong needles are required to transfix all the tissues of the scalp down to the bone, and if a large flap is

[1] *Local Anæsthesia*, Leipzig, 1904. [2] Heidenhain, *Centralbl. f. Chir.*, 1904, No. 9.
[3] v. Hacker, *Centralbl. f. Chir.*, 1904, No. 29.

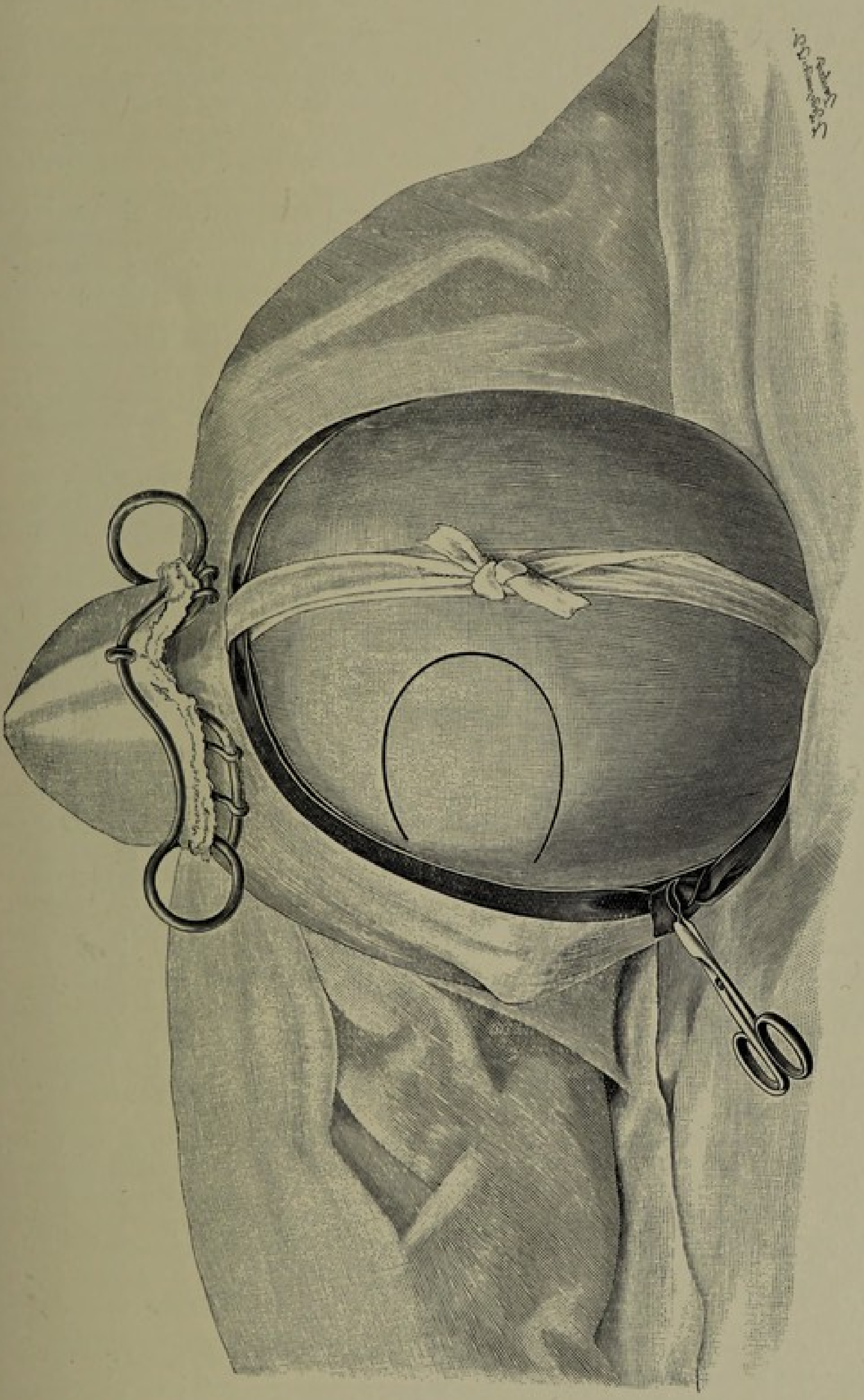


FIG. 78.—Elastic band applied round the skull, at the same time holding the sterilised sheets in position.

turned down, a considerable number of stitch-holes are made and no small amount of strong thread is necessary for this continuous suture.

We have found the method of service in exposure of the cerebellum, when an occipital flap is turned down, but like Hacker we only insert the sutures on the convex (upper) side of the incision, as it is easy to control the bleeding from the flap by pressure on its base and the application of a few artery forceps. Like Heidenhain, we have found that the constriction suture can be retained without any harmful results, even till the wound is healed.

It is quite unnecessary to adopt these measures in the event of the incision being placed above a line joining the glabella to the occipital protuberance, through the attachment of the auricle. The application of Esmarch's elastic band round the greatest circumference of the skull (as practised by Corning and Matas) is much simpler and more effective.

Cushing[1] has described a pneumatic tourniquet which is applied round the head and then inflated, although he has abandoned its use since November 1905, as he found that it could not be submitted to repeated sterilization. He now employs a rubber band, and, to prevent it slipping downwards, he secures it with a bandage passing from the glabella to the external occipital protuberance.

We invariably make use of a strong elastic band about 3 cm. broad, which when stretched is of course of narrower dimensions and which should be knotted at the back of the head, secured with a clamp, and held in position by a gauze bandage reaching from the glabella to the occiput.

The above are the measures to be adopted for the control of hæmorrhage from the scalp during operation. The permanent arrest, however, requires further consideration. At the close of the operation Cushing simply stitches the wound with interrupted sutures and applies pressure by means of a firm bandage. We prefer to close the wound with a continuous suture of strong silk thread including the whole thickness of the scalp. This entirely prevents the possibility of hæmorrhage and does away with the necessity of firm compression, which is not only difficult to apply but in many cases proves unreliable.

Bleeding from the edges of the bone may be more troublesome to control. In our experience we have found that adrenalin injected twenty minutes before the operation (along with novocain) materially diminishes the bleeding even from bone. In any case, it is the large veins which bleed to the greatest extent. According to Frazier of Philadelphia, who has had excellent results in the surgery of cerebral tumours, in operations on the occipital region the emissary veins are sometimes very numerous and present great variations. They may often give rise to great trouble.

No method has yet been discovered by which the hæmorrhage from these veins can be controlled, as they frequently drain off highly congested blood from the interior of the skull. The bleeding is most effectively controlled by plugging the diploë with wax as Horsley recommends. According to Heidenhain[2] the bleeding is materially diminished by the use of rapidly rotating sawing instruments, especially the Cryer-Sudeck burr.

If, as occasionally happens, the bleeding from the bone is so brisk as to be dangerous to life, we have no other choice but to compress (or temporarily ligature) one or both carotids, as Frazier recommends in extreme cases. For this purpose we advise the use of Halsted's metal clamps, instead of circular constriction, as with a metal clamp, the grip of which can be graduated, the large vessels are only partially obstructed, and the danger of severe cerebral anæmia is avoided. We employ small clamps and attach a piece of string to them which enables us to effect their removal even if the wound is practically closed.

The arrest of hæmorrhage from vessels on the dura and the surface of the brain is dealt with in a later chapter.

(*b*) *Partial Circumscribed Craniectomy.* Just as every surgeon ought to be familiar with the method of performing cranial and cerebral puncture, so ought he to

[1] *Med. News*, New York, March 1904.

[2] "Exstirpation von Hirngeschwulsten," *Arch. v. Langenbeck*, Bd. 64.

possess a thorough knowledge of the operation of circumscribed trephining, for in the latter case the indications are generally of an urgent nature, as, for example, in a case of cerebral hæmorrhage with rapidly increasing intracranial pressure.

The appliances already mentioned for the prophylactic arrest of hæmorrhage must always be at hand. (Rubber bandages are best kept in 5 per cent carbolic solution.) It is also advisable to be provided with Braun's novocain and adrenalin tablets, for the production of local anæsthesia, under which limited openings in the skull can be readily effected, and which have a strong influence on the extent of the bleeding.

The old trephine (with a crown about 2-3 cm. in diameter) is still the best instrument when a circumscribed opening in the skull is desired. There is no risk of dangerous hæmorrhage when an opening of this size is made, the wound, if aseptic, ultimately cicatrising very firmly, and ossification taking place to such an extent that one need have no hesitation in entirely removing the disc of bone. On the other hand, the disc may be kept in sterile solution till the completion of the operation when it may be replaced (Cushing).

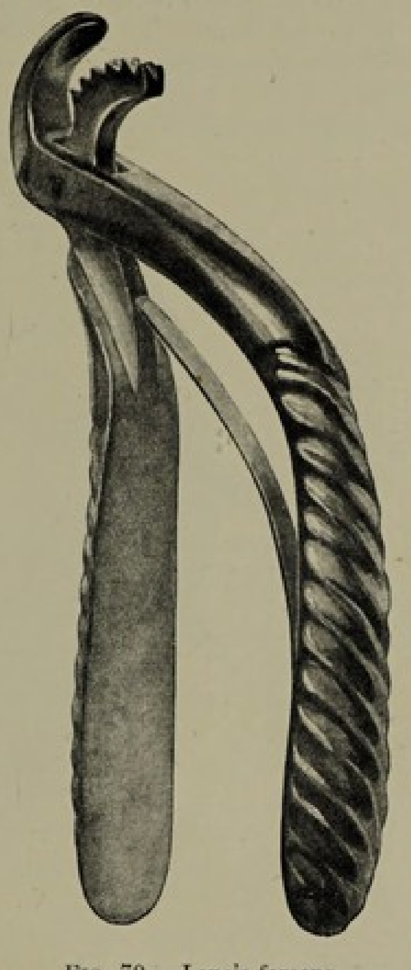


Fig. 79.—Lane's forceps.

A longitudinal incision in the soft parts is sufficient for the removal of a small disc of bone, and the bleeding from the edges of the scalp can be completely controlled by forcible traction with sharp hooks. When the inner table has been penetrated the disc of bone is removed with a strong elevator, and the edges are trimmed with a sharp spoon or forceps. Any extra-dural effusion can be reached by pushing a blunt dissector underneath the bone, should evidence of such not be manifest in the circumference of the trephine opening. To open the dura, it should be seized with fine sharp hooks and incised with a delicate knife through both layers (which are easily recognised), parallel to the vessels, and after it has been raised up as much as possible, the blade of a blunt-pointed pair of scissors can be inserted and the opening enlarged to the desired extent, a second incision being then made in it transversely to the first. Any large vessels in the flaps of dura thus formed can easily be caught and tied with catgut, care being taken not to injure the pia mater.

The brain can now be probed with a large needle or, if necessary, incised without fear of injuring the vessels on the surface. If more room is required, or if the situation of the trephine opening is not quite accurate, it is easy to enlarge the opening in any direction.

Luer's forceps are the best for this purpose, as they do not cause any concussion or splintering of the bone. In an emergency, or if the skull is particularly hard, the opening can be rapidly enlarged with Lane's powerful skull forceps.

(*c*) *Extensive Resection of the Skull.* Although the above method (limited resection) is still employed for exploratory operations, a more extensive resection of the skull is particularly indicated in the operation of decompression. Here it is necessary to remove a large portion of the skull in order to make room for the cranial contents. The indications for this operation are twofold: (1) To relieve the symptoms of general and local pressure in the case of epilepsy (originally suggested by us and made the subject of careful research in 1893). (2) To diminish the intracranial pressure in cases of new growth.

Two important works have recently appeared, one by Friedrich of Greifswald[1]

[1] Friedrich, "Die operative Beeinflussbarkeit des Epileptikergehirns," *Arch. f. klin. Chir.* Bd. 77.

and the other by Cushing of Baltimore,[1] which afford excellent testimony to the value of operation in the above conditions. Following our advice, Friedrich attacks the bone and dura over the motor area, while Cushing devised an original method (intermuscular method) in which he provides for the expansion of the brain by trephining over the temporal region. Both methods have their own indications. Whenever a large portion of the skull is to be removed, a general anæsthetic is essential. At the same time a local anæsthetic may be also used, while all prophylactic measures for the arrest of hæmorrhage must be efficiently arranged so that the incision in the soft parts can be made without the operator being encumbered by any bleeding. When a straight incision will suffice, it is the simpler method, but a curved or flap incision must be made in cases where a considerable amount of bone is to be removed. Friedrich makes a large skin flap similar to that adopted in Wagner's osteoplastic method. The skin incision must always be made 1 cm. or

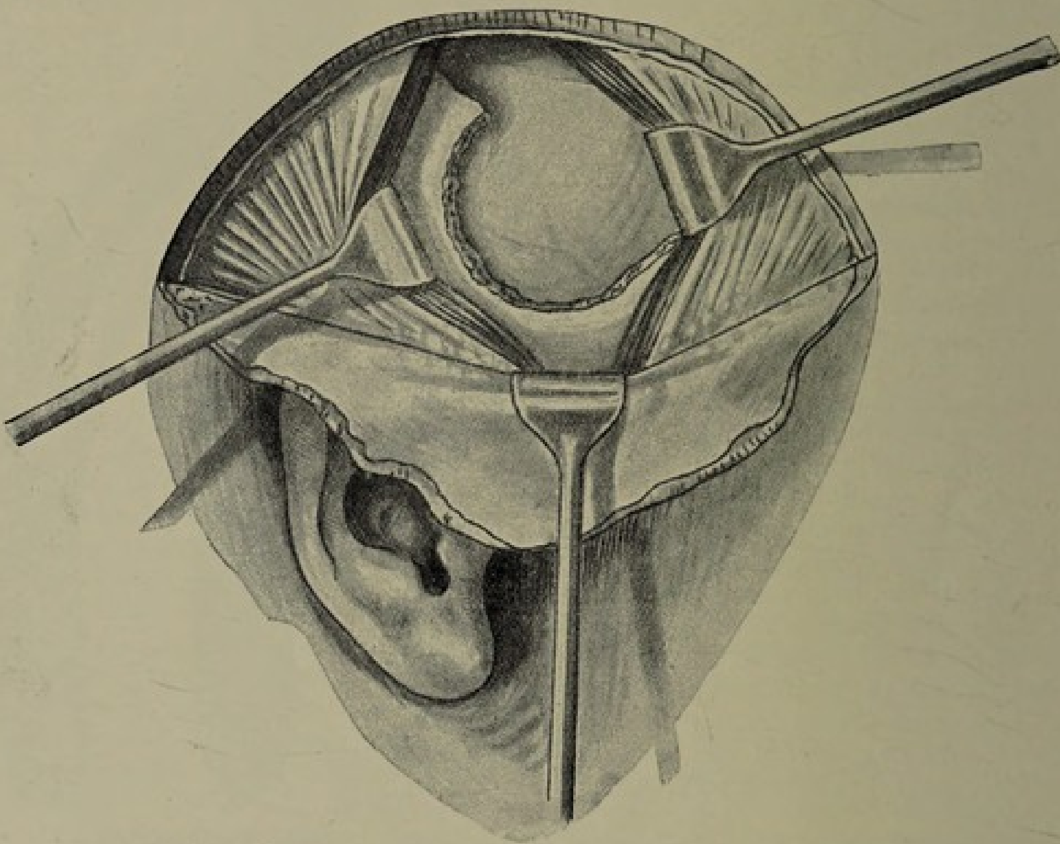


FIG. 80.—Trephining for decompression (Cushing's temporal method).

more outside the circumference of the bone to be removed, and this is still more important when recourse is had to a curved incision (Cushing). The stitches in the skin must never be placed so as to lie over the edges of the bone.

The incision is carried right down to the bone, and the soft parts are raised along with the periosteum with a sharp elevator down to the base of the flap. The layer of muscle must not be injured in any way as it forms an excellent cushion when the soft parts are replaced.

The preservation of the muscles is an important factor in the formation of artificial cerebral herniæ, and is the essence of Cushing's temporal operation (intermuscular) for dealing with cerebral tumours (Fig. 80).

In the latter operation the curved incision only divides skin and fascia which are turned down off the outer surface of the thin temporal fascia. The temporal muscle is incised parallel to its fibres down to the periosteum, the edges are retracted, and

[1] Harvey Cushing, *The Establishment of Cerebral Hernia, etc., Surgery, etc.*, Chicago, Oct. 1905.

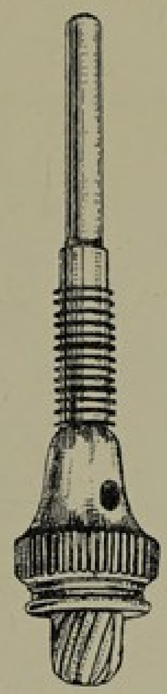
the periosteum is separated and removed. Cushing has obtained brilliant results by this method in inoperable tumours of the brain, and enormous cerebral herniæ have been tolerated without giving rise to subsequent ill effects.

When there is no question of replacing them, large portions of bone may be resected in various ways. It may be said on principle that the simplest method is that in which a small opening is first made and enlarged as required (*vide* the previous section). This is the procedure adopted by experienced cerebral surgeons, such as Horsley, Frazier, and Cushing. The initial opening is made with a trephine, although Friedrich uses the Collin-Doyen spherical drill. Whatever instrument is used for making the original opening, suitable forceps must be employed for its enlargement.

Horsley enlarges the opening with a large-sized Liston's cutting forceps which allow of the rapid removal of large pieces of bone. Lane's forceps are equally satisfactory, but if such instruments are used, the primary trephine opening must not be too small. On the other hand, gouge forceps or Dahlgren's forceps (used by Cushing and Krause) or the Cryer-Sudeck burr (used by Friedrich and Frazier) require merely a small drill-hole to begin with.

Sudeck's rotatory burr, which, according to Frazier, had been previously described by Cryer, and other electromotor drills is very convenient and causes less bleeding from the bone than cutting instruments are responsible for. It occasionally fails or proves very troublesome when employed on a hard thick skull. Dahlgren's and de Vilbis's forceps work admirably for thin bones, such as the temporal (in Cushing's operation), but for dense thick bone strong forceps are more reliable. Krause uses an extra strong pair of Dahlgren's forceps. It is advisable, therefore, to have gouge and Lane's forceps at hand as well as the ordinary bone forceps.

To relieve the intracranial pressure, the dura must be removed as well. It is first incised in the manner described for exploration, *i.e.* in the line of the larger vessels, after which it is divided transversely, and the vessels are ligatured. The pointed flaps of dura so formed are then raised and divided round the periphery of the opening, a procedure which affords less risk of injury to the bulging brain underneath it. Friedrich makes an opening in the bone from 4 up to 8 cm. in diameter, and that in the dura from 3 up to 7 cm. Cushing maintains that for the relief of tension and the formation of artificial cerebral herniæ, the dura should be cut away almost to the edges of the bone. As has already been stated, the pia mater must be carefully preserved while removing the dura. Cushing as a rule makes the opening in the bone from 6 to 8 cm. in diameter. With regard to the closure of the wound, Cushing first unites the temporal muscle with interrupted stitches of fine silk and then closes the soft parts over it. The larger the wound, the more essential it is, in our opinion, to use a deep continuous silk suture which includes all the bleeding vessels.



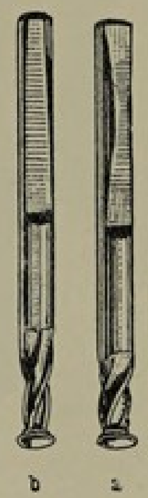


FIG. 81. FIG. 82.
Cryer-Sudeck burrs.

As the exposure of the cerebellum will be considered in a later chapter, the reader is here simply referred to Fig. 83, taken from Cushing's work, illustrating the occipital decompression operation. The incision is made in the form of a crossbow, the arch of the curve being made high up in order to preserve the collateral anastomosis between the occipital and temporal vessels. The vertical limb of the incision reaches down to the spine of the second cervical vertebra, and soft parts and muscles are turned down as far as the foramen magnum.

After removal of the periosteum the thinnest part of the posterior fossa is opened

on both sides, and the opening is enlarged first laterally and then upwards to the lateral sinus and downwards to the foramen magnum. If enlarged towards the middle line, the emissary veins described by Frazier will be encountered and give rise to severe bleeding. The latter are only dealt with when the median bridge of bone is to be removed for the purpose of exposing and ligaturing the occipital sinus.

Cushing also removes the whole of the exposed dura, but expressly states that the

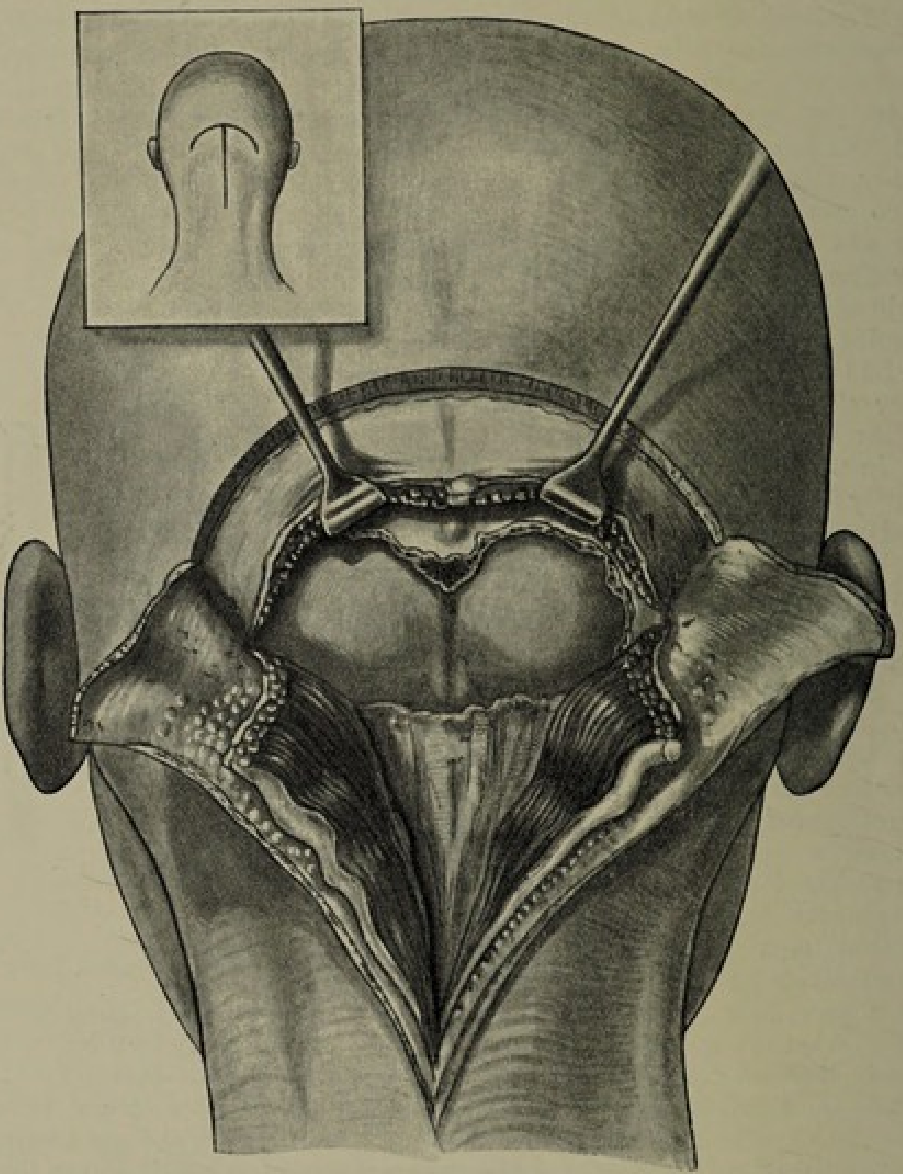


FIG. 83.—Trephining for decompression. Cushing's cerebellar operation.

occipital operation is only to be preferred to the temporal one when there is a prospect of removing a tumour or exposing and removing the original cause of the increased cerebral pressure.

B. OSTEOPLASTIC TREPHINING

3. Osteoplastic Resection of the Skull with the formation of a Flap. Osteoplastic trephining is most commonly undertaken as a preliminary step to operations on the brain itself, be it simply for the application of a ligature or for the removal of a

tumour, etc. The special indications for its use will be discussed subsequently under special heads ; here only the steps of the operation need be described.

Introduced by Wagner, the original method consists in the removal, by means of a horseshoe-shaped or omega-shaped (Ω) incision, of a large flap, placed, as a rule, with its base downwards, and in the formation, with hammer and chisel, of a correspondingly shaped bony flap. This is cut across at its base, and is then turned down, being connected with the rest of the skull merely by the soft tissues, namely, the scalp and the pericranium.

Wagner (Wiemann) preferred flaps measuring on an average 8 cm. (3 inches) high, 7 cm. broad, and 5 cm. (2 inches) wide at the base. Wiemann has recommended for this purpose an angular double-length chisel, bent in the form of a bayonet.

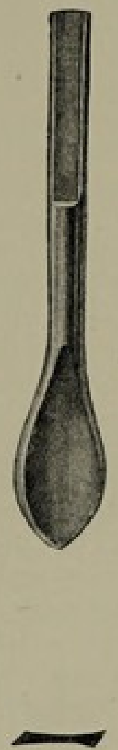


Fig. 84.

The instruments for osteoplastic resection have been perfected by Doyen, special attention being given to those for hemicraniotomy. Doyen forms very large flaps with the base above the ear, bores the bone rapidly in several places with special burrs, and then follows the incision with a circular saw (driven by electricity), possessing a guard which prevents injury to the dura. In this way he is able to turn down an osteoplastic flap in a few minutes. A similarly shaped flap of dura is turned down.

A chisel is now seldom employed except for cutting through the base of the flap, and even then it should be provided with a guard so as to protect the dura from injury. The curved portion of the bony flap is fashioned by drilling a series of holes and dividing the intervening bridges with a chisel, which, of course, should be done expeditiously, as bleeding must be controlled. The hæmorrhage from the drill-holes is slight and may be easily arrested by plugging.

The division of the bone should be carried out rapidly, for the bleeding is greatest at this stage of the operation, and may be so severe as to make the continuation of the operation impossible.

As an osteoplastic resection is as a rule a preliminary step to further operative interference within the cranium, the arrest of hæmorrhage is even more important here than in purely exploratory operations or those performed for relief of tension.

The use of Doyen's electric saw ensures rapidity, but as the dura cannot be sufficiently well protected while handling it, severe bleeding is apt to occur. The method Krause and Cushing recommend may be followed with advantage. By this method a small trephine opening is first made, and the bone, if not too thick, is rapidly cut through with Dahlgren's forceps. Gigli's saw should be used when the bone is thick (Cushing). The saw is passed from one opening to another on a director to protect the dura, or, to follow Frazier's advice, a special opening may be made with the Cryer-Sudeck burr.

Gigli's wire saw, which was modelled on the earlier and more clumsy chain saw, cuts very quickly but is liable to break, so that it is advisable to have a few of the wire saws at hand. The Cryer-Sudeck burrs are much more convenient (Figs. 81 and 82), but require, of course, an electromotor.

The following are the steps of the operation. After a rubber band has been applied round the head, a curved incision of the desired size is made, and the periosteum is divided and separated for a short distance. At one or other extremity of the incision a hole is bored with a trephine or Doyen's burr, and the bone is divided along a line which falls a little inside the incision in the soft parts. The saw line should be made obliquely through the bone so that there may be no subsequent sinking in. The base of the bony flap is then cut through with a guarded chisel.

After the osteoplastic flap has been turned down it is not necessary to incise the dura in a similar way. The latter is so richly supplied with blood that no attempt need be made to preserve the large vessels entering the base of the flap. On the contrary, when the convex border of the bony flap is situated near the middle line

of the head, the dural flap may be inverted *i.e.* the base being placed upwards and the convexity downwards, the large veins in the base of the dural flap being divided.

It is important that the line of incision in the dura should not coincide with the edge of the divided bone. Further, if the bone is to be replaced on the surface of the brain the dura must be retained,—the opposite to what is done in the decompression operation.

The results of osteoplastic trephining in skilled hands are shown in a communication by Cushing (Nov. 1905), in which he stated that out of 100 cases he had not had a single fatality. This shows that, if the proper case is selected, and the technique is good, one need not be so diffident in undertaking it as our experience led us to state in the fourth edition of our work. The indications for operation must, however, be absolutely clear. The fact that half the skull may be turned down with impunity is no excuse for an incomplete or careless diagnosis. Osteoplastic hemicraniotomy must not be undertaken simply for diagnostic purposes. It must be restricted to operations on the brain, particularly the removal of tumours, which require plenty of room.

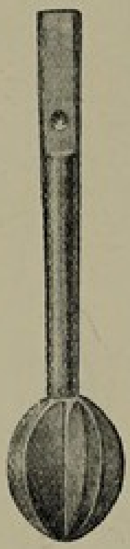


Fig. 85.

It cannot be denied, however, that the osteoplastic operation, in which the flaps are much larger, possesses advantages over simple trephining, because in the latter it is much more difficult to obtain proper subsequent access if the trephine opening is not exactly over the desired spot, or if the deeper part of the wound has to be enlarged.

4. Circular Craniotomy. Lannelongue has put forward the theory that some of the cases of microcephaly and idiocy depend on the fact that the sutures are too soon ossified, and that the box of the skull having become rigid, the development of the brain has been interfered with. He has therefore cut out long strips of bone, and thereby formed artificial sutures. The advantages of this procedure have, rightly, been very much disputed. The best method of procedure is the circular craniotomy, as was first carried out by Dumont, and described by him after conversing with the author about idiocy and microcephaly. It is relatively a less severe operation than hemicraniotomy, and it is attended with less hæmorrhage. We perform it in the following manner: A sagittal incision is made over the middle line of the skull from the forehead to a point above the external occipital protuberance; it divides the skin and occipito-frontalis, which are stripped downwards as a flap with the hand, just as is done in the post-mortem room. The periosteum, which has remained intact upon the bone, is divided horizontally at the level of the bases of the reflected flaps, and the skull is then sawn all round, just as at a post-mortem, but not at such a low level.

One place is drilled through with a Sudeck-Kümmel spherical burr, and a hole, about 2 cm. in diameter, is made down to the dura, which is then carefully separated from the bone. The dura is more adherent to the bone at the situation of the sutures, and to some extent also where the vessels lie. A strip of bone, ½ cm. broad, is rapidly removed with cutting forceps. Opposite the longitudinal sinus, in front and behind, one must be especially careful in separating the dura from the bone; but even here it can be easily accomplished.

In this way the roof of the skull becomes quite movable; but it is necessary to divide the dura to prevent ossification proceeding from it, the importance of which, as we have already mentioned, has recently been pointed out by Beresowsky in connection with the process of healing of trephine openings. The main meningeal vessels are not divided, but, as recommended by Beresowsky, are left *in situ* as bridges.

The operation is attended with very slight hæmorrhage in children. Should the bleeding be severe, it is recommended to postpone the division of the dura for two days. The skin flaps are simply folded back into position and united by a

continuous suture. We have performed the operation at one sitting without causing any shock, and have used merely a collodion dressing; but where there is any bleeding of importance it is better to apply pressure of bandage.

5. Craniotomy for the Covering in of Osseous Defects in the Skull. The question as to how defects of the skull may best be covered in has occupied surgeons of late years more than is necessary, and has exercised their inventive faculties. Doubtless the peculiarity of the cerebral circulation is dependent on the presence of a capsule which is essentially tense. Small defects are, thanks partly to the osteoplastic properties of the outer layer of the dura, as a rule, eventually closed. Sometimes, however, the deficiency becomes filled with such a firm scar that no injury to the circulation in the skull accrues. For this to occur a very large defect is requisite. The covering in of such defects has, however, distinct disadvantages, especially when the contents are pathological.

In this connection the case described by Depage is very interesting, where, on account of a lesion of the lateral sinus following a comminuted fracture, an extensive trephining was performed with resulting hernia cerebri. The slight intellectual disturbances, especially affecting speech and intelligence, were very distinctly improved as soon as a firm plate was applied, but led repeatedly to epileptiform attacks from the pressure connected with its use.

It has to be proved, therefore, especially in regard to post-traumatic epilepsy, whether, when a large defect in the skull is associated with intellectual disturbances, a firm closure with pressure produces real benefit, and whether this is attainable without injury. If this is so, then an endeavour should be made to obtain a covering.

The best means of securing a good bony covering is that of the Müller-König autoplastic method. The flap, as in other plastic operations, is pedunculated, with its base directed towards the vessels supplying the scalp, and is taken from the immediate neighbourhood. Instead of merely raising the pericranium and skin from the bone, the outer table of the bone is taken along with them by means of the chisel or a fine saw (Nicoladoni). The distinctive feature of this operation is that not only is an excellent bony plate obtained, but, as we shall point out later in speaking of resections and amputations in general, the osteoplastic layer of the surface of the bone, *i.e.* the deep layer of the pericranium, is retained quite intact. The fact that the bone breaks into splinters has no disadvantage whatever. The layer of bone which is laid bare in the neighbourhood of the flap is covered by transplanted skin.

If one wishes to obtain a really solid closure, it is desirable that the transposed bony layer be firmly connected with the sound bone. This applies in particular to all methods of covering, whether by applying bone from other portions of the body or by applying other materials. Martens has recently, on Eiselsberg's suggestion, studied the behaviour of transplanted bone in defects of the skull, and has come to the following conclusions: Decalcified bone, recommended by Neuber, Senn, and Kümmel, delays the healing, because it must first be absorbed. Burnt bone, recommended by Landerer and Barth, and proved to be of value by the latter from numerous investigations, in that it brings about healing of bony defects solely on account of the introduction of lime salts, causes a very slow healing, because it opposes little resistance to the penetration of the granulations. The best material for this purpose is a firmly-placed boiled layer of bone, as recommended by Westermann and David.

According to Barth, the implanted material itself disappears, but into this solid layer of boiled bone granulation tissue grows from the diploë, from the dura, and from the pericranium in the well-known fashion, and rapidly takes on the form of the absorbed implanted material. Cancellous bone is more easily grown into than compact cortical bone. Instead of taking the substitute, as Czerny does, from the inner surface of the tibia, it is better to saw out a slightly curved layer of bone of the necessary shape from the epiphysis of the tibia by means of a fine double-edged saw (similar to that used for opening the spinal canal in the post-mortem room), and to place it securely in position. If dead bone be employed it must be boiled.

In the strictly heteroplastic method, the celluloid plates of A. Fränkel have advantages over the others, as they are readily disinfected and easily obtainable.

Fränkel very rightly starts with the idea that it is not desirable that adhesion should take place between the implanted portion and the cerebral membranes, as is unavoidable in the granulation formation to which the implanted bone gives rise. But it should be mentioned that these adhesions between dura and skull bring about no real disadvantages, and that, according to Beresowsky, it is only in defects of the dura that adhesion with the inner membranes of the brain is to be feared. Further, it is only an intact pia which can afford protection against cicatrical processes extending to the cerebral cortex.

It is well, therefore, when the pia-arachnoid is laid bare, to follow Fränkel's advice and to interpose a layer which does not lead to adhesion with the subjacent membrane, either his celluloid plate, as a permanent heterogeneous layer, securely introduced without drainage, with suture of the skin; or (as we have elsewhere mentioned, on the grounds of Beresowsky's investigations) we may employ auto- or hetero-plastic bone, one of the serous membranes (for example, a piece of tunica vaginalis) being introduced as a smooth under-layer to protect the pia against the growing granulations.

Schifone[1] (Durante's clinic) has published the results of thirty-two trephining operations on dogs, in which he found that large defects in the skull and dura were replaced by dense connective tissue which ultimately became adherent to the cerebral cortex, and led to partial disappearance of the nerve elements (ganglion cells) and the substitution of neuroglia. No motor or sensory disturbances (epilepsy or prolapse of the brain) were observed.

C. SPECIAL INDICATIONS FOR TREPHINING

There can be no service rendered in considering at this stage the numerous conditions in which trephining may be indicated, so that only a few necessary indications will be discussed, from which the technique of the operation can be readily deduced.

6. Trephining over the Sinuses of the Dura Mater. The superior longitudinal, occipital, and lateral sinuses can all be easily exposed, and, if necessary, ligatured, being exposed in certain injuries to the skull, and ligatured if the lesion is extensive. When the sinus is only slightly injured, as happened, for example, in a case of gunshot injury which recently came under our observation, plugging is the simplest remedy; but when an infective thrombosis has to be faced, a condition most common in the lateral sinus secondary to inflammation of the middle ear and mastoid cells, the question of opening and clearing out the sinus and subsequently plugging it has to be taken into careful consideration.

(*a*) *Trephining over the Superior Longitudinal Sinus.* Ligature of the superior longitudinal sinus has been recently recommended by Delagenière in the treatment of epilepsy, a suggestion made as the result of an accidental discovery. The circulatory disturbance produced by ligature is of the slightest description, as the large veins on the surface of the brain which open into it ramify in various directions and form quite a sufficient collateral anastomosis.

Similarly, interference with the cerebral circulation is seldom to be expected, except in the sense that from the sudden obstruction produced in the sinus by the application of the ligature, the blood contained in it cannot find its way directly into the veins in the anterior portion of the brain. The ligature should therefore be applied on the central side of the point at which the veins proceeding from the affected zone of the cortex enter the sinus. In our opinion this method of treatment should not be attempted without due consideration, as we have known a hemiplegia to result.

The superior longitudinal sinus lies, according to Horsley, entirely to the right of the mesial plane, but this is disputed by Dana. It is very broad (1 cm. according to Poirier) and, including its lacunæ, measures as much as 3 cm., so that at a distance

[1] *Deutsche Zeitschr. f. Chir.* Bd. 75.

of $1\frac{1}{2}$ cm. from the middle line the bone must be cautiously divided and the dura carefully separated. The thin walls of the lacunæ are more readily torn than the walls of the sinus itself.

When it is necessary to wound the dura in the neighbourhood of the sinus, it is well to provide sufficient space, in order to be prepared for all emergencies, for there are communications here with the diploic veins (spheno-parietal sinus), and

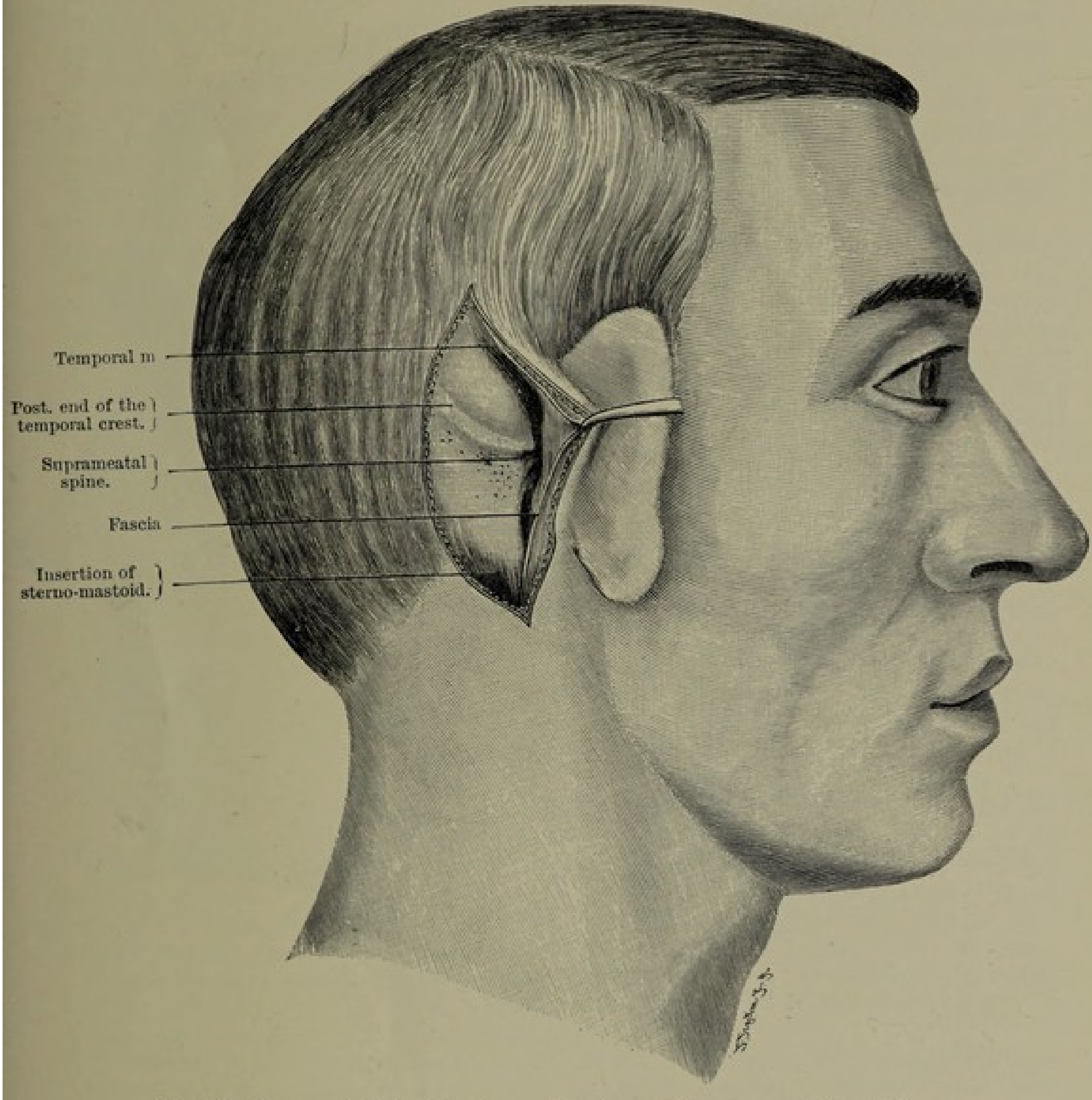


FIG. 86.—Post-auricular incision for opening the mastoid antrum, the lateral sinus, and the descending cornu of the lateral ventricle.

the large central veins arising from the surface of the brain open into the sinus and the lacunæ. Bleeding from these can only be properly controlled by careful ligature.

Ligature of the sinus is not an easy operation to perform, as the needle (aneurysm or sharp) may readily injure lacunæ or the entering veins. After the bone has been raised from the sinus and removed, it is more advisable to open the dura on both sides of the sinus, and pass the needle which carries the ligature from the one opening to the other.

(*b*) *Trephining over the Occipital Sinus.* The occipital sinus is formed by the

downward continuation of the superior longitudinal sinus below the level of the external occipital protuberance. It is ligatured in providing relief for cerebral tension as well as for the removal of cerebellar tumours. As already mentioned, when trephining is undertaken for decompression, it is often difficult to arrest the hæmorrhage which arises from the division of emissary veins near the middle line during the exposure and ligature of the sinus.

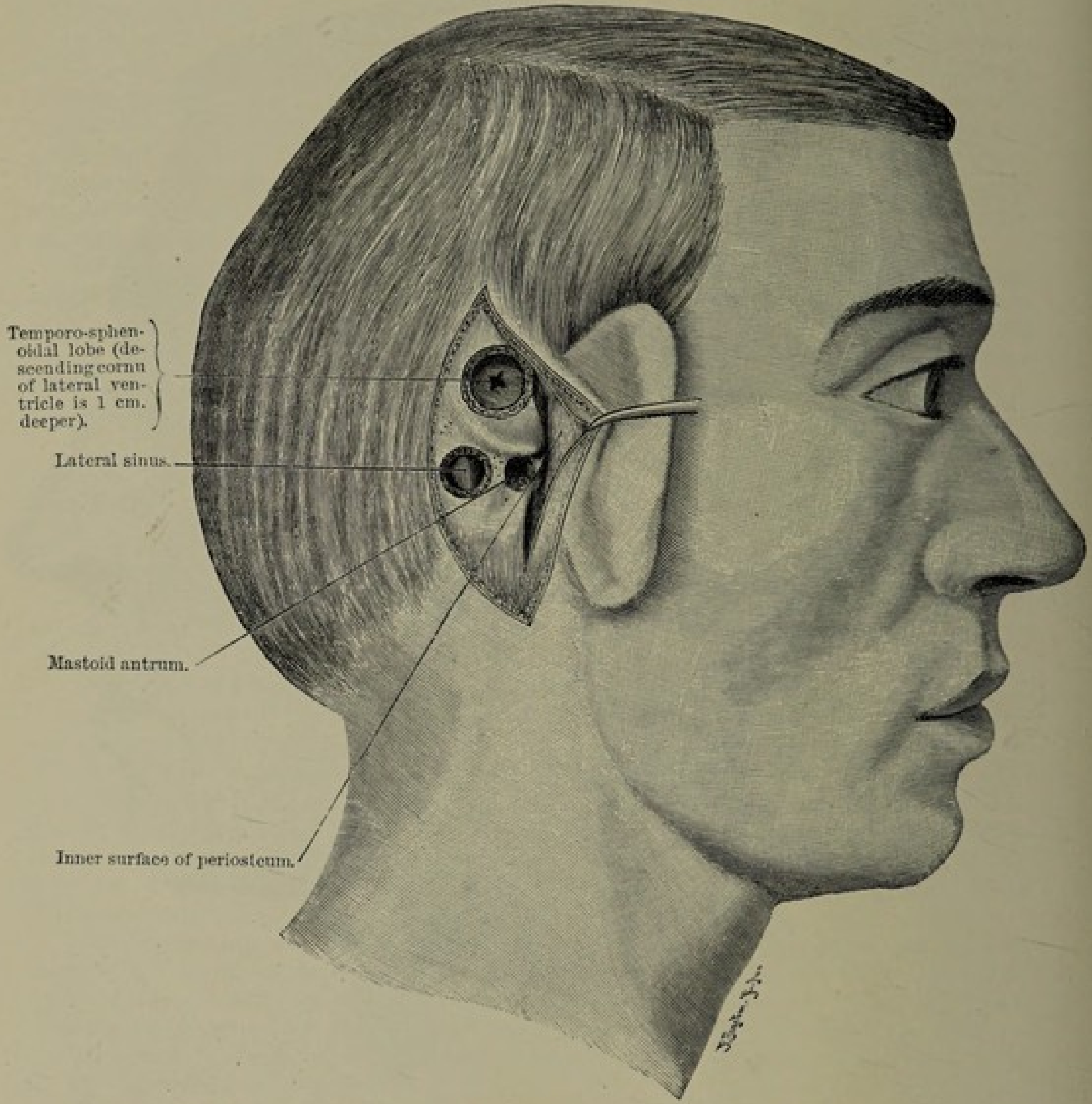


FIG. 87.—Opening the mastoid autrum and the lateral sinus. Exposure of the temporo-sphenoidal lobe and puncture of the descending horn of the lateral ventricle.

(c) *Trephining over the Lateral Sinus* (Figs. 86 and 87). This is a comparatively frequent operation, because thrombosis and suppuration occur most frequently in this sinus in consequence of its implication in inflammation of the middle ear. It is especially the descending limb of the sinus with which we are concerned in this operation. The point for trephining is determined by feeling for the most prominent part of the base of the mastoid process, which forms a projection behind the attached margin of the auricle. There is a ridge, a finger's-breadth higher, which passes obliquely backwards and upwards, and corresponds to the posterior extremity of the

temporal crest. Between this ridge and the above-mentioned prominence, on the inner surface of the bone, is the lateral sinus. It corresponds to the posterior part of the middle third of the mastoid process, and can be followed a little farther downwards beyond it. With the auricle applied to the skull, an incision is made corresponding to its posterior free border (Fig. 86). Superiorly, the incision divides some fibres of the temporal muscle. The periosteum is divided at the same time, and the flap is separated forwards, the attachment of the sterno-mastoid being detached with the knife and the posterior margin of the wound retracted backwards. On chiselling through the bone the wall of the sinus is exposed. The emissary mastoid vein traverses the bone opposite the middle third of the mastoid process.

Death followed injury to the lateral sinus in all the eight cases collated by Gargolphe and Picry. Depage, in February 1900, had a recovery by plugging, in a patient in whom a splinter of bone had wounded the sinus. Much more frequently, however, we desire to avoid opening the sinus in operations in this situation, especially in opening the mastoid cells.

On the other hand, we have to open the sinus in cases of infective thrombosis resulting from mastoid disease. Before opening it, we do well to partially detach the wall of the sinus from the groove in the bone in which it lies, so that, after the thrombus has been removed, the hæmorrhage may be effectively checked by packing between the bone and the sinus wall.

7. Trephining for Intracranial Hæmorrhage. (*a*) *Trephining in Intracerebral and Subdural Hæmorrhage.* Trephining is not only indicated in meningeal hæmorrhage, especially from the middle meningeal artery, but more recently surgeons have gone a step farther and endeavoured, in cases in which the hæmorrhage is more deep-seated, to relieve the general cerebral pressure and the local damage produced by the extravasated blood.

But the indications for operation in such cases are not so definite as they are in extradural hæmatomata, the result of laceration of the middle meningeal artery. Schulz[1] reports a case (trephined by Henle in the clinic at Breslau) in which 6¼ ounces of blood were extravasated beneath the dura in the frontal region. The indications for operation were found in descending neuritis of the right optic nerve with amblyopia, injury to the right oculomotor, with ptosis, and some interference with the movements of the eyeball, anosmia, and, particularly, in paresis of the opposite (left) leg, with increased reflexes, and paresis of the left lower branches of the facial nerve.

These multiple focal symptoms, as well as the affection of the leg without the arm, Schulz considers of special importance as pointing to the diagnosis of an intradural, rather than an extradural, hæmatoma, because the blood in the former may have a wider and more unequal distribution. Multiple nerve lesions at the base of the skull, so far as they are not to be explained by fissured fractures, may, if other circumstances point in that direction, lead to a diagnosis of intradural hæmorrhage, because the dura is with difficulty stripped off in that region. Simultaneous paralysis of the optic and oculomotor nerves alone, as also choked disc on the same side, are by no means unusual, even with extradural hæmatomata.

We may direct special attention to a further peculiarity, namely, that in subdural hæmatomata it occasionally happens that the paralysis is not "crossed," and is therefore liable to suggest an extradural, or a central, lesion of the opposite side.

Stabel reports a case of right subdural hæmatoma (90 c.c.), operated on by Hahn, in which there was deviation of the head and eyes to the right, complete paralysis of the right lower facial region and of both right extremities, while on the left side there was merely spasm, with increased reflexes in the leg and arm. We cannot accept Stabel's explanation of an anomalous course of the nerve tracts, but, as shown in discussing local cranial pressure, we regard the right-sided paralysis as due only to displacement of the falx cerebri. We have published a case, after personal observation, which proves that, in intradural extravasation, the local pressure is much less than the general or conducted pressure, because the blood distributes

[1] *Inaug. Diss.*, Breslau, 1897.

itself more, and may cause a lesion of the opposite cortical centres (in Hahn's case there was great tension of the dura on the opposite side), or may interrupt the conduction along the fibres of the corona radiata.

By trephining, not only may the blood extravasated under the dura be removed, but the source of the blood may be discovered and the hæmorrhage successfully arrested by ligaturing the bleeding artery on the surface of the brain. Schneider[1] of Königsberg, for example, in a case of punctured wound in the left temporal region, with aphasia and increasing right-sided paresis, trephined, divided the dura, cleared out the extravasated blood, ligatured a spurting branch of the middle meningeal artery, and sutured the dura with catgut. The hemiplegia improved on the second day after the operation and the aphasia on the third day.

Mention must be made of the aid to the diagnosis of subdural hæmorrhage afforded by the presence of blood in the cerebro-spinal fluid drawn off by means of Quincke's lumbar puncture.

Intracerebral hæmorrhages which have given rise to hemiplegia have also been successfully treated by trephining and opening into the extravasation so as to let out the blood.

Horsley insists on the necessity of surgical interference in contusions of the brain, and in extravasations of blood into the substance of the brain. In his communication to the International Medical Congress in Berlin, 1890, he stated that he could not recollect a single case where he would not have interfered in complicated cases of laceration of the brain, whether recent or of old standing. Further, he also advises active measures in all cases of simple laceration of the brain, in order to prevent the occurrence of epilepsy sooner or later. He referred, in this connection, to a case which was saved by operation, and contrasted it with a similar one with expectant treatment in which death occurred (with coma and convulsions) within eight days. The successful case was that of a medical man with extensive laceration of the frontal, parietal, and temporal lobes, in whom hemiplegia and unconsciousness had existed for ten days and was followed by coma and Cheyne-Stokes respiration. By means of extensive trephining and washing out of the blood-clot, which occupied the entire left subdural space, complete recovery resulted, so that the patient was able to resume the practice of his profession.

Cushing[2] has also reported a number of interesting cases of fracture of the base of the skull in which he removed and washed away subdural effusions of blood. He trephined over the temporal bone (intermuscular method) and the patient recovered without further disturbance. He further holds that where bulbar symptoms develop after a head injury, the occipital bone should be trephined on both sides of the middle line.

By his advocacy of trephining in the new-born, Cushing has opened up an important range of possibilities, which the obstetrician must take into careful consideration. In a paper published by him[3] dealing with subdural hæmorrhages in the new-born, he states that he found in still-born children and in children who died soon after birth, that the cause of death was most frequently due to hæmorrhage on the surface of the brain.

The hæmorrhage most commonly arises from the large mid-cerebral veins, which tear at their upper end during the over-riding of the parietal bones. In this situation they are most easily torn, as in traversing the subdural space they are least supported. Hence the thickest deposit of blood is found over the upper end of the motor cortex in the region of the centre for the lower extremity. It is here also that the lesions are chiefly found in spastic cerebral palsy (Little's Disease). In fractures of the base, the basal ganglia chiefly suffer, and cases of athetosis are attributed by Cushing to this cause.

When the symptoms all tend to the presence of a subdural hæmorrhage, *i.e.* when there are bulging of the fontanelle, slow pulse and respiration, dilated pupils, and convulsions, and moreover when blood is found mixed with the spinal fluid after lumbar puncture, the brain should be exposed and the clot removed by turning down

[1] *Arch. für klin. Chir.*, 1886, Bd. xxxiv. [2] *Loc. cit.*

[3] "Intracranial Hæmorrhages of the New Born," *Amer. Jour. of Med. Sc.*, Oct. 1905.

an osteoplastic flap of the parietal bones. Cushing has effected this with success on both sides.

Subsequent spastic paralysis can thus be prevented, as well as the epileptic and other mental disturbances associated with changes in the brain following a hæmorrhage.

Trephining may also be performed with benefit in non-traumatic hæmorrhage, as was proved by the brilliant cure of a case recently under the care of Khol of Chur. In the cases described by A. Fränkel, and correctly differentiated by him from pachymeningitis hæmorrhagica interna, there was found upon the brain at one time 200 c.c., and at another 140 c.c. of fluid blood. These cases clearly show that at any rate immediate death from cerebral compression is to be avoided by relieving cerebral pressure. The presence of spasms amounting to a tetanic condition, and of unilateral nystagmus along with other symptoms of cerebral pressure (fixation of the pupils, etc.), allows the diagnosis to be made with sufficient certainty.

Abernethy long ago drew attention to the bloodlessness of the bone overlapping large subdural hæmorrhages, a fact which we were able to confirm in December 1897, in the case of an old man. For further information we must refer the reader to the author's work on cerebral compression and concussion in Nothnagel's *Pathology*.

(*b*) *Trephining for Supradural Hæmorrhage.* We agree entirely with Krönlein that the first object of the trephining, even in hæmorrhage of the cerebral meninges, must be to find the hæmatoma, or, more correctly, the hæmatomata. The removal of 50 c.c. of blood-clot may not be sufficient where there are signs of obvious cerebral compression. According to Wiesmann, pressure symptoms may be entirely absent even with 75 c.c., and this is in agreement with experimental observation; on the other hand, hæmorrhages have been seen to amount to 250 c.c. before death occurred, *i.e.* over $\frac{1}{6}$ of the normal weight of a man's brain (1430 grams), or exactly $\frac{1}{6}$ of the normal volume of the skull (1500 c.c.). When, therefore, the escape of blood at the site trephined is too small to account for the symptoms, it is advisable to search in another place.

It is only after the blood has been removed that the question of ligature of the bleeding artery arises. Most frequently we have to deal with the middle meningeal artery. Bleeding from this vessel terminates fatally, according to Wiesmann, in 90 per cent of the cases in which no operation is performed, while 67 per cent are cured by operation. The middle meningeal artery supplies the membranes of the brain. Jacobson gives the point for ligaturing it as 5 cm. (2 ins.) behind, and 1·2 cm. above, the external angular process of the frontal bone. As a rule Vogt's point is chosen. This point lies two fingers'-breadth above the zygomatic arch, and a thumb's-breadth behind the external angular process of the frontal bone; but it strikes only the anterior branch of the artery.[1] In order to expose the posterior branch at the same time, the trephine must be applied immediately above the middle of the zygomatic arch. In addition to the integuments and the periosteum, some vertical fibres of the temporal muscle are divided. A vertical incision extending below the zygomatic arch cannot be made on account of the distribution of the facial nerve. We employ an incision extending obliquely from the external angular process of the frontal bone,[2] downwards and backwards, to the posterior extremity of the zygomatic arch, and from thence, upwards and backwards, to above the auricle. After we have divided the skin and the strong temporal fascia, and ligatured the superficial temporal artery, the incision is carried down to the bone at the posterior border of the temporal muscle, and this muscle along with the periosteum is detached forwards. In this way hæmorrhage from the deep temporal arteries is avoided, and the anterior part of the squamous temporal, under which the meningeal arteries lie, is exposed. The bone here is very thin. Poirier (and we agree with him) recommends trephining 5 cm. (2 ins.) above a point midway between the external auditory meatus and the frontal process of the malar. The temporal bone is exposed and a portion, 3 cm. in diameter, chiselled out above the zygoma. The middle meningeal artery lies on the superficial surface of the dura, being occasionally imbedded in it.

[1] Cf. Merkel's *Anatomie*, S. 65.

[2] In Fig. 90 the anterior incision is drawn too deep in its anterior half.

Krönlein, who has had great experience of bleeding from the middle meningeal, has determined the two points at which the extravasation from the anterior and posterior branches of the artery is most likely to be met with. These two points of Krönlein lie in a line drawn horizontally backwards from the supraorbital margin, that for the anterior branch being 3 to 4 cm. behind the external angular process of the frontal bone, while that for the posterior is where the above line intersects a line drawn vertically upwards from the posterior border of the mastoid process. For

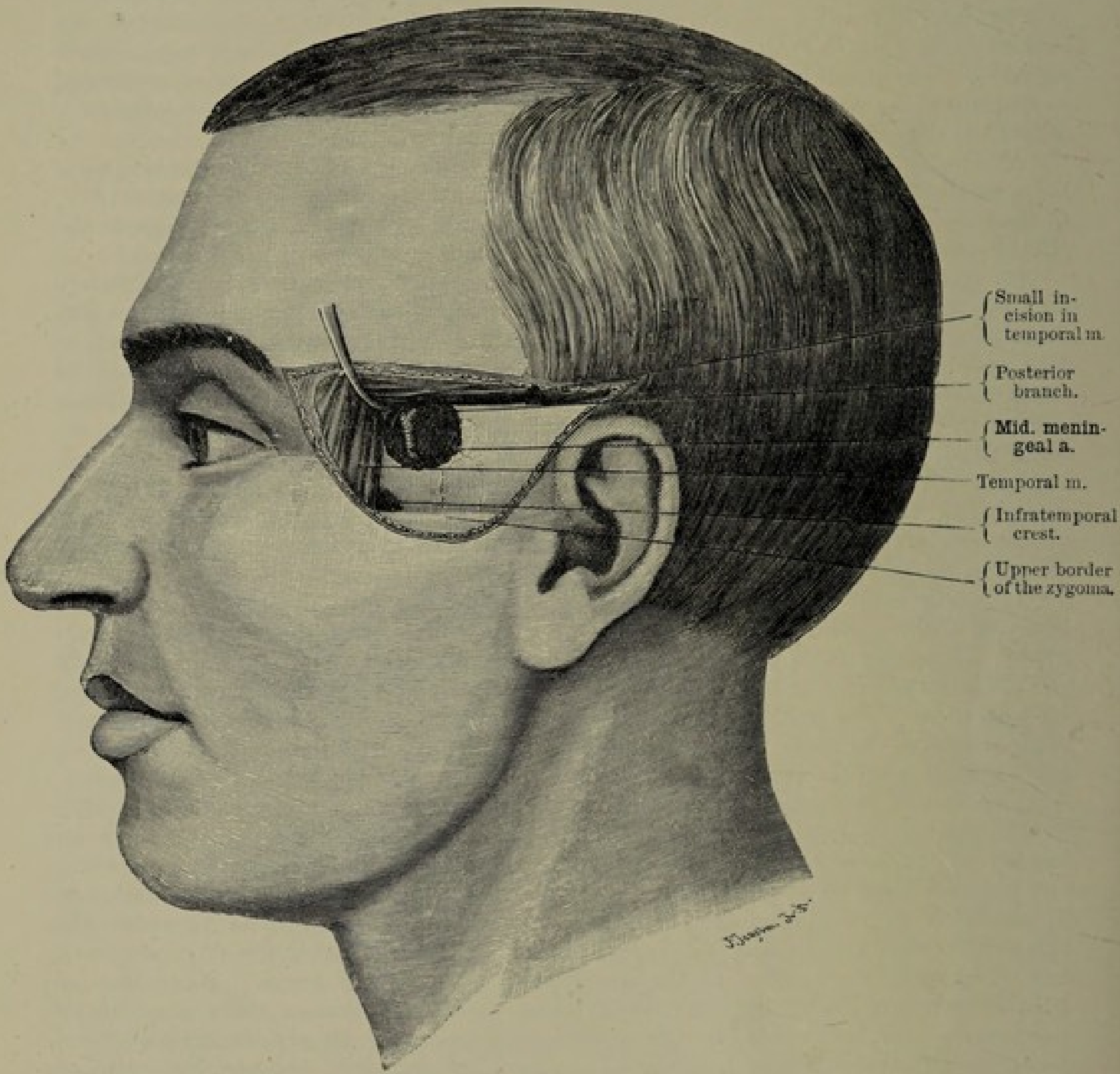


FIG. 88.—Ligature of the middle meningeal artery.

extravasations (as he once observed), which reach almost as far as the foramen magnum, Krönlein gives a third point for trephining, viz. below the middle of the right or left half of the superior curved line of the occipital bone.

Steiner, after investigating a hundred skulls, has found the anterior branch invariably at the crossing point of a vertical line drawn from the mid point between the middle of the glabella and the apex of the mastoid process, with a horizontal line drawn from the middle of the glabella around the skull. The posterior branch, in 90 per cent of the cases, is at the crossing point of the above-mentioned horizontal line, with a vertical line drawn upwards in front of the mastoid process.

8. Trephining for Abscess of the Brain.—Cerebral abscesses, like subdural abscesses, most frequently arise from an extension of the inflammatory process in the coverings of the brain (skull and soft parts), the inflammation either originating in an external injury (complicated fractures) or in a cavity lined by mucous membrane (nose, frontal sinus, and particularly the middle ear). The abscess may further be metastatic in origin (*e.g.* in osteomyelitis staphylomycotica).

When due to an injury, a cerebral abscess may occur in any situation, usually, however, on the convex surface of the brain, the antiseptic treatment of the wound having prevented the outbreak of a diffuse meningitis. The skull in such cases is trephined over the seat of the injury.

In regard to the method in which trephining is performed, it is most important, when once suppurative inflammation has occurred in the region of the brain, to provide absolutely free drainage by extensive removal of bone. An osteoplastic operation is, of course, not to be considered.

If there is an existing defect in the bone, *e.g.* a depressed fracture, the latter must be enlarged with cutting forceps, or with Lane's forceps if the bone is very hard. The extent of the subdural collection of pus must then be determined, and the bone completely removed for a corresponding distance. The dura is then thoroughly cleansed and opened, the size of the opening depending on the extent of discoloration present. Occasionally the dura in the region of an abscess appears markedly pale. The position of the abscess having been determined by means of cerebral puncture, the larger vessels on the surface of the dura are ligatured, after which the dura is incised, and the abscess freely opened.

Unless the opening has been made sufficiently large, it is apt to become occluded by prolapsed brain, with the result that the pus spreads laterally, and in a few days has to be evacuated at the sides of the trephine opening.

We lately operated on a patient in whom a cerebral abscess had ruptured into the lateral ventricle (posterior horn). For some days the pus escaped so freely through a drain that we had hope of his recovery. The drainage, however, was not sufficiently complete, and at the autopsy we learned that we might have prevented the fatal extension to the other ventricle had we trephined over the posterior horn originally affected.

In contrast to the traumatic cases, there are definite situations in which cerebral abscesses develop, when extension has occurred from the nasal cavities (especially the frontal sinuses) and from the tympanic cavity and its annexes (otitis media and mastoid disease), in which cases the trephine must be applied over the original source of the infection.

Frontal abscesses originate from the nose and frontal sinus, temporo-sphenoidal abscesses from the middle ear, and cerebellar abscesses from the mastoid process. In these cases it is advisable to follow the golden rule and invariably attack the abscess through its origin in the skull itself. For an abscess in the frontal lobe, the frontal sinus and roof of the nose must first be opened. When the source of infection is in the tympanic cavity the mastoid antrum is attacked, and after the latter has been opened the track by which the suppurative process has extended is followed out. Macewen laid down this rule in his classical work, on which the specialist's knowledge was originally based. Müller (Trautmann) has recently urged in strong terms that the middle ear should always be opened into before an attack is made on a cerebral abscess of aural origin. Krause has opened abscesses on the posterior surface of the petrous-temporal with success, subsequently plugging them.

In many cases, even when an examination by an aural specialist has failed to reveal anything abnormal in the ear, by opening the antrum and mastoid cells the presence of pus can be demonstrated and the direct route of infection followed out.

It would be mere repetition to describe the steps of the operation at this stage, as they are dealt with under trephining of the frontal sinus and mastoid antrum. It should be noted, however, that as in every case where there is the smallest suspicion of intracranial suppuration, the essential feature of the operation consists, as in the case of injuries, in a thorough exposure of the area of suppuration. This means that the early stages of the operation must be devoted to providing efficient access.

9. Trephining for Cerebral Tumours.—In trephining for cerebral tumours Wagner's osteoplastic operation is the one commonly used, and except in those cases in which the tumour can be very exactly localised, the flap turned down must be of considerable size (cf. arrest of hæmorrhage, p. 178). As already stated, the osteoplastic operation is more difficult to perform than is simple trephining, and in dealing with a cerebral tumour this difficulty is even more marked. No operator should therefore attempt the removal of a cerebral tumour unless he has obtained a large amount of experience in trephining.

Severe venous bleeding must always be expected, on account of the increased intracranial pressure. We agree with the views Cushing has evolved as a result of his brilliant experiments, that the increase in the intracranial pressure initially produces a state of venous congestion, but that the consequent obstruction to the passage of blood through the brain (dysdiæmorrhysis cerebri) is overcome by a rise of blood-pressure resulting from irritation of the vasomotor centre.

Frazier has very properly observed that the latter rise in blood-pressure will suddenly fall whenever the intracranial pressure is reduced. This both Cushing and the author have confirmed, while Frazier attributed the shock and collapse that frequently follow operations on cerebral tumours to this cause. In addition, the loss of blood, and possibly the action of the anæsthetic, tend to aggravate the condition.

One is therefore inclined to follow the clear instructions Frazier has given in connection with the two-stage operation, namely, first to estimate the blood-pressure with a sphygmomanometer and observe whether a sudden or significant fall occurs after opening the skull and turning down a flap of dura, as in the event of a marked fall in the blood-pressure a few days should be allowed to elapse before completion of the operation. Horsley always operates for cerebral tumours in two stages (a method also adopted by v. Bergmann in cases of large tumours), in which case the wound must be very securely closed before the second part of the operation is undertaken.

After reflecting the flap of dura, the operator encounters another complication which, as Frazier has shown, proves very troublesome, viz. an enormous bulging of the brain. The prolapse of the brain may be either "initial" or "consecutive," the former caused by the increased intracranial pressure; the latter, which may be very serious, by a local œdema of the brain following thermal or mechanical injury (Canon). The surgeon must therefore rapidly decide by inspection, palpation, puncture, and incision, whether the operation should be continued. If not, the wound must be instantly closed. In a case on which Keen and Frazier operated, the opening could only be closed by means of inserting a flap of pericranium between the edges of the dura.

If these operative dangers are kept in mind and steps are adopted to combat them, in many cases it will be found that the tumour is situated superficially, that it proceeds from the dura, and that it only causes death mechanically, first giving rise [1] to severe headache, vomiting, epileptic attacks, and mental disturbances. It is a great injustice to persevere in the medical treatment of a case when a patient exhibits the symptoms we have mentioned, and is becoming blind and mentally disordered, simply because one has too little faith in the aid of surgery. Because, as has been already stated, the consolation in all these operations is that even if it is impossible to remove the tumour, one can always be assured of the certainty of relieving the cerebral pressure.

After this description of the attendant dangers, we find the operation performed as follows:[2] The patient is carefully prepared, stimulants and morphia being administered, with ether as the anæsthetic. The skin is cleansed with the strictest antiseptic precautions and should be thoroughly protected even during the operation by means of sterile cloths attached to the wound-edges with skin clips. A preliminary injection of novocain and adrenalin may be administered ten minutes before the incision is made.

[1] According to Cushing, Blackburn found twenty-eight tumours, most of them operable, as the original source of disease in patients in his asylum.

[2] We partly follow Heidenhain's excellent description. He has successfully operated on three successive cases of cerebral tumour (*Arch. f. klin. Chir.* Bd. 64).

A rubber band is fastened round the skull, the patient's head and shoulders are elevated, and care is taken to have the operating table heated. A large curved incision is then made through the soft parts down to the bone, and the flap of bone (Wagner), the base of which is below, is mapped out with a drill and the Cryer-Sudeck burr or Gigli saw (*vide supra*). The base of the flap is then broken by raising it up on a strong elevator, the hæmorrhage being arrested by means of Horsley's wax. A horseshoe incision is made in the dura (base of flap upwards) or it may be opened by a crucial incision.

The position of the tumour is then determined, and, provided that the patient's blood-pressure permits of proceeding with the operation, the brain is incised, after double ligature of the vessels in the pia mater. The edges of the wound in the brain are held apart with a gauze-covered spatula or suitable retractors, and the tumour is isolated, not too close to it, however, on account of the greater bleeding that is encountered.

If the tumour is separated with the fingers, sterilised gloves must always be worn, as it is of the greatest importance to avoid even the slightest risk of infection. The wound must not be irrigated but should be carefully mopped with gauze swabs wrung out of lotion. Our goitre spoon will be found very useful for raising up the tumour. The wound is then packed with strips of iodoform gauze wrung out of carbolic lotion, and the dura is accurately sutured, the vessels being ligatured with fine silk, after which the skin incision is closed with deep sutures, including all the layers of the scalp, and the dressings are applied.

The gauze packing should not be removed for five or six days, by which time it has become somewhat loosened by the formation of granulation tissue. The superficial dressings must be changed whenever any discharge soaks through, and antiseptic gauze must be reapplied.

(*b*) *Trephining for Cerebellar Tumours.* At the present time, even when one is confident of the presence of a cerebellar tumour, it is often impossible to decide in which lobe of the cerebellum it is situated, *i.e.* it is more difficult to localise exactly a tumour in the cerebellum than one in the cerebrum. Cerebellar ataxy (disturbances of equilibrium in standing and walking, without actual motor ataxy), giddiness, marked pressure symptoms (choked disc, headache, vomiting), and also rigidity of the neck, are symptoms common to tumours in various positions. It is only when the tumour invades the base of the brain and involves special centres and nerve-roots on one side, that one can definitely locate the side on which the tumour is situated. In exposing the cerebellum, therefore, an operator must employ a method which enables him to examine the whole posterior surface of the cerebellum, *i.e.* both right and left lobes. This is all the more indicated by the fact that the incision to expose both sides of the posterior fossa inflicts less injury than the exposition of one side only.

The incision passes vertically upwards behind the mastoid process on one side and is carried a finger's-breadth above the superior curved line of the occiput and over the external occipital protuberance to a corresponding point on the other side. Ten to fifteen minutes before the operation, $2\frac{1}{2}$ drachms of a $\frac{1}{2}$ per cent solution of novocain and adrenalin may be injected with advantage. A continuous or a series of interrupted loop sutures may also be inserted above the convexity of the incision in order to control the hæmorrhage from above (Heidenhain and Hacker). The bleeding from the edges of the flap can be easily arrested by compressing the flap between the fingers of the left hand and clamping the branches of the main artery (occipital) and vein with forceps.

The periosteum is now detached with a knife and elevator from the occipital bone along with the attachments of the neck muscles as far down as the foramen magnum, after which the posterior fossa is opened and the dura freely separated all round, which must be done carefully in the region of the sinuses, especially the occipital sinus, although the bone covering the lateral sinus may be more freely removed. The opening is then enlarged in all directions till the dura covering the cerebellum is exposed in its whole extent (Fig. 89).

The freer the exposure, the less will the brain be injured in looking for the

tumour. The dura is not opened till one is certain that a large part of both cerebellar hemispheres and the vermiform process can be directly examined. A flap incision, convex upwards, is then made with a fine knife and the edges of the dura are retracted with small sharp hooks, after which the occipital sinus is clamped with our artery forceps and ligatured above and below.

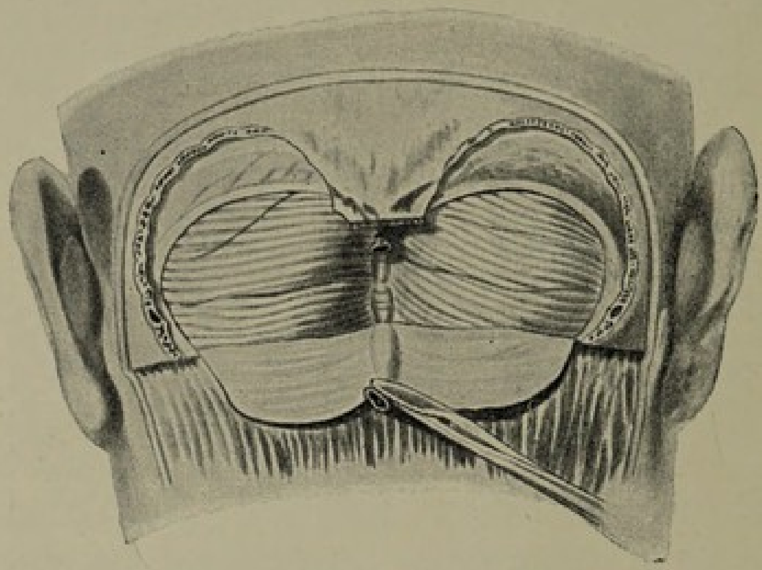


FIG. 89.—Exposure of both cerebellar lobes. The figure also shows the ligatured ends of the occipital sinus; the mastoid processes; a large and constant sinus in the bone transmitting a tributary of the lateral sinus; the lateral sinus; the external occipital protuberance.

If there is marked intracranial pressure, the cerebellum now bulges prominently outwards, and if the tumour is not at once observed, the cerebellum must be carefully palpated with gloved fingers. In one of the most recent cases on which we operated we located (from symptoms of marked ataxy and giddiness) the tumour as probably situated in the vermiform process, or, at any rate, rising from the upper or posterior and not from the inferior surface, as no nerve-roots were involved. We expected to find the tumour on the right side as the disc on this side was the more congested, and our diagnosis proved correct except with regard to the last point. The tumour was situated on the left side, and at first could only be detected as a firm area under the surface the size of a cherry. The tumour, however, was found to measure 5 cm. long and $2\frac{1}{2}$ cm. broad, and extended towards the middle line and into the superior vermiform process. It was successfully removed by blunt dissection, the copious venous bleeding that occurred at the moment of removal being arrested by plugging.

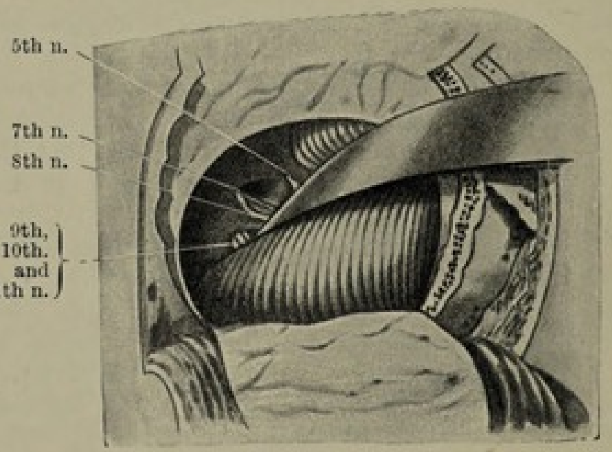


FIG. 90.—Unilateral exposure of the cerebellum for the removal of a tumour in the region of the cerebello-pontine angle.

After all bleeding vessels have been ligatured, the wound should be completely closed except for the insertion of two short glass tubes, one in each angle of the wound. There is no risk of a cavity forming underneath the flap owing to the increased cerebral pressure. If any oozing continues xeroform gauze packing may be inserted. The accompanying two figures are reproduced from Frazier's excellent work on cerebellar tumours.[1] In Fig. 89 the entire posterior surface of the cerebellum has been exposed by turning down a flap of dura, while the occipital sinus has been ligatured and cut across, the lateral sinus being well seen. It should be noted that more bone may have to be removed higher up, but it is very desirable to preserve the external occipital protuberance as a protection for the underlying sinuses.

[1] *New York and Philadelphia Med. Journ.*, 11th and 18th February 1905.

In Fig. 90 the cerebello-pontine angle is shown exposed from above, the cerebellum being retracted downwards and inwards. The posterior surface of the petrous temporal and the 5th, 7th, 8th, 9th, 10th, and 11th nerves are also exposed.

Krause [1] exposes the cerebello-pontine angle (Henneberg and Koch) [2] and posterior surface of the petrous temporal in tumours of the auditory nerve through an osteoplastic flap (base below) by means of an incision in the middle line between the cervical muscles down to the back of the head; but he is also of opinion that the bone should

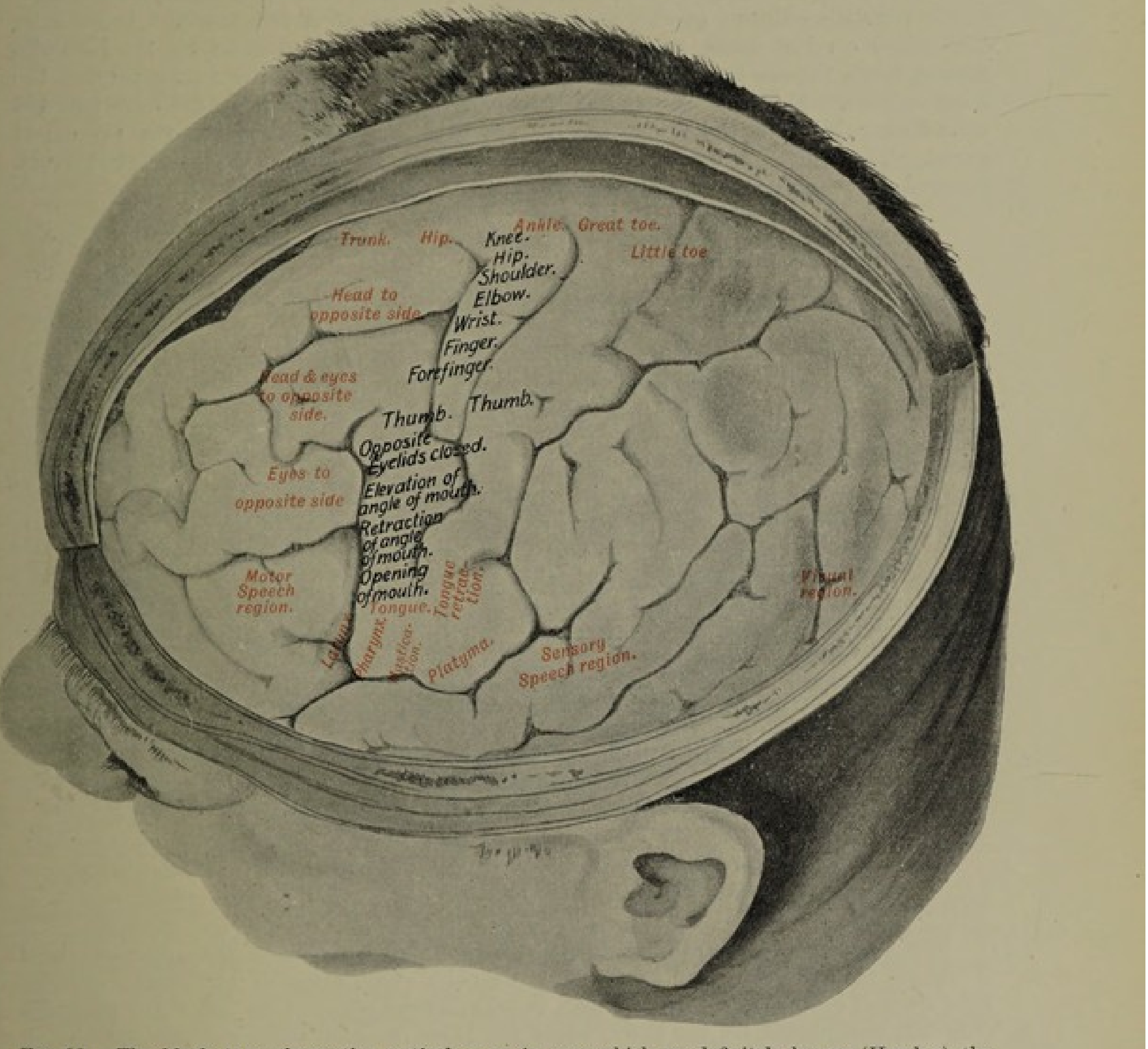


FIG. 91.—The black type shows the cortical areas in man which are definitely known (Horsley), the red type those less definitely known. The importance of the relations of the precentral line to the areas is well seen.

be entirely removed and both sides of the cerebellum exposed. According to Picqué and Mauclaire [3] Willems of Gand employs an osteoplastic flap.

[1] *Beiträge z. klin. Chir.* Bd. 37, 1903.
[2] *Arch. f. Psychiatrie*, Bd. 36.
[3] Twelfth Congress of Surgery in Paris.

D. CRANIO-CEREBRAL TOPOGRAPHY

In order to avoid having to make unnecessarily large trephine openings, *e.g.* of the nature of Doyen's hemicraniotomy, one must be in a position to locate, from the nature of the symptoms, the situation of a hæmorrhage, abscess, or tumour. The more precisely this is effected (especially in the early stages) the smaller is the opening required. But if the situation of the tumour cannot be accurately localised, then of course there must be no hesitation in turning down a large osteoplastic flap.

In previous editions of this work we mentioned that it is a mistake to consider that those cortical areas, whose functions are known, are indicated by the Rolandic fissure, while the methods which depend on the recognition of the fissure are not the most reliable. More recent researches by Sherrington and Grünbaum [1] have afforded abundant proof that the motor centres are contained exclusively in the precentral gyrus. They do not extend backward across the fissure of Rolando, but reach forward to the precentral sulcus.

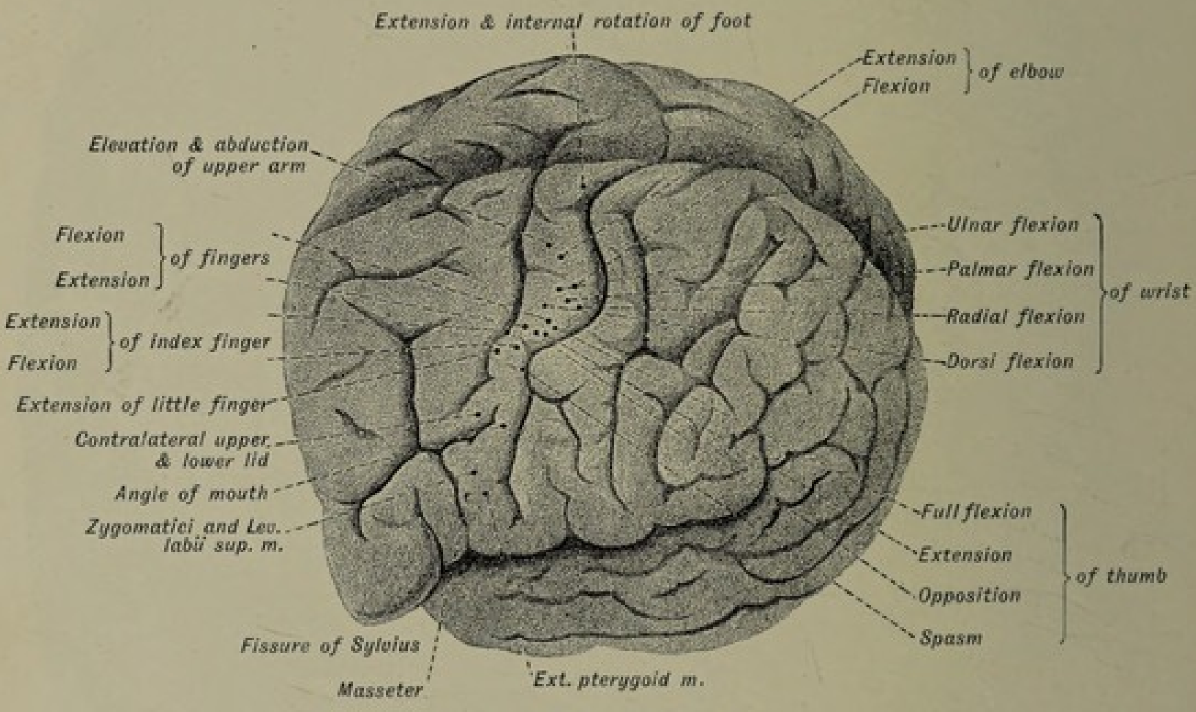


FIG. 92.—Position of the motor areas in man (Krause). Note, they are all situated in the precentral gyrus.

The experimental results of these observers in the case of the ape have been confirmed by Krause in man by means of unipolar stimulation of the brain. Krause used a small induction coil, fitted with two Leclanche cells. One large flat platinum electrode was placed on the body, while the other, a small spherical platinum point, insulated and sterilised, was applied to the brain, the latter being stimulated with a weak current. Fig. 92, taken from his work, illustrates the position of the various centres which he was able to determine by this method.

We reproduce, mapped out in the figure of the left hemisphere (Fig. 91), those areas with whose localisation we are most exactly acquainted. The lettering is so arranged that those areas which in man may be regarded as fully settled are indicated in black. The remaining centres, on the other hand, about which there may be a doubt, or which are not exactly delineated, are indicated in red.

It will be clearly seen from this figure, the cerebral surface of which is drawn from nature, that the majority of the known centres are grouped round the precentral

[1] *Proceedings of the Royal Soc.*, vol. 69, and *Transactions of the Path. Soc. of London*, vol. 53, 1902.

sulcus, *i.e.* in the whole length of the gyrus centralis anterior and in the foot of the third frontal convolution. The precentral sulcus is therefore a much better guide for the exact localisation of the motor cortical centres than the sulcus of Rolando, all the more so since the upper and middle frontal sulci open into it, and furnish two very exact points by which the level of the various centres may be identified. From the point of view, therefore, of cranio-cerebral topography it is of the first importance to define exactly the position of the precentral sulcus.

It will be readily observed, from a comparison of Fig. 91 with Fig. 92 (the latter illustrating the position of the centres as determined in man by Krause) that all the cortical motor areas lie exclusively in the gyrus centralis anterior.

The Sylvian fissure has a great significance, as anteriorly it limits the lower end of the precentral gyrus, in which lie a number of centres; and it also forms the upper limit of the first temporal convolution, which is the main seat of the sensory speech area.

Less importance is at present to be attached to the fact that the prolongation of the precentral sulcus upon the mesial surface of the hemisphere indicates the approxi-

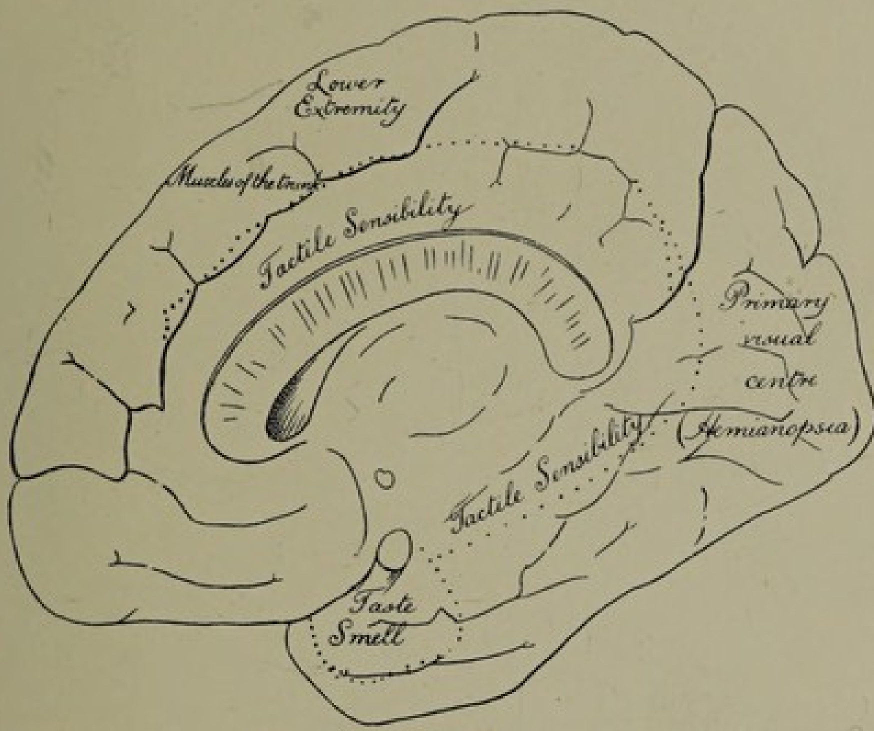


Fig. 93.—Centres upon the inner surface of the hemisphere, according to Horsley.

mate position of the cortical area for the muscles of the trunk, and that the temporo-sphenoidal lobe has its tip determined by the Sylvian fissure, as the centres for smell and taste, and in part also the tactile centre, are situated upon the mesial surface. Fig. 93 gives a sufficient idea of the relations. We have also to define the visual region, because disturbances of vision, especially in the form of hemianopsia, frequently furnish very good data for determining the site of a cerebral lesion. The mechanism of sight is very extensively represented in the cortex of the occipital lobes, both upon their outer and mesial surfaces, and it is sufficient to be able to map out the limits of the occipital lobe with a fair amount of precision. The occipital lobe is separated from the parietal by the parieto-occipital fissure, which lies 1 cm. in front of the lambda. Its posterior extremity lies a little above the external occipital protuberance, while, below and anteriorly, it joins the temporo-sphenoidal lobe.

All these points can be defined with sufficient accuracy by means of the craniometer, such as we now employ (Fig. 94). This consists of two nickel-plated flexible steel bands, graduated in millimetres, one of which is placed horizontally above the attachment of the auricles, and embraces the equator of the head from the glabella to the external occipital protuberance. It is kept in position by means of screws. A

second band, fixed firmly at right angles to the above, is stretched sagittally in the middle line from the external occipital protuberance to the glabella. A third band is made to slide upon this, and is so arranged that it can be placed at any desired angle to the sagittal band.

When one end of this band is fixed over the lambdoidal suture and the other carried round to the glabella, a line is obtained which corresponds to the Sylvian line of Poirier, but which, however, does not quite indicate the Sylvian fissure. We have termed it the *linea temporalis* 1, because, while it corresponds, anteriorly, to the upper part of the first temporal convolution (and therefore also to the anterior part of the Sylvian fissure), posteriorly, it overlies its lower part.

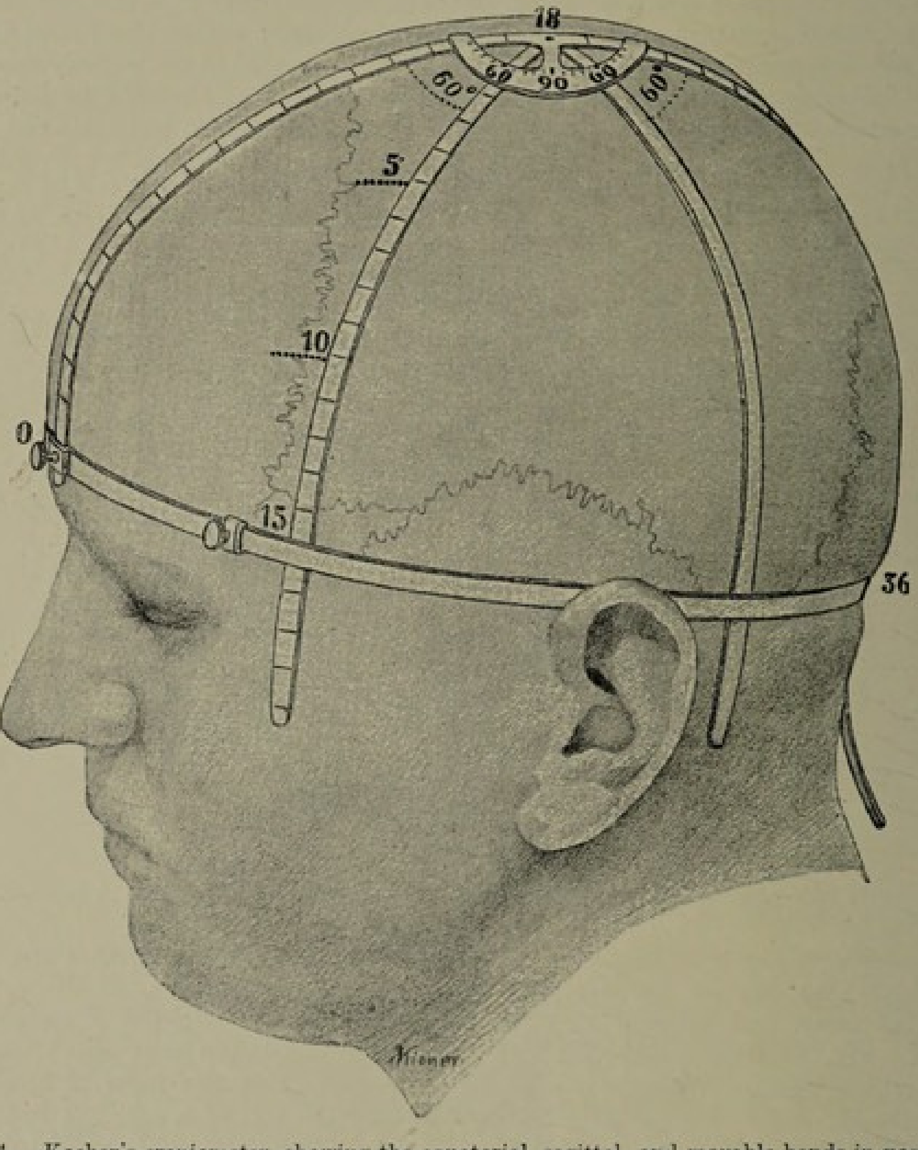


Fig. 94.—Kocher's craniometer, showing the equatorial, sagittal, and movable bands in position, the latter of which determines the precentral and Sylvian fissures.

In Fig. 95 the lines are indicated which can be rapidly and easily mapped out on any head by employing our apparatus. If the movable meridian band is placed midway between the glabella and the external occipital protuberance, and at an angle of 60° to the sagittal band, it will overlie the precentral sulcus. We have therefore named this the *linea precentralis*. By trisecting the part of this line, which reaches from the mesial line of the vertex to the equatorial line, we can exactly define the origins of the superior and inferior frontal sulci.

In this way, as may be seen by comparing Figs. 95 and 91, the linea pre-

centralis, and the two points which trisect it, suffice to localise, with sufficient accuracy, the centres in the precentral gyrus and at the base of the third frontal gyrus. It is satisfactory to note that authorities like Neisser and Polack, who have employed our craniometer, state that they have always found the localisation to be very accurate.

If the band be rotated backwards so that it forms an angle of 60° with the sagittal one, a line is obtained which is termed by us the *linea limitans*, because it denotes pretty exactly, below the point where it crosses the linea temporalis 1, the boundary between the temporal and occipital lobes, while above the crossing it corresponds to the junction of the supra-marginal and angular convolutions. The naso-lambdoid line is determined by sliding the movable clasp back to a point 1 cm.

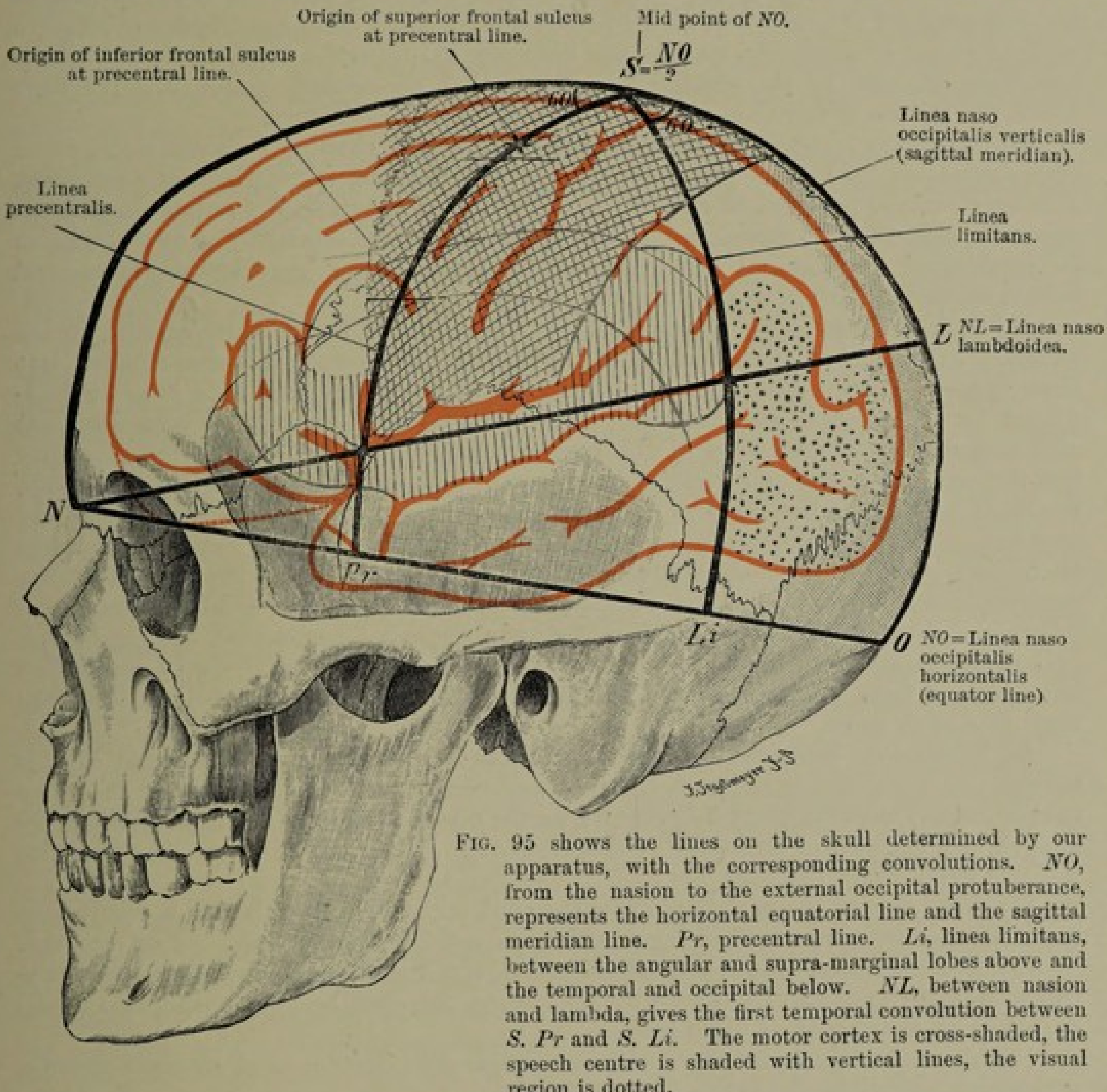


FIG. 95 shows the lines on the skull determined by our apparatus, with the corresponding convolutions. *NO*, from the nasion to the external occipital protuberance, represents the horizontal equatorial line and the sagittal meridian line. *Pr*, precentral line. *Li*, linea limitans, between the angular and supra-marginal lobes above and the temporal and occipital below. *NL*, between nasion and lambda, gives the first temporal convolution between *S. Pr* and *S. Li*. The motor cortex is cross-shaded, the speech centre is shaded with vertical lines, the visual region is dotted.

above the apex of the lambdoidal suture, and then by carrying the band round to the glabella. This line corresponds, between the precentral line and the linea limitans, to the first temporal convolution, and, where it crosses the precentral line, it corresponds to the anterior end of the Sylvian fissure. The posterior end of the linea temporalis 1 indicates the parieto-occipital fissure, and therefore the boundary between the occipital and parietal lobes. A glance at the figure affords a better explanation than it is possible to give in words. As will be seen, we have adhered to the method of percentage measurements which was introduced by Hare, and fully worked out by Müller. Compared with absolute distances the method has the advantage that it can be applied to any form of skull.

We cannot, therefore, understand how Krause, who has fully recognised the significance of the precentral sulcus, still prefers to be guided by the determination of the fissure of Rolando.

E. SURGERY OF THE SPINAL CORD AND ITS COVERINGS

(a) Puncture of the Subarachnoid Space. Lumbar puncture, which was introduced by Quincke, has now become a very important therapeutic as well as diagnostic measure. As we have already stated in the chapter on anæsthesia, Bier utilised it for producing anæsthesia of the spinal cord, or cauda equina, and since less toxic substances are now used for the injection, and their effect is rendered more local by a combination with adrenalin (Braun), the method has been rescued from the disrepute into which it had been brought by the alarming accidents that occasionally followed. We have found the results of novocain injections (Merck) most satisfactory.

The method of puncture has been explained in the chapter on anæsthesia. The chief indication for lumbar puncture, as it is badly termed, is for diagnostic purposes. Not only can the presence of effusion of blood and of inflammatory exudations in the subarachnoid space be revealed, but the nature of the inflammatory process can also be established by bacterial examination. This may be of considerable value, and should never be omitted in doubtful cases.

A further indication for its use is the determination of the pressure existing in the subarachnoid space of the spinal cord and brain, and the nature of the effusion into these spaces. Very special care must be exercised if cerebrospinal fluid is to be withdrawn for therapeutic purposes by lumbar puncture. Lumbar puncture does not give any very certain measure of the pressure inside the skull, as the pressure may fall very quickly in the spinal cavity, and remain high in the cranial cavity. Further, the fluid in the lumbar region (Volke) may be richer in albumen than it is in the ventricles. The transudates in cases of tumour, for example, are richer in albumen than they are in cases of hydrocephalus. Lastly, cases of sudden death have occurred from lumbar puncture, because where there has been a high intracranial pressure sudden diminution of the pressure in the canal has caused the cerebellum to be forced down into the spinal canal, with the result that paralysis of respiration has occurred from pressure on the medulla. Gumprecht has collected no less than seventeen such cases.

(b) Extensive Exposure of the Spinal Cord. Exposure of the spinal cord is undertaken when the function of the cord as a conducting structure (rather than as a central organ) is endangered by pressure, as the result of an inflammatory process, the growth of a tumour, or an injury of the vertebræ. The most usual conditions, which indicate exposure of the cord, are :—

(1) Fractures of the vertebræ when the cord is compressed either as a result of a dislocation or by a fragment of bone, which cannot otherwise be replaced or removed.

(2) Inflammatory conditions, which are rarely due to osteomyelitis staphylomycotica, but are generally of a tuberculous nature, the cord becoming compressed and damaged by the spread of the disease.

(3) Tumours, which interfere with the conduction in the cord by their growth, and which may either be extra- or intra-dural.

The presence of a tumour urgently calls for operation, and a number of brilliant results have been reported, in both extra- and intra-medullary growths. According to Lloyd's records, out of 51 operations on tumours of the spinal cord 31 per cent of cures were obtained, the mortality being 10 per cent. The cause of death is shock, generally from hæmorrhage. McCosh,[1] however, operated on 6 cases without a fatality. Harte[2] records a mortality of 47 per cent in 92 cases, 30 deaths resulting from the operation.

The chief reason why surgical interference has hitherto failed is, that it is under-

[1] *The Journal of American Medical Association*, Aug. 1901.
[2] *Annals of Surgery*, Oct. 1901.

taken at too late a stage, and further, that the patient's health has deteriorated as a result of the long-continued anti-syphilitic treatment followed so zealously by the physician. If every physician would, like Oppenheim, make an early diagnosis and call in the surgeon at the proper time, much better results would be obtained. Auerbach and Brodnitz have recently published particulars of a brilliant case in which a tumour in the cervical portion of the cord extending up to the atlas was successfully removed.

It is a case of more difficulty to decide when one ought to operate in inflammatory conditions, more especially in tubercular disease of the vertebræ, as in these cases delay is not injurious to life, and indeed the impairment of the spinal cord is not infrequently removed by appropriate orthopædic and general treatment.

It may be regarded as an axiom that operation is indicated when, after some weeks of correct mechanical and general treatment, the paralysis and other evidences of pressure show no material improvement, or do not disappear altogether within a few months.

Trendelenburg's advice is to operate after the tuberculous disease is healed, if there is still pressure on the cord from the destruction or displacement of the bones. His results have proved entirely satisfactory.

It is still more difficult to know when to operate in the case of fracture of the spine. Naturally when the injury has not given rise to complete interruption of conduction, and when after continued treatment and observation no improvement can be recognised in the paralysis and sensory disturbances, a decision can be more easily arrived at. One must not, however, unduly delay in relieving the pressure, although excellent results have been obtained by laminectomy even after a long interval has elapsed (McCosh, Munro, and others). In two cases Munro found only a circumscribed collection of fluid, the evacuation of which produced the desired effect.

Sultan [1] has recorded the results obtained by Trendelenburg, who has had a wide experience of spinal surgery. In children, when the cause of the paralysis was due to an epidural abscess, granulation tissue, or narrowing of the spinal canal, especially in the lower part of the spine, very gratifying results were obtained by laminectomy.

The question of operation in recent severe lesions of the cord due to fractures and dislocations of the vertebræ is also surrounded with uncertainty. If one is influenced by the experience of Munro,[2] who found that during a period of ten years, only in one of thirty cases of injury in the upper dorsal and cervical region did restoration of function occur without operative interference, while in the same period there were three complete recoveries after operation, one naturally leans towards surgical intervention in every case. The cases must, however, be very carefully selected, and if the temperature is very low (as often occurs early with high lesions of the cord) the question of operation should not be considered. In all Munro's cases, where there was severe crushing of the cervical cord, the patients succumbed. If there is sudden, complete cessation of mobility and sensation, with immediate total loss of the tendon reflexes, we must conclude that there is an irreparable total transverse lesion of the cord; but if, on the other hand, evidences of incomplete division of the cord become apparent in a few hours or days, if not at once (*i.e.* slight sensation remaining), then the prognosis is much more favourable.

Many cases have been described (McCosh) in which, at first, although all the signs of a total transverse lesion were present, improvement and recovery followed operation. On the strength, therefore, of this evidence, surgical interference would seem to be indicated, even in the most desperate cases.

Mixter and Chase have shown that in spite of the loss of conduction, normal fibres may still exist in the crushed area of the cord.

The question whether the actual conductivity of the cord can be re-established by early suture in cases where it has been completely divided (as has been attempted by Fowler and Stewart) [3] cannot be determined with certainty from the cases that have been published.

[1] Sultan, *D. Zeitschr. f. Chir.* Bd. 78.
[2] Munro, *55th Report of the American Medical Association.* [3] *Annals of Surgery*, Oct. 1905.

10. Technique of Laminectomy. The technique[1] is simple in ordinary, *i.e.* not osteoplastic, laminectomy. Experience has shown that the removal of three or four vertebral arches does not materially impair the supporting power of the spinal column. Osteoplastic methods, therefore, have not come into general use. Marion,[2] however,

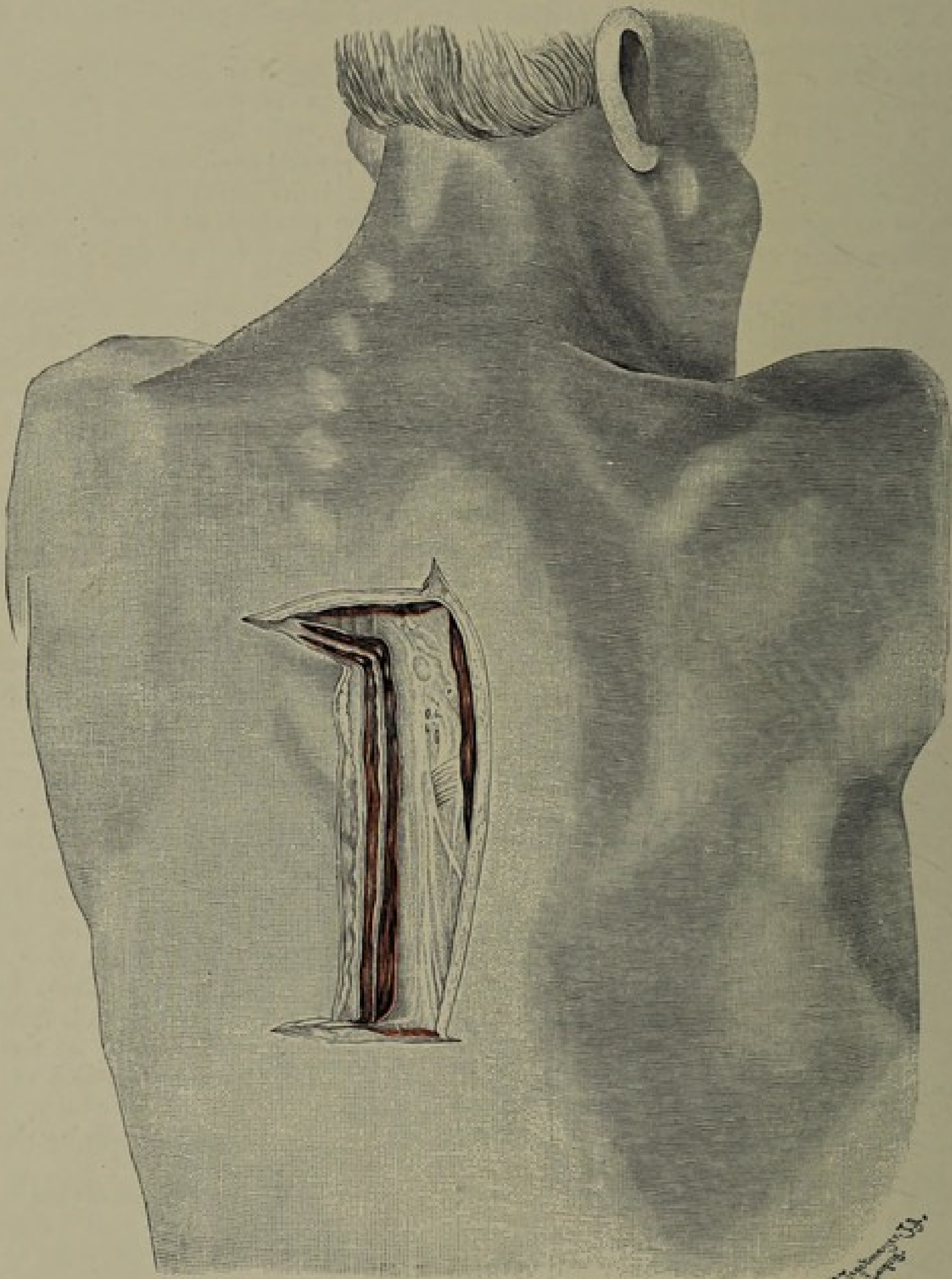


FIG. 96.—Incision for osteoplastic laminectomy. The muscles of the back have been detached from the transverse processes on the right side, and cut across above and below.

speaks in high terms of the osteoplastic operation, especially of the method introduced by Cavicchia and performed by Durante, a method which we also regard with favour.

It is performed as follows: A curved, or preferably an angled incision (see Fig. 96)

[1] Cf. detailed accounts by Chipault, *Étude de chirurgie médullaire*, Paris, 1904, and Marion, *Chir. du système nerveux*, Paris, 1905. [2] *Chir. du système nerveux*, Paris, 1905.

is made over four or five vertebral spines, dividing skin, fascia, and superficial muscles (above, the trapezius, and the fascia covering the rhomboids, splenius capitis and colli, and the serratus posticus superior; below, the latissimus dorsi and serratus posticus inferior). The large muscles of the back are incised transversely above

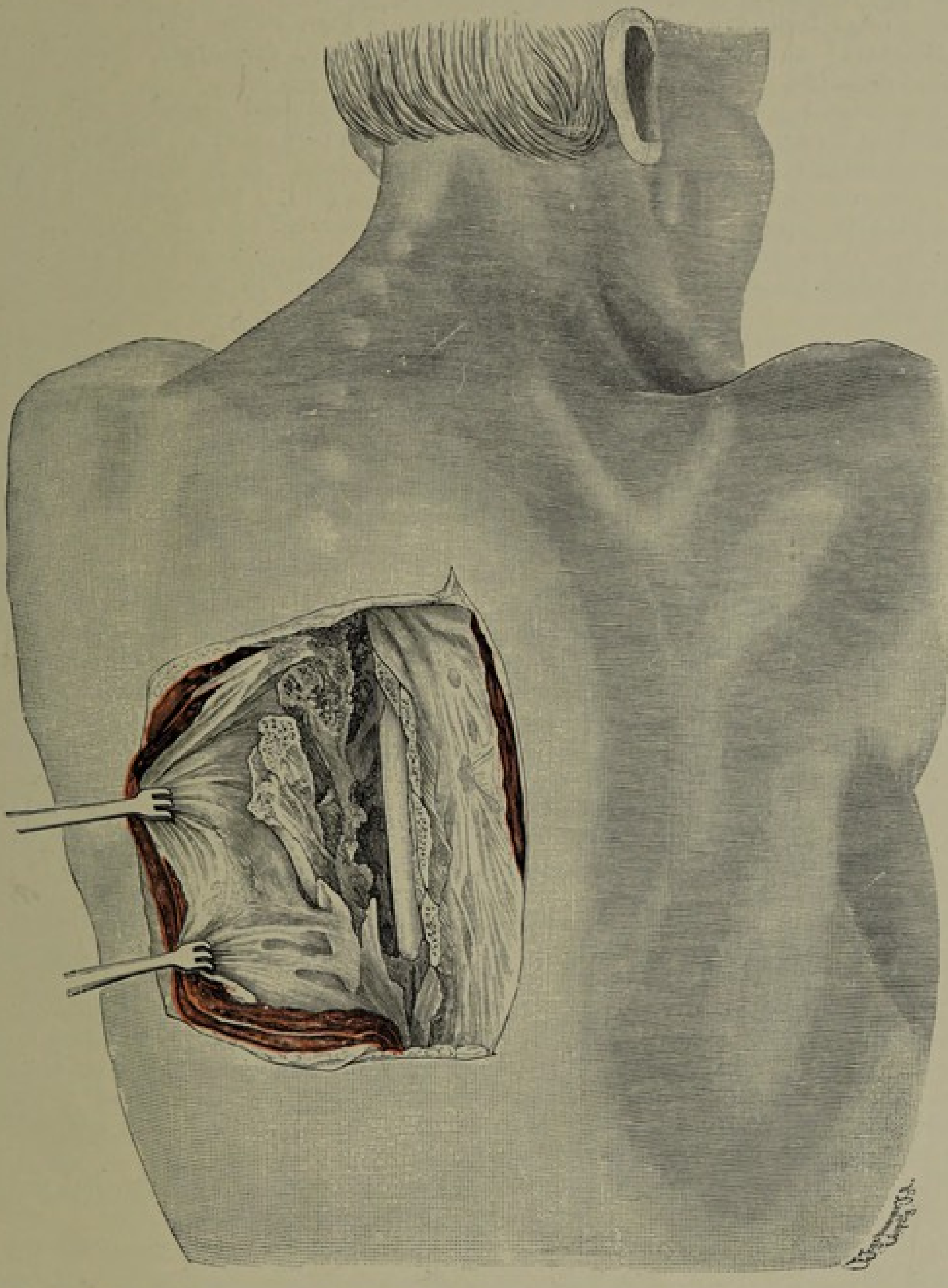


Fig. 97.—Osteoplastic laminectomy, 2nd stage. The spinous processes have been chiselled through at their bases and turned over to the left. The laminæ have been cut across with bone-forceps, exposing the spinal dura.

and below as far as is necessary, namely the longissimus dorsi, with the iliocostalis and the accessorius farther out. The longissimus dorsi is raised and retracted towards the middle line, and, without detachment of the muscles (semi-spinalis, multifidus) which are in direct contact with the arches, a broad chisel is applied

to the roots of the spines, which are then divided, and forcibly retracted to the other side with strong hooks. Hæmorrhage is considerably lessened by avoiding excessive dissection of muscle off the bones. The vertebral arches are now sufficiently exposed and a pair of forceps is inserted under them on each side, after which they are cut across and removed. The dura then lies exposed.

The osteoplastic exposure of the cord is shown in Figs. 96 and 97.

Bickham[1] also advocates an osteoplastic operation, employing, however, the method described by Urban in 1902.

The normal operation, as practised by most experienced surgeons and recommended by Harte, who collected a series of 92 cases, is performed as follows: A long mesial incision is made over four or five vertebral spines. It is important to carry the incision sufficiently high up, as the lesion of the cord is frequently at a higher level than is expected. The muscles are rapidly separated with the knife on both sides from the spinous processes and retracted with strong hooks covered with gauze, through which pressure can be applied and the bleeding, which is often considerable, controlled.

There is no advantage in trying to separate the muscles subperiosteally, as the periosteum can be more easily detached from the roots of the spines and from the posterior surfaces of the arches. The most important point, according to McCosh, is to effect the separation as rapidly as possible without stopping to secure vessels, by which means the bleeding is most effectively reduced.

Having examined the extent of the injury, the operator then proceeds to divide the bases of one, two, or three spines with strong specially-curved cutting forceps (Horsley), after which the laminæ on either side are removed with Luer's gouge forceps.

The bleeding, even before removal of the bone (or immediately after exposure of the fatty tissue and the venous arches between the dura and the bone) may be so severe that it is advisable to plug the wound and delay, for a day or two, the completion of the operation. The two-stage operation has proved most successful in Auerbach's and Brodnitz's hands, and is specially to be recommended in difficult cases.

The extradural fatty tissue and veins are then incised in the middle line, after which the further procedure will depend on the nature and extent of the lesion. If the tumour is situated within the dura, or if the dura is implicated in the inflammatory process, and caseous or granulation tissue has been deposited on its inner surface, or if it is thickened and adherent, the dura must then be split open in the middle line with scissors.

On opening it the escape of cerebrospinal fluid may be excessive, so that it is advisable, first of all, to lower the head and shoulders, as is recommended by Auerbach and Brodnitz.

The spinal cord is now exposed. If the tumour or diseased focus is situated on its anterior aspect, or if the operator wishes to divide the nerve-roots, the cord must be lifted up on an aneurysm needle. If necessary the nerves may even be divided in the dorsal and lumbar regions where their loss does not involve any material disturbance. When the spinal cord is found to be cut across, the question of suture may be considered, but only if the cut edges are not bruised.

The dura is finally closed with interrupted sutures without drainage, but if the bleeding has not been entirely arrested a drain must be inserted.

F. SURGERY OF NERVE-ROOTS

(a) Intracranial and Intraspinal Nerves

There is this similarity between the surgery of the brain and the surgery of the intracranial and spinal nerves, that in both cases preliminary trephining is necessary.

[1] *Annals of Surgery*, 3, 1905.

Operative measures take the form either of division of the sensory nerve-roots or of extirpation of the ganglia with which they are associated. Apart from the peripherally situated ganglia of the sympathetic, ganglion extirpation is limited to the trigeminal nerve. On the other hand, division of sensory nerve-roots is undertaken in connection with spinal as well as cranial nerves.

11. Extirpation of the Gasserian Ganglion, Division of its Root and Intracranial Branches (Figs. 98, 99, 100). (*a*) *Extirpation of the Gasserian Ganglion.* Although the removal of the Gasserian ganglion is an operation of comparatively recent date, it has occasioned a considerable amount of literature, partly from the fact that brilliant results have been obtained by its means [1] in the treatment of trigeminal neuralgia, and partly because of the almost insuperable difficulties which are occasionally encountered and for which a large number of operative suggestions have been devised.

Those alone who have frequent opportunities of performing the operation can really hope to master the difficulties in technique associated with it, and can expect to obtain the gratifying results which may be procured even in the most obstinate cases of neuralgia, without causing injury to the neighbouring structures.

In the last edition of this work reference was made to the statistics collected by Tiffany, who, in a series of 102 cases, estimates the mortality at 22 per cent. Up to the end of the year 1905 Cushing of Baltimore had excised the ganglion entire in 34 cases (partially in three) with only one fatal result, *i.e.* a mortality of 2.75 per cent). In another series of 100 cases collected by Carson, the death-rate is given as 11 per cent, while Cushing further mentions 50 cases operated on by Lexer and himself in which the mortality was only 5 per cent. Krause had previously operated on 49 cases, but his results do not appear to have been published.

These figures show the advances which have been made in technique since the year 1889, when the operation was unsuccessfully attempted by Macewen and Horsley, and since 1890, when the first successful case was intimated by Rose, with a second case in 1891. Rose employed the pterygoid route which was originally suggested by J. E. Mears in 1884, but this method, although simplified by Novaro in 1891, has now been abandoned. It is to Horsley that the credit is mainly due for having brought into general recognition the "temporal," or, as Cushing terms it, the "high temporal" operation, to distinguish it from the most recent "low temporal" or "temporo-sphenoidal" method. Horsley used it originally simply for the section of the main divisions of the trigeminal nerve, performing his first successful operation in 1888, although subsequently he utilised the same procedure for excision of the ganglion.

The method has been named after Hartley and Krause, because these two surgeons, particularly Krause (Hartley and Krause, 1891), first devised it for the intracranial section of the divisions of the trigeminal. In 1897 Krause produced 14 cases, in 13 of which the operation was successful. Andrews, MacBurney, and J. Roberts, Keen, Tiffany, and others, all reported cases shortly after that of Krause. It is interesting to observe that Krause still adheres to the "high temporal" method which he has performed on 49 occasions.

The latest process of reaching the ganglion, viz. by the temporo-sphenoidal route with division of the zygoma, was, according to Peyrand,[2] originated by Doyen in 1893, and was carried out in a cumbrous form by Poirier, till it was finally perfected by Quénu in 1894. Since then it has found many adherents and has provided the most satisfactory statistics. In our fourth edition we alluded to this method as Cushing's operation. Cushing himself states that Coelho first suggested the modified resection of the zygoma, which Lexer has lately still further simplified. From the statistics already given the "low temporal," or temporo-sphenoidal route should be selected, and since we adopted it our results have been considerably improved.

[1] As far as we can judge from our own experience, and from the literature published on the subject, excision of the ganglion gives most certain end-results as soon as the immediate risks have been removed.

[2] Thèse de Bordeaux, 1902.

We always use the same incision as that described and illustrated under section of the root of the third division of the trigeminal nerve, as we consider that the branches of the facial nerve are least injured by this method (a point also recognised by Lexer), and further because it entails no division of muscle. For the direction of the skin incision, division of the fascia, resection of the zygoma and the method of raising the periosteum together with the muscle, the reader is referred to Fig. 108, p. 225.

As the photograph (Fig. 98) shows, practically no disfigurement is produced.

Cushing and Lexer turn down a temporal flap similar to that in the Hartley-Krause method, but not extending so high up on the skull.

They endeavour to avoid injury to the branches of the facial nerve by paying special attention to the direction of the skin incision where it begins and terminates. Lexer places the base of his flap almost exactly in the direction we have recommended for avoiding the facial nerve, viz. along a line corresponding to the lower part of our angled incision (*vide* Fig. 99), *i.e.* the posterior extremity of his incision on the root of the zygoma lies a finger's-breadth in front of the ear, while the anterior end is placed over the body of the malar bone a little behind its frontal process. The convexity of the flap does not extend above a horizontal line through the tip of the auricle.

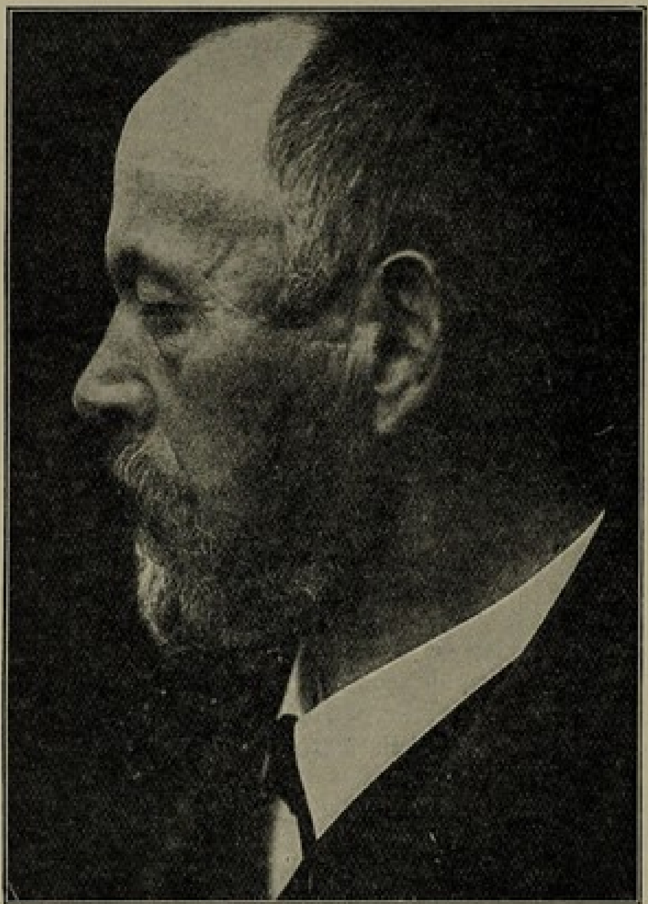


Fig. 98.

Cushing does not carry the anterior limb of his incision far forward, so as to avoid the frontal branch of the facial nerve, and dissects the skin and temporal fascia downwards and forwards, before he divides the temporal muscle.

The flap is turned down together with the periosteum, and the anterior and posterior extremities of the zygoma are exposed and divided with a Gigli's saw, chisel, or strong bone-forceps. Posteriorly, the zygoma is divided at its root, while anteriorly it is cut across at the body of the malar so that sufficient room may be obtained. Cushing removes the entire zygomatic arch subperiosteally, and maintains that this method is advantageous even from the point of view of disfigurement, as with the subsequent sinking-in that occurs, the atrophy of the muscles of mastication is less noticeable. Removal of the zygoma complicates the operation to a considerable extent, while there is a further risk of the facial nerve being torn when the bone is forcibly depressed with a hook, which may result in facial paralysis. Possibly the case reported by Anschutz might be explained in the same way. The fascia and pad of fat lying under the arch must be carefully preserved.

The lowest part of the temporal fossa is now exposed, down to the infratemporal crest, and the periosteum and soft parts are carefully separated from the base of the skull (*i.e.* from the great wing of the sphenoid), till the sharp border of the pterygoid process behind which the foramen ovale lies, is observed. Hæmorrhage from the

pterygoid plexus of veins is arrested by forcible depression of the soft tissues with a blunt hook covered with gauze and by the application of pressure, when the foramen ovale through which the third division of the nerve passes can be either seen or felt.

The skull is then opened a thumb's-breadth above the infratemporal crest with a chisel or Doyen's burr, and the opening is enlarged in front and behind with gouge forceps, the dura at the same time being raised off the bone as far as the foramen

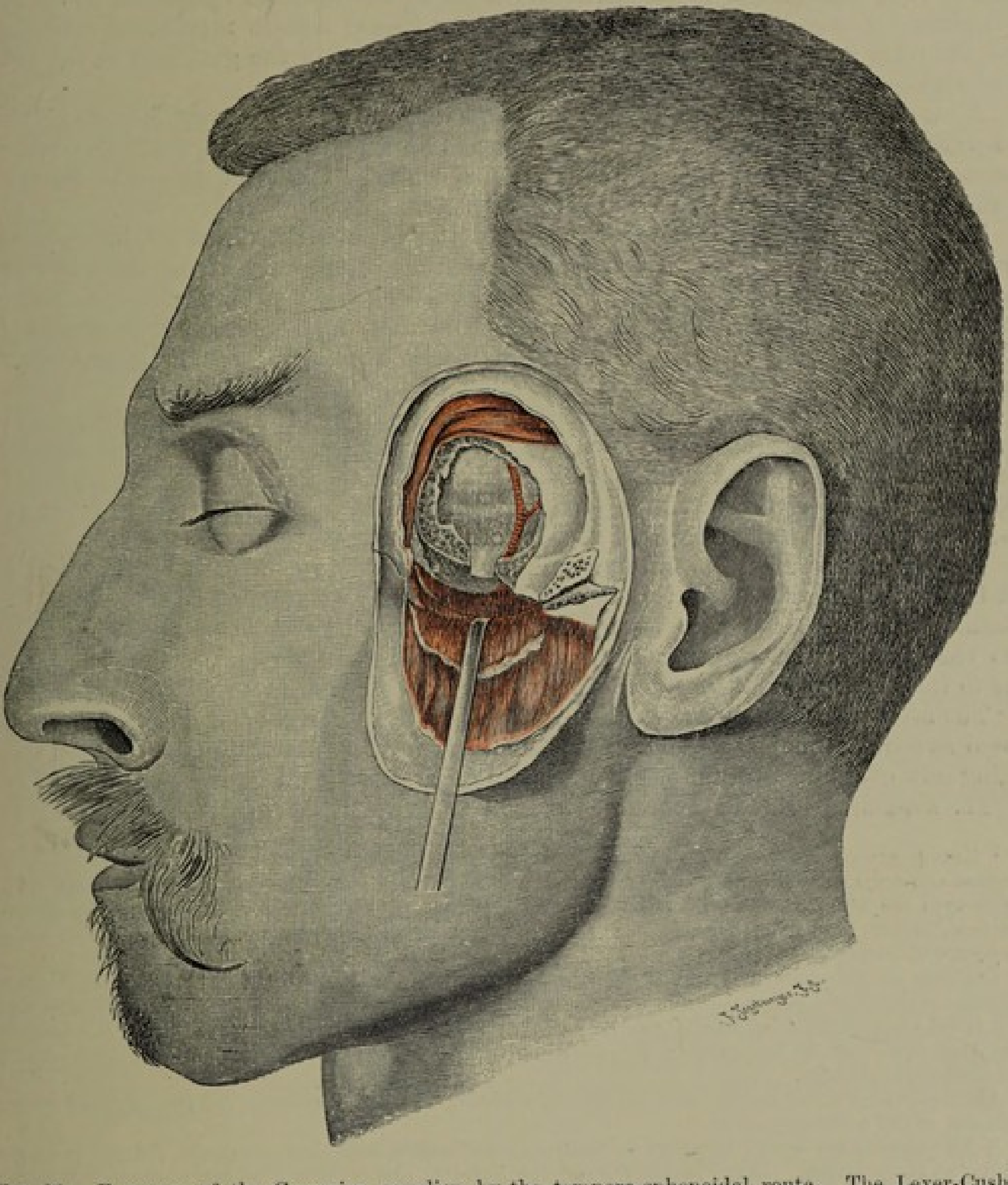


FIG. 99.—Exposure of the Gasserian ganglion by the temporo-sphenoidal route. The Lexer-Cushing incision has been made, and the zygoma divided. The base of the skull has been chiselled away to expose the third division at the foramen ovale. The middle meningeal artery is seen on the dura, which has not yet been incised.

ovale and foramen rotundum. The low position and limited size of the opening required have, according to Cushing, the advantage over Krause's higher method that the groove (often a canal) in the parietal bone, in which the middle meningeal artery lies, is avoided; the bleeding from the injured artery in this position is very difficult to control.

With the low temporal opening (reaching at most 3 cm. in height) there is, further, less chance of the brain being injured when it is held out of the way by means of a retractor. According to Cushing, Krause, who employs the higher opening, has reported superficial bruising of the brain at eight autopsies, and Poppert has described a case of hemiplegia (and death) as a result of pressure by the retractor during Krause's operation (*Deutsch. med. Wochenschrift*, No. 22, 1906).

The dura is then rapidly separated from the bone with the finger or with forceps covered with gauze (or a blunt dissector) as far as the foramen spinosum, ovale and rotundum. Lexer, like Krause, now ties the exposed middle meningeal artery, so that the dura may be more freely raised towards the root of the ganglion, at the same time avoiding the risk of accidentally tearing the artery.[1]

A number of surgeons, following v. Bergmann, regard it as very important that the patient should sit upright before the dura is opened in order to limit the venous hæmorrhage and the loss of cerebrospinal fluid, while at the same time the lowering of the pressure permits of the brain being retracted.

The dura is now incised by cutting on to the bone in the interval between the second and third divisions of the nerve, and detached backwards along the outer and upper surfaces of the ganglion as far as the root. The root is then elevated from its bed by passing a long slender spatula underneath it, and if possible it should be raised up with a hook or small aneurysm needle to ensure that it is thoroughly isolated.

The root is grasped with a pair of Kocher's long artery forceps, and the ganglion is raised and freed as much as possible, after which the second and third divisions are divided at their exit from the skull. Traction is then made on the ganglion by pulling on the third division, thus stretching and facilitating the section of the first division of the nerve. Finally the root is torn away.[2]

Very free hæmorrhage is encountered, and attempts to control it by plugging are apt to produce severe shock similar to that caused by retraction of the dura by a spatula. It is for this reason that Cushing carefully observes not only the pulse but also the blood-pressure during the operation in order that any fall of blood-pressure due to interference with the vasomotor centre may be at once recognised.

The after-treatment is carried out on general lines, the wound being completely closed as soon as one is convinced the hæmorrhage has been arrested. Should some oozing still continue, a drain or strip of iodoform gauze should be inserted.

12. Summary of the Technique which we regard as best. Excision of the

[1] Krause grasps the vessel with artery forceps, where it lies exposed between the dura and the foramen spinosum for a distance of about 1 cm., and ligatures it on the proximal side, after which the forceps are removed. He then separates the dura as far as the upper border of the petrous temporal, arrests the hæmorrhage, and by blunt dissection frees the ganglion from its bed and grasps the root with forceps.

Cushing, on the other hand, finds on separating the dura that the artery runs a straight course between the two fixed points, viz. the foramen spinosum and the groove in the parietal bone, and that, as it is not abnormally stretched, it can be easily avoided. Lexer has shown that when the bone has been removed down to the base of the skull, as described above, the artery can be quite readily ligatured extracranially.

In certain circumstances the best method of arresting the hæmorrhage is by means of temporary occlusion of the common carotid.

[2] All surgeons are agreed in regard to restricting the hæmorrhage that occurs on freeing the inner surface of the ganglion. Lexer avoids freeing the ganglion there, while Cushing postpones it to the last, and only separates it just before dividing the branches and the root, as does Krause also. Lexer begins by raising up the third division on a hook, and then passes a loop of thread round it, so that by pulling on it the ganglion will be put on the stretch. He then separates the dura on the upper surface of the ganglion until the ophthalmic division in front and the root posteriorly are exposed. The latter is then pulled upon by means of a hook. He now divides the second division and the root, after which the first division is exposed by drawing down the ganglion, and is cut across, leaving the ganglion only connected with the third division.

Krause first of all divides the second and third divisions, and after having freed the ganglion grasps it in forceps and twists out the first division and the root. Cushing, who has published excellent statistics, divides the branches first, then frees the ganglion thoroughly by blunt dissection and tears out the root. The risk of injuring the cavernous sinus is thus greatly diminished. The bleeding following accidental tearing of the sinus is very copious.

Gasserian ganglion is an operation necessarily associated with unusual difficulties, and every surgeon who operates on his first case must be prepared to cope with a situation which in some cases may be exceedingly embarrassing. Before undertaking the operation he will do well to practise it several times on the cadaver, and take every opportunity of seeing it performed by those who specialise in surgical neurology.

In many of the cases on which one is called upon to operate, medical treatment and surgical measures of a less drastic nature have already been tried in vain. Of the latter neurexeresis is the most effectual. It is in such cases, however, that excision of

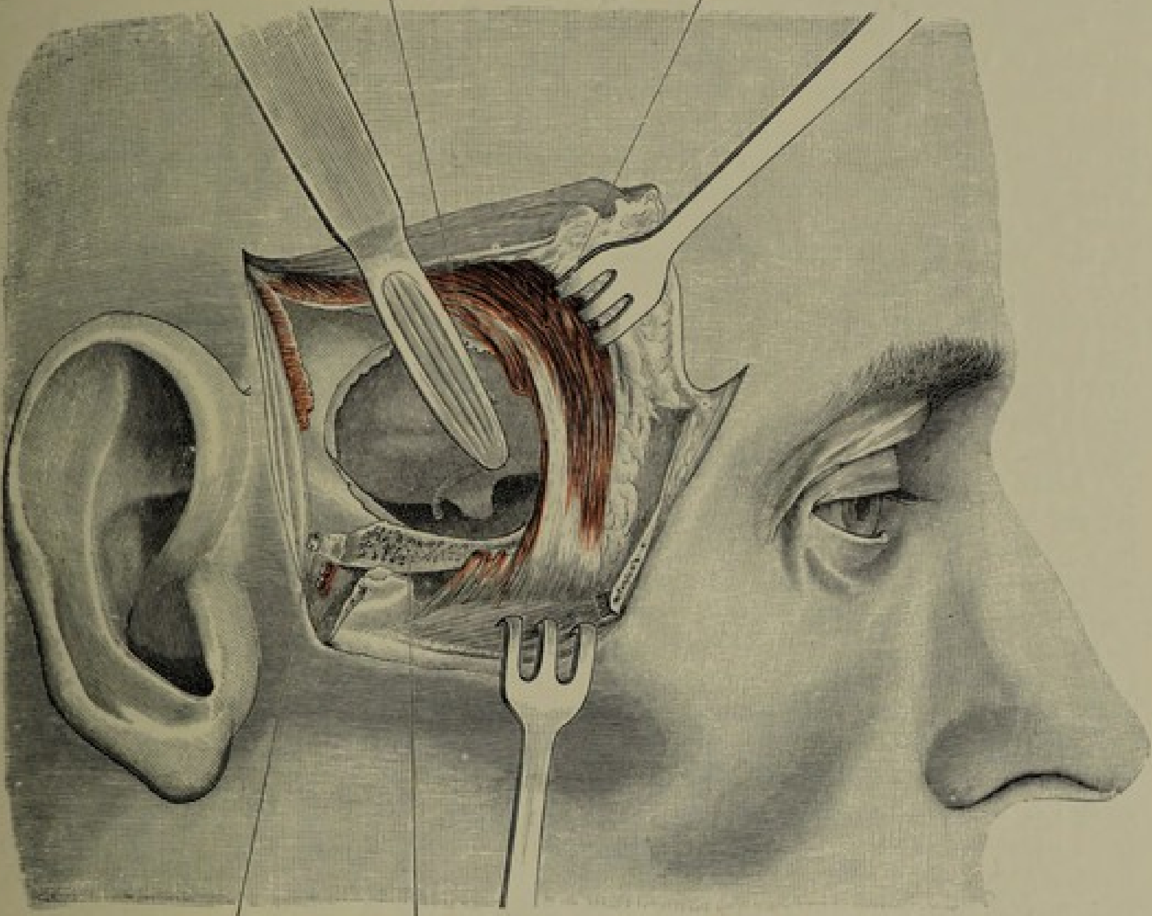


FIG. 100.—Excision of Gasserian ganglion through an angular incision. The zygoma is divided in front and behind and turned downwards, the temporal muscle being freed and drawn forwards. The skull is opened, and the bone at the base of the skull removed. The dura is raised up, exposing the middle meningeal artery at the foramen spinosum and the third division of the trigeminal nerve.

the ganglion is especially indicated, as it affords the most certain cure of facial neuralgia. The operator must be prepared for these cases, the difficulties of which may be to a large extent overcome by attention to the following points.

In the first place, ligature of the external carotid (Friedrich) is of real advantage as it limits the bleeding, although it may be dispensed with by an experienced surgeon. It is easily performed and might also be combined with temporary compression of the internal carotid.

The position of the patient is of great importance. The half-sitting posture (advocated by Villar and Ricard) is to be recommended. The head must, however, hang well back over the end of the table, so that the blood and cerebrospinal fluid

may escape freely instead of collecting at the base of the skull, and so that the brain may fall back into the cranial cavity.

It is of no great consequence whether the skin and fascia be divided by an incision convex downwards (as in our method) or be horseshoe-shaped, with the convexity upwards (Hartley-Krause). The branches of the facial nerve (zygomatico-temporales) which supply the orbicularis and occipito-frontalis muscles must, however, be avoided where they cross the malar bone (as in our method and in Cushing's). The incision we employ is shown in Fig. 100, the superficial temporal vessels being ligatured where they cross the zygoma, and the temporal fascia raised along with the periosteum from the upper border of the zygomatic arch, after which the latter is divided subperiosteally in front and behind.

Surgeons who have had little experience of the operation will find that a subfascial division of the zygoma (Doyen) as far in front and behind as possible is an advantage, as by turning it downwards considerably more room is obtained. Further, it is easier when trephining to remove the bone (as Horsley invariably does) instead of insisting on an osteoplastic operation. The reposition of the bone is of no real advantage when one considers the small size of the defect that is left. It is also advisable to raise the periosteum and soft parts not only on the temporal side but also on the base of the skull, and to remove the bone to within a finger's-breadth of the foramen spinosum, ovale, and rotundum, a procedure which makes the determination of the ganglion more easy and entails less removal of bone on the temporal side. We detach the periosteum and soft parts on the temporal side for a distance of 3 cm. and for an equal distance on the under surface of the skull, and then with a few strokes of the chisel above and at the sides, rapidly remove as large a piece of bone as possible from this area. On raising the flap of bone it breaks easily at its lower border.

After the foramen ovale has been exposed and the dura elevated, the latter is then incised over the third division of the nerve (which is 6 mm. long), and is dissected backwards from this point off the upper surface of the ganglion. On account of firm adhesions this must be effected by means of a fine knife or a delicate dissector with comparatively sharp edges. The middle meningeal artery which ascends on the dura can easily be traced to the foramen spinosum, and when the dura is raised up it can be readily reached and ligatured. If a preliminary ligation of the carotid has been performed, the artery can be simply cut across at the foramen spinosum, thus avoiding further trouble in detaching the dura from the base. The dura should be raised by means of a slender flexible spatula, and the portion covering the upper surface of the ganglion (6 mm. in length) which is always firmly adherent, should be dissected off from before backwards as far as possible. The adhesions here are very firm, and in freeing them the operator must cut down on to the ganglion until, according to Prat, the smooth cavity in which the root of the ganglion lies is suddenly entered.

This "portion retrogasserienne" or plexus triangularis is entirely free from adhesions with the dura for a length of 9 mm., according to Peyraud, so that the root can therefore be most easily isolated in this space with less risk of injury, and after it has been raised up on a hook, it is grasped with suitable forceps (without including the dura) and *very gradually* twisted out. Of course on the inner side, where the petrosal sinuses open into the cavernous sinus, it is necessary to keep close to the root.

If the root has been thoroughly isolated and grasped with forceps, one need not make a point of removing the ganglion. We have never met with a case in which neuralgia recurred after the root of the ganglion had been torn away.

Surgeons who have had considerable experience of the operation raise the ganglion from its bed by blunt dissection, and, after incising the dura in a forward direction, cut through the second and third divisions just in front of their respective foramina, after which the ganglion is torn out by the root, and the first division twisted, or better, simply cut with the knife. This entails, however, very severe bleeding, owing to the tearing of the veins which accompany the nerves and those which enter the bone on the under surface of the ganglion, and for the arrest of which plugging is necessary.

The wound is closed with deep sutures, including the skin, muscle, and fascia, no drain being inserted if the bleeding has been completely arrested.

(*b*) *Division of the Root of the Gasserian Ganglion* (*the Operation of Spiller and Frazier after Van Gehuchten*). This operation was first performed unsuccessfully by Horsley in 1890—before excision of the ganglion had been attempted,—and has been raised to the status of a recognised method by Spiller and Frazier, after whom it is named. Spiller[1] originally suggested it as a substitute for excision of the ganglion. Both authors jointly published their experimental researches, while no little credit is to be assigned to Van Gehuchten. Frazier performed the first successful operation on man. He and Spiller describe the method as "Physiological Extirpation of the Gasserian Ganglion" (Van Gehuchten).[2]

Simple division of the root, which constitutes a preliminary stage of the more severe and bloody operation of excision of the ganglion possesses undoubted advantages. The most severe bleeding follows separation of the ganglion on its under and inner aspect (sinus cavernosus), especially if there are firm adhesions. This does not occur, however, in section of the root.

Injury to the nerves in the wall of the sinus is avoided (oculomotor, trochlear, and abducent), while the duration of the operation is shortened and shock is diminished. The only question is whether the operation fulfils its real object, *i.e.* whether by division of the root a permanent degeneration of the fibres running centrally from the ganglion is obtained, with the result of a radical cure. Frazier, Spiller, and Van Gehuchten are of one opinion that degeneration occurs down to the bulbospinal root, while, according to the last-named author, the fibres remain permanently atrophied.

If this is the case, simple section of the root has certainly advantages over extirpation of the ganglion, not only in regard to the dangers of hæmorrhage and injury to neighbouring parts, but also in regard to the conditions of the eye. Without any precautions being taken, no ill effects are noticed on the eye, and the so-called trophic changes are absent.

Frazier and Spiller look for the explanation of this in the fact that, according to Kreuzfuch's researches, sympathetic nerve-fibres are contained in the first division of the trigeminal just as Budge had previously demonstrated the existence of pupil-dilating fibres in the Gasserian ganglion and in the fibres of the trigeminal (especially the first division) peripheral to the ganglion.

Frazier points out the further advantage that the motor root, which runs internal to the sensory root and on the under surface of the ganglion, may be preserved while the sensory root is divided, by which means atrophy of the muscles of mastication can be avoided.

In four cases operated on by Frazier, there was no repetition of the pain, while we have also found brilliant immediate results with, up to the present, no recurrence.

In our opinion there is a future before this operation; and we consider that it should replace extirpation of the ganglion, at any rate in difficult cases associated with continuous bleeding, or when the ganglion is firmly adherent.

The technique of the operation has already been described in detail under excision of the ganglion. If the root cannot be satisfactorily exposed and cut across low down, it may be divided at its junction with the ganglion. In tumours of the ganglion, the ganglion must, of course, be removed.

(*c*) *Intracranial Section of the Divisions of the Trigeminal.* This operation has been occasionally resorted to in difficult cases. Horsley performed it in 1888 (the first intracranial operation on the trigeminal nerve), and also in 1891, both times with success, while it was also undertaken in 1891 by Hartley and in 1892 by Krause. We have resorted to it in cases where excision of the ganglion was impracticable on account of incessant bleeding. According to Van Gehuchten, in 1881 Blum performed the operation, which was subsequently repeated by Doyen.

Abbé considers the method as effective as excision of the ganglion and recommends its general adoption.

In this operation only the second and third divisions are divided, so that it is not to be undertaken when the neuralgia also affects the first division. In comparison

[1] *American Journ. of Med. Sc.*, Nov. 1898.
[2] *Bull. acad. royale de méd. belgique*, Aug. 1903.

with the method described in (*a*) and (*b*) the difficulties are considerably less as it is relatively easy to isolate the second and third divisions; and the only question in the technique is whether the nerves should be cut across or torn out in the manner practised by Thiersch for the peripheral branches of the trigeminal.

Van Gehuchten [1] contends, and Spiller confirms his view, that when the branches are divided on the distal side of the ganglion the cells in the latter do not atrophy, but that when the nerves are torn out, a degeneration, not only of the nerve-fibres but of the corresponding ganglion cells, takes place right up to the bulbospinal root.

Van Gehuchten, from his experiments, recommends extracranial avulsion of the principal branches; while Chipault [2] maintains that complete peripheral resection of all three divisions of the nerve in most cases gives as good results as the much more serious resection of the ganglion. Incomplete peripheral resection is less satisfactory. Dege has recorded the results of resection of the peripheral nerves (Krause) in 55 patients, whose subsequent history he was able to trace. Only 11 were free from recurrence, while of the others the average period of freedom was two years and two months. In 77 resections he had three deaths. The immediate results, which we have observed after intracranial section, have been entirely satisfactory, but have not always been permanent. According to Van Gehuchten's and Spiller's experiments, exeresis with Thiersch's forceps is preferable to simple division. It is essential, however, to isolate thoroughly the branches before twisting them.[3]

Abbé has recorded satisfactory results from the method he adopts for preventing the reunion of the nerves after division, viz. by the interposition of gutta-percha tissue between the dura and the respective foramina.

We agree with Bockenheimer that it is just as difficult to expose the branches of the trigeminal at the base of the skull extracranially as it is to attempt intracranial exposure, especially of the second division.

There is still another procedure, which is considered in a later chapter, for the cure of trigeminal neuralgia, viz. resection of the sympathetic.

13. **Division of the Posterior Roots in the Spinal Canal.** The performance of intradural resection of the posterior nerve-roots at the point where they leave the cord is only to be considered when the pain is caused by affections of the meninges and cannot be relieved by any other means, as also in the case of neuralgia when all other methods of treatment have failed.

The results of this operation have hitherto been far from encouraging. Not only does Chipault record two fatalities in 7 cases, but it is certain that the recoveries in other reported instances (McCosh, Munro) were incomplete, local pain persisting and even motor paralysis being observed, so that the operations should be restricted to cases of extreme necessity.

In regard to the technique, the reader is referred to the description of laminectomy. After the dura has been opened, the nerve-roots may with comparative ease be lifted up and divided, either close to the cord or at the point where they pierce the dura.

If severe bleeding is encountered either before or after the dura has been opened, the operation may with advantage be performed in two stages.

G. SURGERY OF INDIVIDUAL PERIPHERAL NERVES

(a) General Remarks on Surgery of Nerves

Exposure of peripheral nerves is, as a rule, undertaken with the object of either temporarily or permanently interrupting conduction to the nerve-centres in painful conditions of the nerve, *i.e.* neuralgia. Permanent abolition of conduction is obtained

[1] *Bull. acad. royale belgique*, Aug. 1903.

[2] *Indépendance médicale*, No. 25, 1901.

[3] Laplace (*New York Med. Journal*. Dec. 1905) reports 4 successful cases in which, in the course of twenty minutes, he twisted the peripheral branches on a pair of forceps.

by avulsion or tearing out of the nerve (Thiersch's Neurexeresis). Simple section, neurotomy and neurectomy, afford much less reliable results.

On the other hand, motor nerves are also cut down upon in order to restore their function, especially when the nerve is adherent to, or is compressed by, some adjacent structure. Removal of the pressure and the separation of the adhesions often effect a permanent cure in neuralgia, while nerve-stretching is employed for the same purpose. By simply freeing the nerve motor symptoms can also be cured, and there is no doubt that surgery lags behind in regard to the treatment of traumatic lesions of nerves, *e.g.* by removing an effusion of blood either in or around a nerve, the function of the nerve can be restored even if it has been impaired for a considerable time. Tumours and cicatrices in the course of a nerve may be excised and conduction re-established by suture. The ends of the nerve must be sutured soon after division, otherwise they retract and become surrounded by a mass of connective tissue.

It is essential that healthy nerve-fibres should be brought into accurate contact and be supported in loose connective tissue.

Tubulisation of nerves has been employed with advantage in order to prevent the formation of adhesions at the site of suture, and to ensure the outgrowth of nerve-fibres from the central into the peripheral end. Foraminti[1] wraps up the nerve in an artery removed fresh from an animal or in one that has been hardened. If a fresh artery is utilised only delicate adhesions are formed with the intima; if a hardened artery is employed, it is first of all drawn over a glass tube, then fixed in formalin, washed, and boiled.

When the ends of the nerve cannot be approximated, portions of fresh animal nerve may be made use of to fill up the gap in order to aid the downgrowth of nerve-fibres from the central end.

A form of nerve-grafting which is of special interest in connection with the cure of paralysis (facial) consists in the union of a divided nerve with one still in normal connection with its centre. We shall deal more fully with nerve-grafting in considering the surgery of the nerve, only mentioning here that it has also been employed in the extremities in cases of infantile paralysis. Hackenbruch[2] records a case in which a very satisfactory result was obtained by implanting the posterior tibial nerve into the paralysed arterior tibial nerve. He exposes the nerves in the lower third of the thigh where they are deeply situated. The posterior tibial nerve is divided for one-third of its thickness, split longitudinally upwards, and the freed portion grafted into a slit in the anterior tibial nerve. As an alternative, one might endeavour by cutting the nerves almost completely across, to approximate them end to end, so that the sutures may be inserted laterally away from the cut surface.

(b) Cranial Nerves

In the chapter on trigeminal neuralgia we have already encroached on the surgery of individual cranial nerves. We shall now consider the subject methodically.

As far as we are aware, there is an entire absence of operations on the olfactory nerve.

14. Surgery of the Optic Nerve. The optic nerve is exposed in excising tumours situated in the orbit which are in contact with or growing from the nerve. An incision carried horizontally outwards from the external canthus affords good access to the space behind the eyeball. By detaching the orbital periosteum upwards and downwards, and removing a wedge of bone with a chisel from the outer wall of the orbit, the outer and posterior surface of the eyeball can be readily exposed without entailing any injury.

Krönlein's osteoplastic resection is the operation generally employed. We practise it in the modified form recommended by Franke (Fig. 101).

An incision is made below the eyebrow on the outer half of the supraorbital margin and is prolonged downwards to the junction with the infraorbital margin, from which point it is then carried backwards over the malar bone to the middle third of

[1] Langenbeck's *Archiv*, Bd. 73.

[2] *Deutsche med. Wochenschr.*, 1905, No. 25.

the zygoma. The zygoma is divided subperiosteally, and the zygomatic (external angular) process of the frontal bone, which forms a distinct crest, and which, along with the sphenoid, helps to form the postero-lateral wall of the orbit, is chiselled through subperiosteally as far as the spheno-maxillary fissure. The malar bone is then divided through the antero-inferior angle of the incision, the line of division extending backwards into the spheno-maxillary fissure and outwards as far as the attachment of the masseter, after which it is forcibly dislocated out of the wound. The rest of the crest-like projection of the sphenoid, which forms the lateral wall of the orbit, is clipped away, thus exposing the orbital fat in which the nerve is embedded and the lachrymal gland (Fig. 101).

Our incision has the advantage over that recommended by Krönlein in that (as Bockenheimer has shown) it causes no injury to the branches of the facial nerve either to the upper or the lower lid. The disfigurement is in consequence less ; while

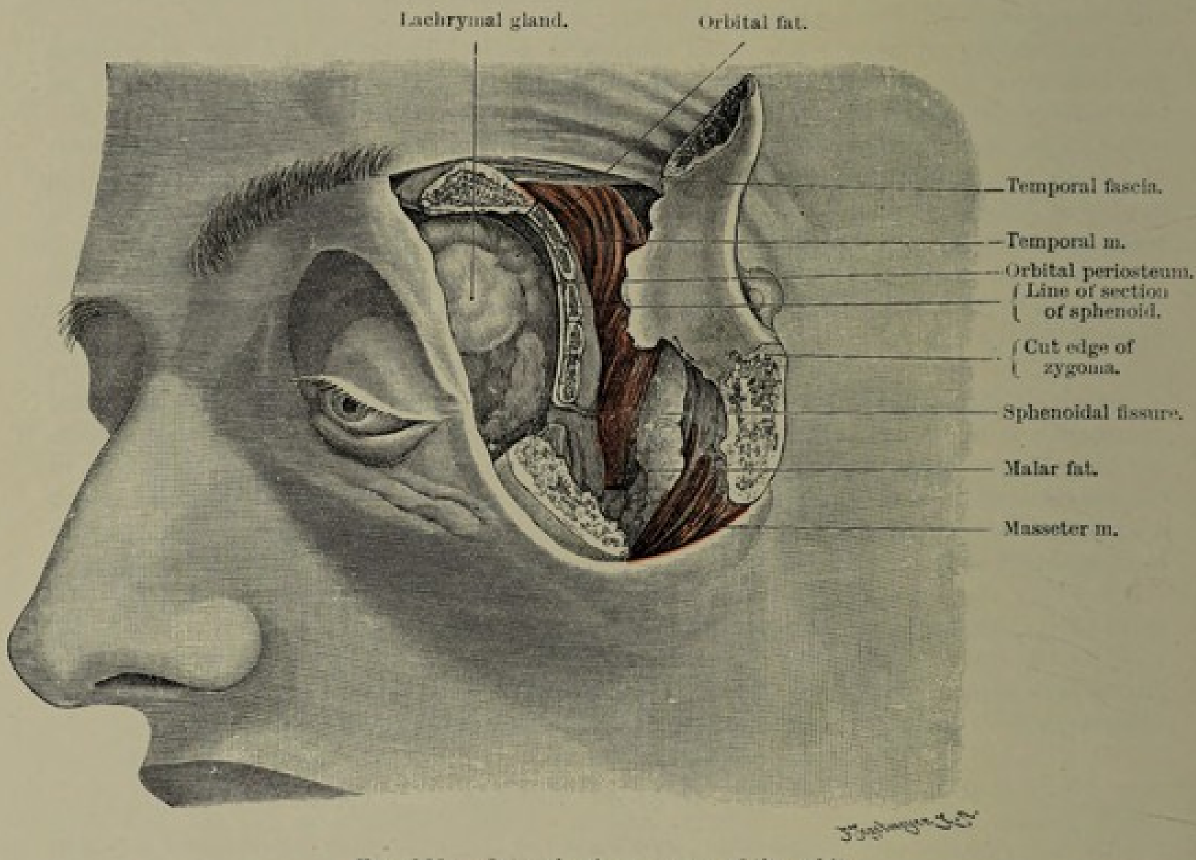


Fig. 101.—Osteoplastic exposure of the orbit.

it has the further advantage of giving more room, especially above, as it enables the operator to divide the bone more easily and more freely. The importance of this is observed from Heilbron's statistics of 120 cases, in which it is shown that after Krönlein's operation for the removal of tumours of the orbit, the mobility of the eye was frequently impaired, as the muscles and their nerves could not be sufficiently preserved. The better the access the less liable is the optic nerve to be injured.

Occasionally even more room may be required than is given by our modification of Krönlein's operation. Czermak has recommended in cases where Krönlein's operation gives insufficient room, the removal not only of the lateral border of the orbit, but of the whole malar bone as well, the latter being divided at its articulation with the superior maxilla and the zygoma. The disarticulation of the superior maxilla should be undertaken through a special incision.

According to Heilbron,[1] Becker performs a still more thorough operation, while

[1] See details of Krönlein's operation, Domela and Heilbron, Berlin, 1905.

Rollet's operation, in which the skin incisions correspond to the line at which the bone is divided, is also an excellent method as regards the direction of the skin incision.

Tumours in the upper and inner parts of the orbit must be approached by a different route if the eyeball is to be preserved, namely, by our normal incision for exposing the upper part of the nasal cavity. An incision is made from the eyebrow on to the bridge of the nose. The nasal bone and the nasal process of the superior maxilla are divided, while the ethmoid may perhaps also be removed (*vide* Operation to expose the nasal cavity).

Our method permits of the bone being replaced without causing subsequent deformity, and as the branches of the facial (ramus maximus, and rami zygomatico-temporales Bockenheimer) remain uninjured, the movements of the lids are in no way impaired.

The osteoplastic method of exposing the orbit, which was originally proposed by

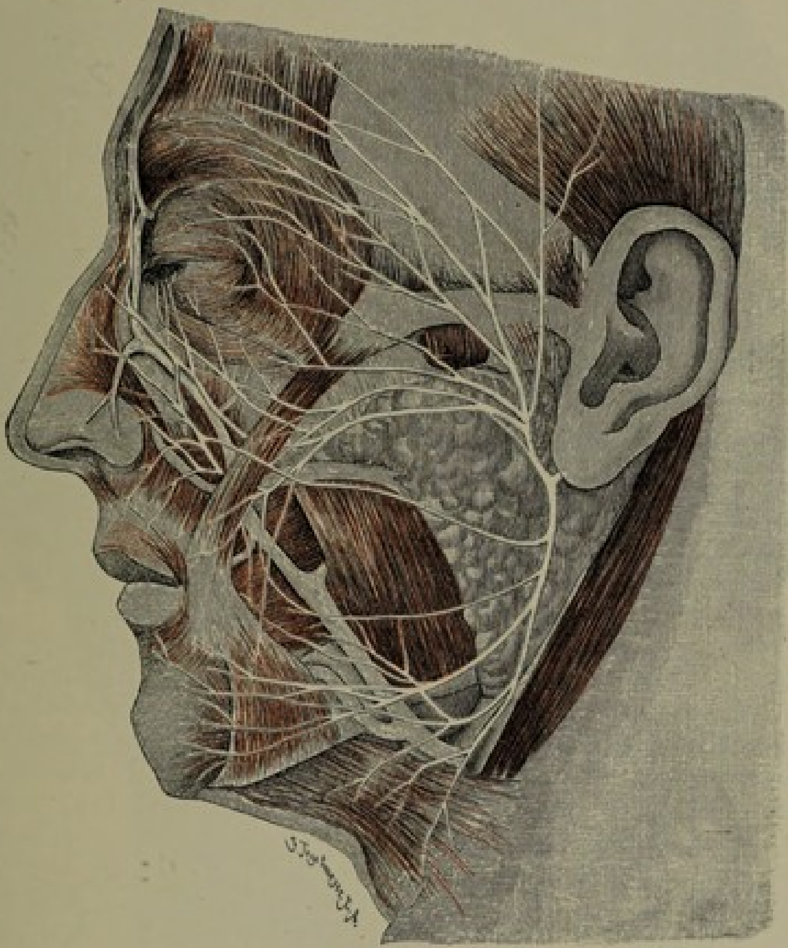


FIG. 102.—Ramifications of the facial nerve (after Bockenheimer), to illustrate the proper direction of incision on the face. The figure shows the three large branches which ascend over the zygoma, the subzygomatic branches, and the division which is distributed to the neck and lower lip.

Krönlein, has given satisfactory results in dealing with tumours of the optic nerve, as well as with single tumours in the orbital fat. According to Heilbron, it is unsuitable for the extraction of foreign bodies. Not long ago we successfully extracted a bullet by means of temporal resection. In inflammatory conditions of the orbit an osteoplastic operation is not indicated.

We are not aware of any operation having been performed on the oculo-motor and trochlear nerves. On the other hand, the **fifth cranial nerve (trigeminal) and its branches** are dealt with surgically for the treatment of neuralgia.

Before the introduction of the intracranial operation of excision of the Gasserian ganglion or its root, the divisions of the trigeminal nerve were severed as near as

possible to the base of the skull. But although the second and third divisions could be divided in this way, section of the first division was impracticable.

Division of the peripheral branches of the trigeminal is at the present time practised more frequently than the intracranial operation, because in neurexeresis (Thiersch) a much more effective method of treatment has been found than that of simple neurotomy. It was devised as a result of van Gehuchten's histological and

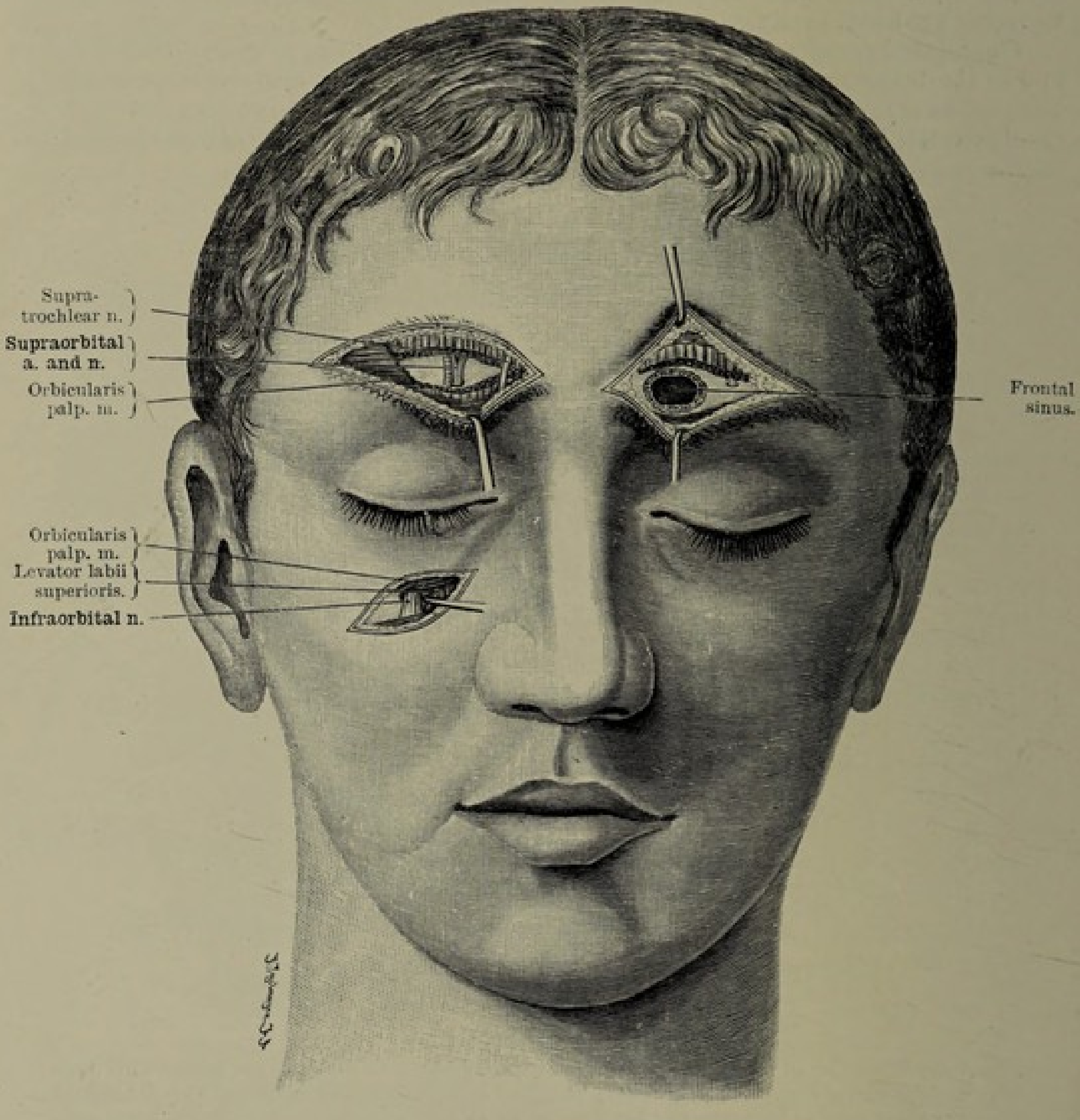


FIG. 103.—Ligature of the supraorbital artery. Exposure of the supraorbital nerve. Infraorbital nerve. Opening of the frontal sinus.

experimental work. Only a limited portion of a nerve requires to be exposed, after which it is seized with strong forceps, twisted, and torn out both from its central and peripheral connections. According to van Gehuchten, when the nerve is partly torn out instead of being simply divided, a greater effect is produced on the central ganglion cells, more especially on those in the Gasserian ganglion, and in the sensory root to the bulbospinal centres. The method which Blum first practised on the infra-orbital nerve gives the greatest certainty of success, while, as no extensive preliminary dissection is required, the operation is greatly simplified. In the following sections

we therefore describe typical operations by which definite portions of the nerve are most easily and most safely exposed, and begin with the operations to expose the main trunks at the base of the skull.

(*a*) *First* (*Ophthalmic*) *Division of the Trigeminal Nerve*.—Of the three branches of the ophthalmic nerve, the lachrymal, which supplies the lachrymal gland, is of no surgical interest. Only the nasal and frontal branches require consideration.

(1) Frontal Nerve (Fig. 103). In the accompanying figure (Fig. 103) both branches of this nerve are shown exposed, the larger supraorbital nerve lying external and the smaller supratrochlear internal. The supraorbital notch (frequently a foramen), which can be readily felt through the skin on the orbital margin, transmits the nerve as it passes from the orbital cavity on to the forehead, the artery of the same name occupying a superficial position. The supratrochlear branch lies $1\frac{1}{2}$-2 cm. to its inner side, and ascends vertically over the inner canthus.

To expose these nerves an incision is made along the lower border of the eyebrow down to the supraorbital margin, thus avoiding the zygomatico-temporal branches of the facial nerve which pass horizontally forwards, as well as those branches which ascend from below to supply the pyramidalis nasi and corrugator supercilli muscles (Fig. 102). The terminal branches of the frontal and supraorbital arteries are divided and ligatured.

By depressing the eyeball and freeing the artery (which has been already tied) both nerves are followed backwards under the periosteum of the roof of the orbit till the parent stem is exposed. The latter is then seized and twisted out with Kocher's artery forceps.

If the smaller supratrochlear nerve can be isolated by itself, each nerve may be twisted out individually. The so-called supraorbital neuralgia, which is met with in malaria, and in disease of the frontal sinus, etc., will practically always yield to this treatment.

(2) Nasal Nerve. The nasal nerve gives off the long root to the ciliary ganglion and the two long ciliary nerves (which may be the seat of ciliary neuralgia) and then divides into the ethmoidal branch which supplies the inner surface and tip of the nose, and the infratrochlear branch which is distributed to the eyelids and root of the nose.

The nerve is exposed by an incision extending from the middle third of the eyebrow downwards towards the bridge of the nose, *i.e.* the upper portion of our normal nasal incision. The periosteum and periorbital tissues are carefully raised off the roof and inner wall of the orbit, until the nerve is observed running transversely towards the anterior ethmoidal foramen. If possible, the periosteum should be separated farther back and the nerve traced back to the origin of the infratrochlear, so that the main root can be torn out. Otherwise one must twist out the ethmoidal branch above, and search for the infratrochlear branch close to the inner canthus, and then twist or at least stretch it where it is embedded in the soft parts.

(*b*) *Second* (*Superior Maxillary*) *Division of the Trigeminal Nerve*.—(1) Exposure of the Superior Maxillary Nerve at the Base of the Skull. When the superior maxillary nerve is exposed at the foramen rotundum (Figs. 104 and 105) the only branch which escapes is the middle meningeal nerve to the dura mater. On the other hand the central operation has the disadvantage that branches of the facial nerve, which pass by way of the Vidian nerve into Meckel's ganglion and into the palatine nerves for the muscles of the palate, are paralysed.

The dissection to reach the foramen rotundum is difficult. Langenbeck introduced a tenotomy knife at the outer margin of the orbit below the external tarsal ligament. This puncture method is now given up, as one can never be sure of avoiding injury to neighbouring structures. The infraorbital artery is liable to injury.

Poirier, without resecting any bone, reaches it by dissecting down to the pterygo-maxillary fissure through a vertical incision behind the frontal process of the malar and extending down to the zygomatic arch. This method, however, gives very little room. The rule now, therefore, is to perform a temporary resection of the malar according to the method of Brüns, and according to Lücke's procedure in the modifica-

tion of Lossen-Braun's operation, which preserves the attachment of the masseter, or according to that of Krönlein. All these methods possess the disadvantage that in consequence of the direction of the incision the branches of the facial nerve are not avoided with certainty.[1] Gussenbauer's method is one which gives very good access, but has the same fault. Friedländer, for the second as well as for the third division of the fifth nerve, has employed that portion of our incision for the third division of the fifth which runs from the eyebrow along the posterior border of the malar and the upper border of the zygomatic arch in combination with the method

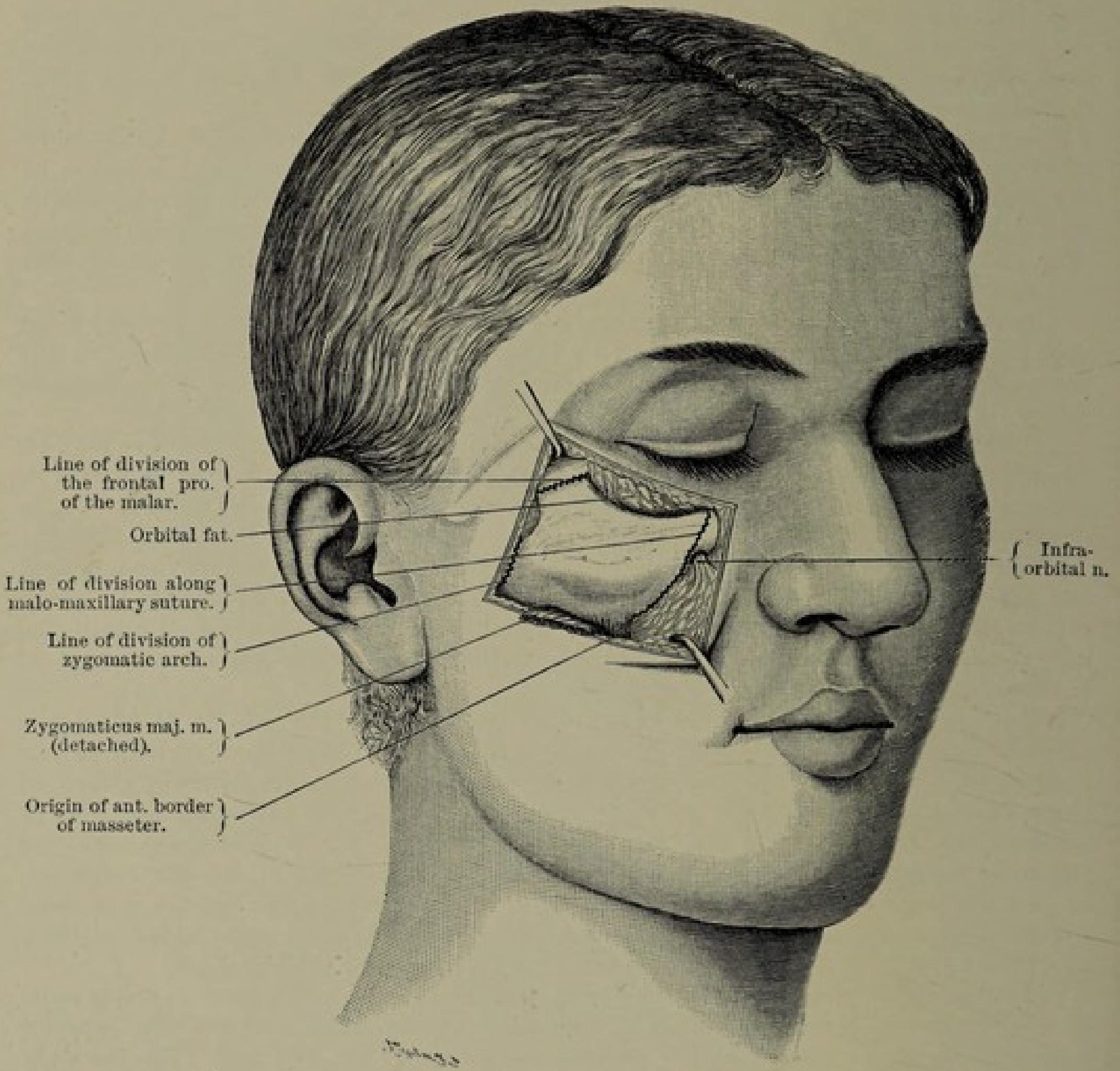


FIG. 104.—Resection of the second (superior maxillary) division of the trigeminal nerve.

described by us for resecting the malar bone. He merely divides the zygomatic arch farther back.

On the grounds of our principle, therefore, of regarding all incisions with disfavour which run at right angles to the branches of the facial nerve, we carry out our method as follows:—The incision is the same as that for exposing the infraorbital nerve, but longer, *i.e.* beginning over the infraorbital foramen and at the inner end of the infraorbital margin, and this is carried horizontally outwards over the lower part of the body of the malar bone to the zygoma. The angular artery is drawn aside or ligatured at the inner end of the incision, whilst Stenson's duct and the greater

[1] Compare Bockenheimer, Langenbeck's *Archiv*, Bd. 72.

branch of the facial nerve lie below it. At its inner end the incision passes down to the bone between the lowest fibres of the orbicularis palpebrarum and above the origin of the levator labii superioris. The former muscle, along with the periosteum, is dissected up as far as the orbit, the latter is separated subperiosteally only so far downwards as that the infraorbital nerve may be exposed at the infraorbital foramen and secured with a tenaculum.

The outer part of the incision passes above the origins of the zygomatic muscles,

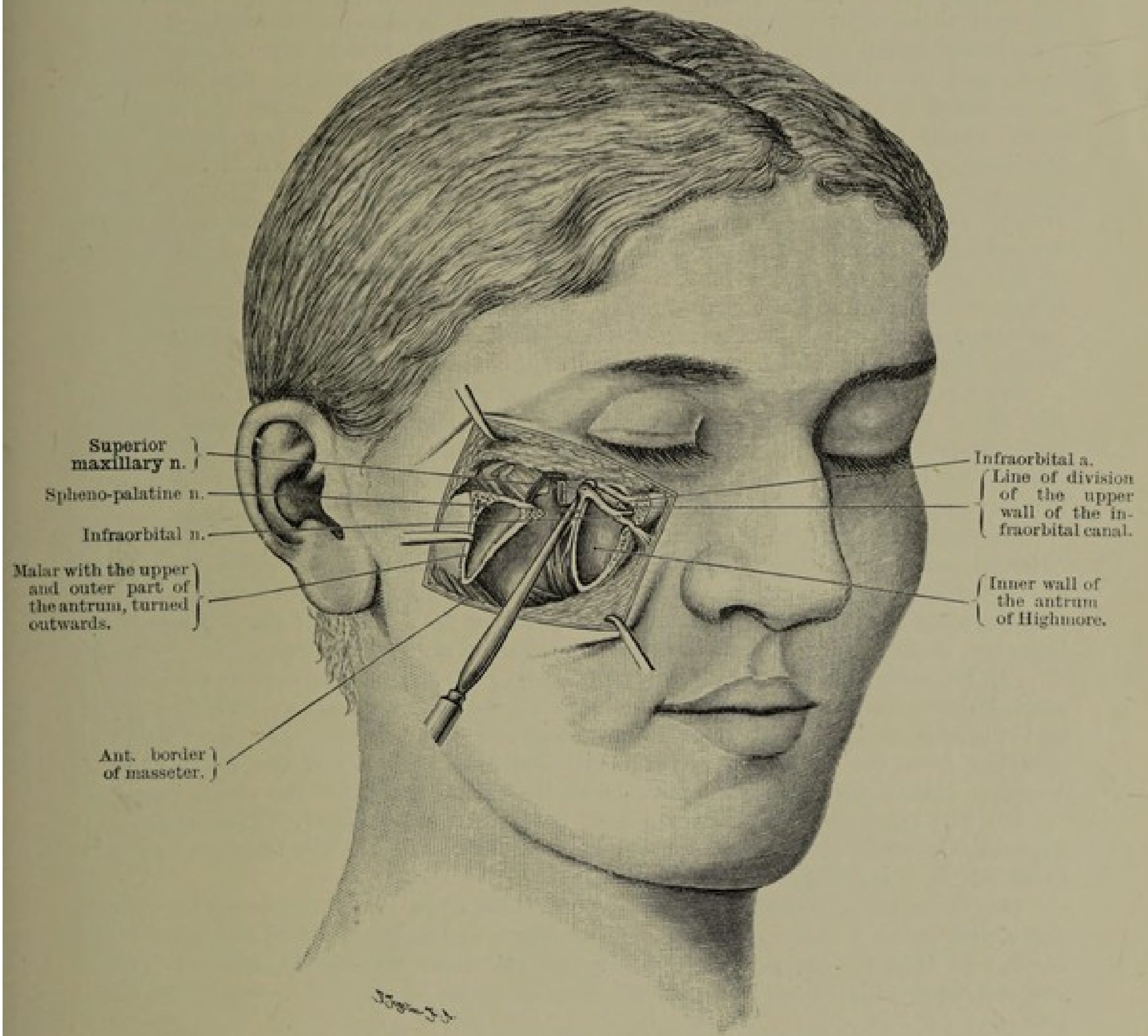


FIG. 105.—Exposure of the second (superior maxillary) division of the trigeminal nerve at the foramen ovale.

which are separated subperiosteally downwards, and the anterior fibres of the masseter are detached from the lower and inner part of the malar bone. The outer and inner surfaces of the malar are laid bare by means of a periosteum detacher (Fig. 104), previous to chiselling it through. The malar process of the upper jaw is bared, upon its anterior surface up to the infraorbital foramen, and upon its upper surface as far back as the spheno-maxillary fissure, and is then detached with the chisel in such a way that the roof of the infraorbital canal is carried with it. Anteriorly, the process is chiselled through from above the infraorbital nerve, downwards and outwards, to just below the anterior end of the origin of the masseter, and then upwards

through the outer wall of the antrum until it meets posteriorly the section through the orbital plate. In this way the outer part of the orbital plate and the superior-external wall of the antrum, together with its hinder angle, remain in connection with the malar bone, and are levered out along with it.

Before this can be done, however, the upper edge of the wound must be drawn upwards to expose the fronto-malar suture (Fig. 104), which is so chiselled through towards the posterior part of the spheno-maxillary fissure that its upper border, along with a portion of the zygomatic crest and of the orbital plate of the sphenoid, is removed along with it. After the zygomatic arch is chiselled through, the malar bone is dislocated upwards and outwards from the large wound with a strong sharp hook, and the orbital fat is carefully raised by a blunt retractor. The infraorbital nerve, which is kept drawn upon, can now readily be followed above the opened-up antral cavity as far as the foramen rotundum. A small hook is now passed behind the descending spheno-palatine nerves around the main trunk which is then caught with fine strong forceps, twisted, and wrenched out (Thiersch). The infraorbital artery, which accompanies the infraorbital nerve, is either avoided or ligatured. According to Potterat, the nerve lies immediately to the inner side of the insertion of the external pterygoid muscle, covered by a ridge of the great wing of the sphenoid which must be cut away with the chisel. The operation is completed by putting the malar bone back into position (fixation sutures being unnecessary) and closing the wound with sutures. The resulting scar is not disfiguring.

We have seen no bad results follow opening of the antrum. It is obvious from the above description that our procedure differs from the Lossen-Braun method, not merely in the more suitable skin incision (to avoid the branches of the facial nerve), but in the fact that the malar, together with the soft parts, is thrown upwards and outwards, thus giving much freer and easier access.

Alexander Fränkel, in resecting the second division of the fifth nerve, discards all external incisions. By an osteoplastic method he throws the anterior wall of the antrum upwards and outwards, and by opening the upper and posterior wall of the antrum, after the manner of Langenbeck's operation for division of the superior dental branches, he exposes the nerve from below, aided by an artificial light.

(2) Exposure of the Zygomatic (Orbital) Nerve. An incision 1 cm. long is carried down to the bone, beginning close to the outer commissure of the eyelids and passing obliquely outwards and somewhat downwards. The periosteum is detached from the outer wall of the orbit, and both branches of the nerve are torn across at their entrance into the foramen at the orbital surface of the malar bone.

(3) The sphenopalatine nerves cannot be divided individually. They are seen in exposing the main trunk of the superior maxillary division at the foramen rotundum (*vide* No. B. 1 and Fig. 106).

(4) The superior dental nerves may be divided alone (v. Langenbeck) by everting the upper lip and making a large incision down to the bone, above the level of the teeth, and then sawing or chiselling through the outer wall of the antrum (and its mucous membrane) from the osseous anterior nares as far back as the pterygoid process.

(5) The Infraorbital Nerve (Fig. 107). The infraorbital nerve is the branch which is most frequently the seat of neuralgia. This nerve may be stretched or avulsed through an incision from the mouth which divides the mucous membrane and periosteum along the line of reflection from the upper lip to the canine fossa. The soft parts, including the periosteum, are separated upwards as far as the infraorbital foramen, through which the nerve makes its exit half an inch below the middle of the infraorbital margin. The nerve is raised on an aneurysm needle, grasped with artery forceps, twisted, and finally torn out in the manner recommended by Thiersch.

A very good method, but one requiring an external incision, is the following:— An incision, 3 cm. long, is made in the line of our normal incision for the upper jaw beginning at the centre of the infraorbital margin and passing horizontally outwards to the upper extremity of the malar bone. This incision is preferable to the curved

incision Wagner uses, because the branches of the facial nerve to the muscles below are avoided, as well as those to the orbicularis palpebrarum. The incision is then carried down to the bone above the origin of the levator labii superioris. The periosteum is now separated downwards as far as the exit of the nerve from the infraorbital canal, where, after being isolated from the infraorbital artery, an aneurysm needle is passed under it. The periosteum is next separated backwards over the infraorbital margin and along the floor of the orbit until the entrance to the infraorbital canal

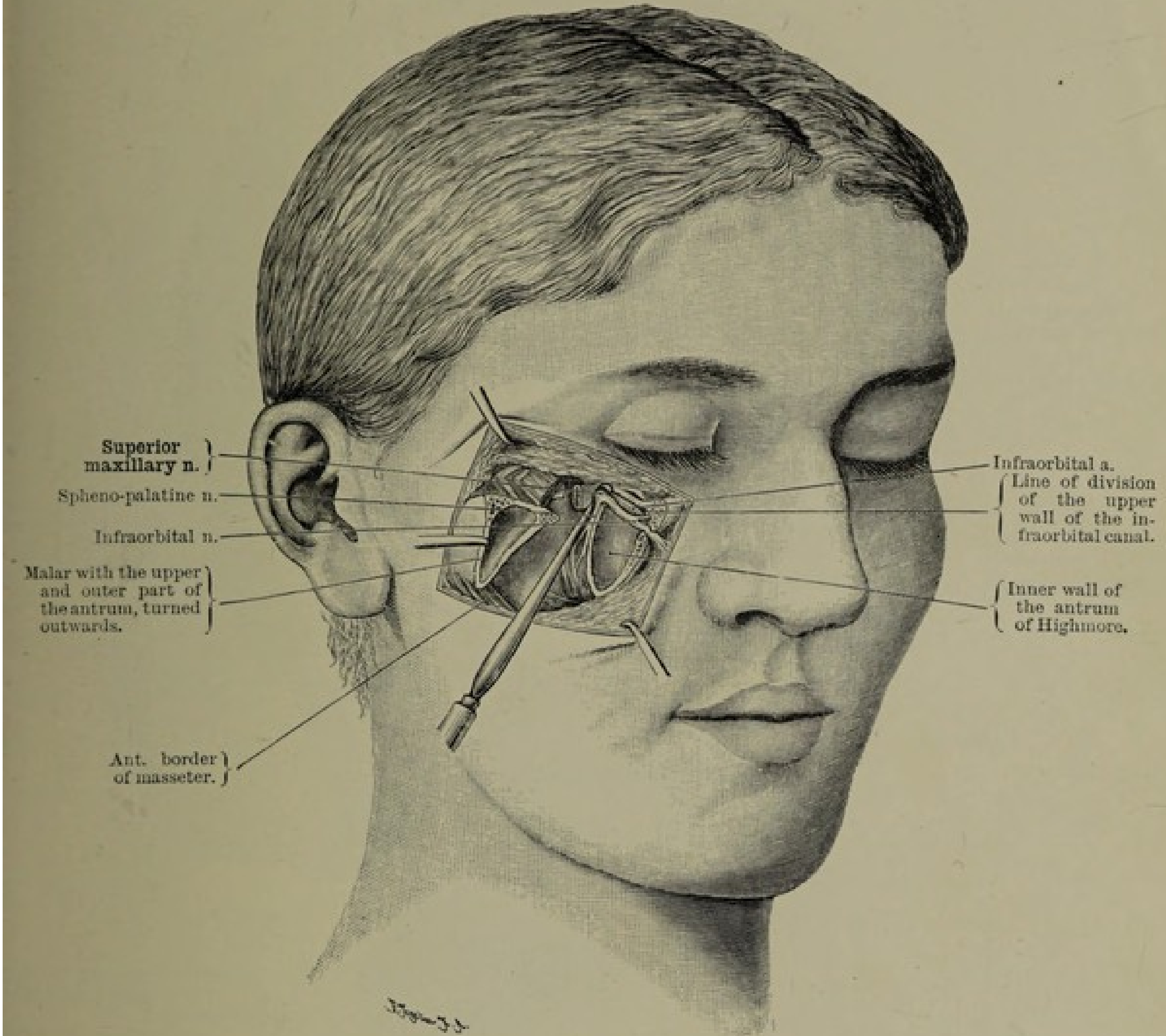


FIG. 106.—Exposure of the second (superior maxillary) division of the trigeminal nerve at the foramen ovale.

is felt or seen (Wagner). The thick anterior part of the roof of the canal is then removed with the hammer and chisel. In this way a considerable extent of the nerve is exposed and can be either stretched or removed. If the antrum has not been opened the wound heals by first intention without leaving any deformity; indeed this is the rule even when the antrum has been opened.

(6) Of the branches of the spheno-palatine ganglion only the palatine nerves can be attacked separately. They may be injected in the neighbourhood of the larger palatine foramen in order to produce anæsthesia in front and to the inner side of the hamular process.

(c) *Third (Inferior Maxillary) Division of the Trigeminal Nerve.* (Fig. 108.) The third division of the trigeminal nerve consists, at the foramen ovale, of motor (posteriorly and externally) and sensory portions so intimately united that they cannot be separated. Central division of the nerve, therefore, has the evil effect of producing a severe concomitant injury which is not intended, namely, unilateral paralysis and atrophy of the muscles of mastication. Happily experience shows (also in our own

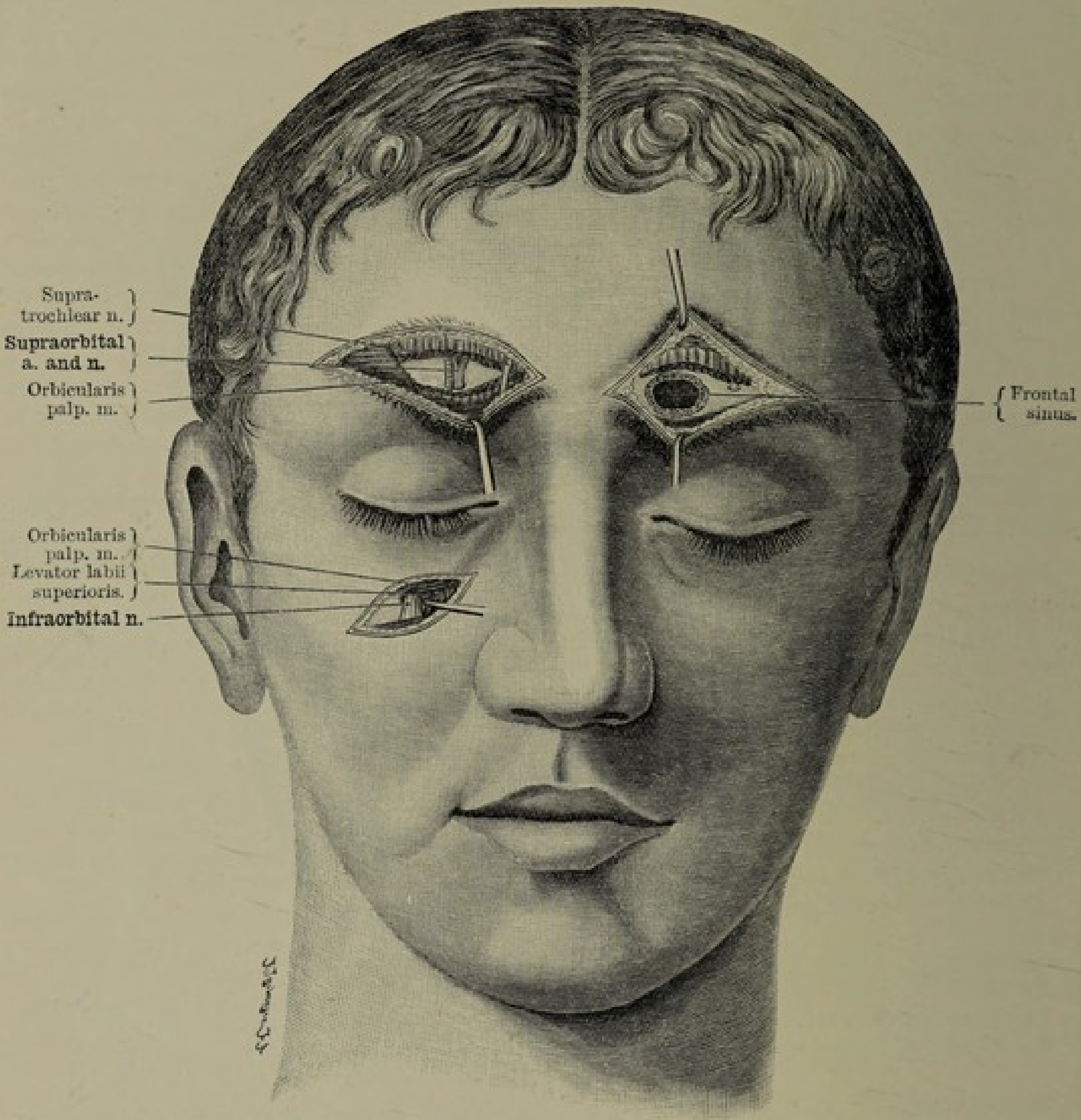


FIG. 107.—Ligature of the supraorbital artery. Exposure of the supraorbital nerve. Infraorbital nerve. Opening of the frontal sinus.

patients) that this unilateral paralysis of the muscles of mastication does not interfere greatly *per se* with the function of the jaw. It merely diminishes the firmness of closure of the jaw and the lateral movement towards the opposite side. These undesirable results of division of the trunk of the nerve at the foramen ovale make it justifiable to attempt a cure by stretching or dividing individual peripheral branches, in spite of the uncertainty of the result.

Operations on the *branches* of the third division of the fifth nerve are so often followed by recurrence of the neuralgia that nothing remains but to expose the trunk

of the nerve at the foramen ovale (Fig. 108). The most certain method of performing this operation is by resecting the zygomatic arch (Lücke, Bruns, Braun, Lossen, Krönlein).

We are firmly of the opinion that here also only those incisions are to be employed which avoid injuring the branches of the facial nerve.

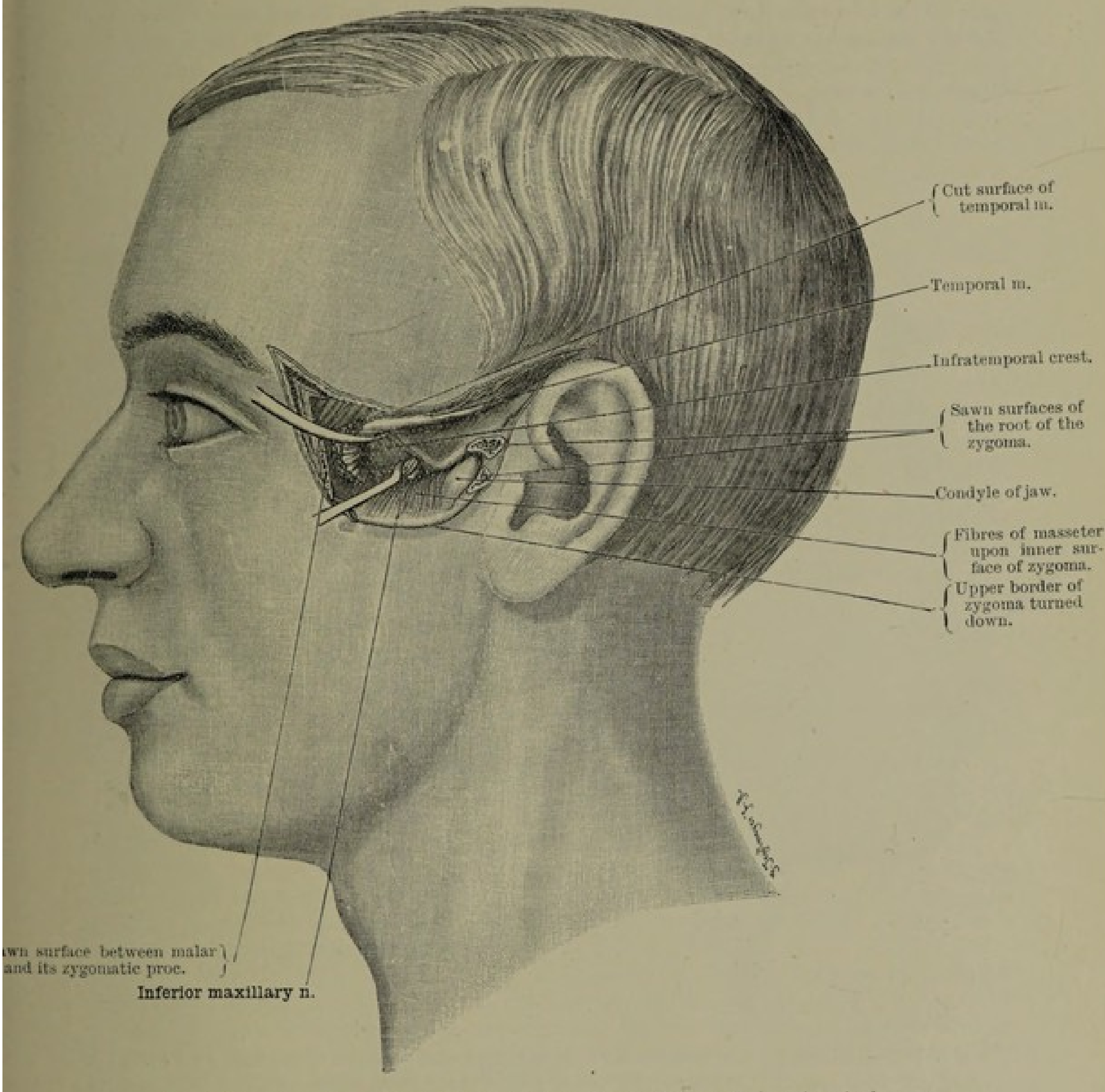


FIG. 108.—Exposure of the third (inferior maxillary) division of the trigeminal nerve at the foramen ovale.

The incision (Fig. 109)[1] begins a finger's-breadth behind the frontal process of the malar, and is carried obliquely downwards and backwards to the posterior extremity of the zygomatic arch, and from thence upwards and backwards in front of the ear at right angles to the first part of the incision. This second part of the incision is carried down to the bone, the superficial temporal vessels being ligatured. The

[1] O. Hildebrand has described as a new method this lower incision with a slight modification, and praises the cosmetic result.

incision divides the skin, and the strong temporal fascia is cut through a finger's-breadth above the zygoma. The malar is now exposed subperiosteally immediately behind its frontal process, and is chiselled through vertically. The zygoma is divided posteriorly close to its root, and the whole zygomatic arch is then carefully drawn down with a hook. The outer surface of the temporal muscle is now exposed covered with fat, and its posterior and lower border is separated from the skull and drawn well forwards with a blunt hook over the infra-temporal crest, at the same time detaching the periosteum and soft parts from the under surface of the skull (sphenoid).

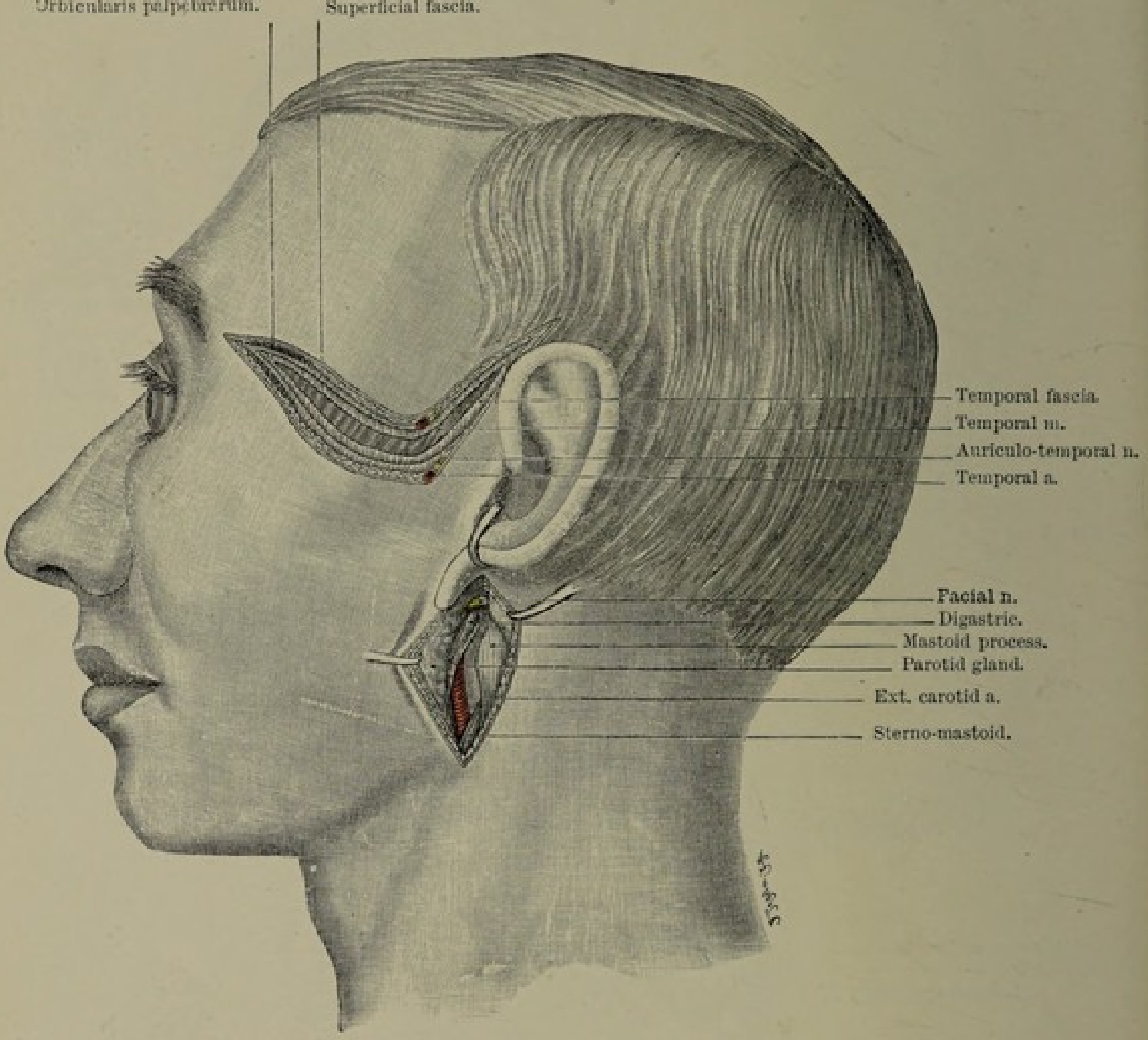


FIG. 109.—Incision for resecting the third (inferior maxillary) division of the trigeminal nerve at the foramen ovale. Exposure of the facial nerve.

This method has the great advantage that all the structures in the retromaxillary fossa can be pushed aside at once, which is not the case if the muscle be detached from below. If the access is not free enough, the insertion of the muscle into the coronoid process may be divided, or the process itself, after being thoroughly isolated, may be nipped off with bone pliers as in Pancoast's and Krönlein's method. There is no special reason for sparing the muscle; but its separation does less injury than its division, and gives a cleaner field for operating.

In this way the entire soft parts along with the periosteum are detached inwards from the under surface of the skull, thus exposing without any further dissection the

outer aspect of the base of the pterygoid process, behind the sharp edge of which the foramen ovale is easily palpable, about 3 cm. deeper than the zygomatic process of the malar. Occasionally there are two openings from which the nerve emerges. The somewhat severe hæmorrhage can be easily arrested by plugging. The larger vessels, branches of the maxillary, lie in the parts which have been drawn downwards, with the exception of the middle meningeal, which lies posteriorly. The trunk of the nerve can now be seized with a strong but small blunt hook and drawn into view: the best plan is to grasp it with a small strong pair of forceps and draw it out entire. If the hæmorrhage has ceased the wound can be closed at once; but if not, or when it is not quite certain that the entire inferior maxillary nerve has been divided (because it is difficult to decide, when the patient is under the anæsthetic), the wound should be stuffed with iodoform gauze, and after one or two days secondary ligatures introduced. The zygoma is replaced and sutured, anteriorly and posteriorly, to fix it in position. The resulting scar is hardly visible.

Lexer has incorrectly described our method as a mere "simplification" of Krönlein's operation, from which it really differs. He does not simplify our method to advantage by merely making an incision over the zygoma, as this necessarily involves injury to the frontal branches of the facial nerve.

It is generally unnecessary to resect the malar either at its orbital plate or at its junction with the upper jaw, except when the second trigeminal branch is to be resected at the foramen rotundum. Krönlein has quite recently (*Arch. f. kl. Chir.* Bd. xlii.) described a *retrobuccal method*; he splits the cheek along with two-thirds of the masseter, and by removing the whole of the coronoid process of the mandible he is able to trace the individual branches up to the base of the skull. If the cheek and the anterior two-thirds of the masseter be divided transversely as far as 1 cm. anterior to the lobule of the ear, one cannot be certain that no branches of the facial are injured. This method has already been employed, in a modified form, by Mikulicz, who saws through the lower jaw. The advantage of Mikulicz's method is that by turning up the entire ascending ramus of the jaw free access is obtained, but the operation is rendered much more serious. Bruns and Sonnenburg go still deeper, down from the angle of the jaw on the nerves.

Simultaneous exposure of the second and third divisions, as already mentioned, cannot safely be performed except by total resection of the zygoma. Even then it is not a convenient operation to perform, and the intracranial route is to be preferred, if one is not content with exposure and avulsion of the main peripheral branches.

(1) Buccinator Nerve. The buccinator nerve is the only sensory twig of the anterior branches of the inferior maxillary nerve, the others are purely motor and call for surgical interference chiefly in cases of unilateral trismus.

It is the sensory nerve for the region of the angle of the mouth. Lying to the inner side of the coronoid process of the lower jaw, on the insertion of the temporal muscle, it is to be secured at the anterior border of the process, whether the operation be performed from without or from within.

The operation from within (Holl) is the simpler. After opening the mouth widely, and feeling for the ridge at the anterior border of the ramus of the jaw, we make an incision down upon it through the mucous membrane and the fibres of the buccinator muscle on the outer surface of which the nerve runs. The nerve will be exposed passing transversely forwards upon the process. Panas was the first to employ this method.

Zuckerkandl's incision for exposing the nerve from the outside which runs horizontally below the malar bone and zygoma immediately above Stenson's duct, involves the serious risk of injuring the ramus maximus of the facial nerve. Preference must be given to Bockenheimer's incision, which is 4 cm. long, and extends from the angle of the mouth to the incisura intertragica, the centre being placed over the anterior border of the masseter. After the pad of fat in the cheek is exposed, the nerve will be found lying on the outer surface of the buccinator muscle. It may be necessary to split the fibres of the muscle and reach the nerve at the inner surface of the coronoid process.

(2) Auriculo-Temporal Nerve. The auriculo-temporal nerve (Fig. 110) is exposed by an incision extending vertically upwards from the root of the zygoma through the skin and fascia. This exposes the temporal artery, behind and under cover of which is the nerve.

(3) Inferior Dental Nerve (Fig. 110). (*a*) By trephining the ascending ramus through an incision along the angle of the jaw. Velpeau and Linhardt advocate a

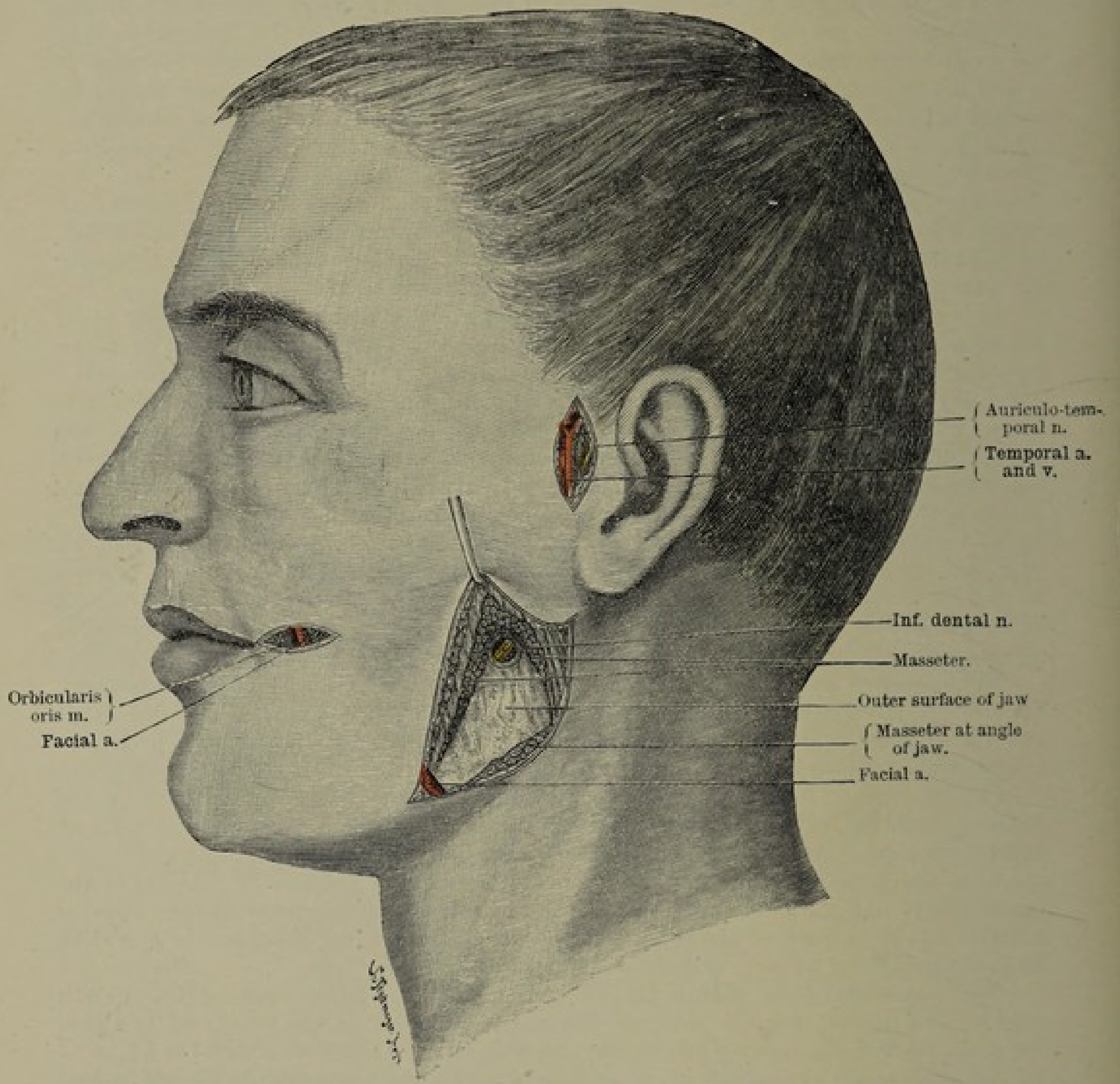


Fig. 110.—Ligature of the facial artery. Ligature of the temporal artery. Trephining the ascending ramus of the jaw to expose the inferior dental nerve.

method, which is preferable to that of Kühn and Bruns, in which the angle of the jaw is chiselled through. The incision in "the middle line of the ascending ramus," however, is not such a good one as that described by us. It is just in this position that the branches of the facial nerve supplying the muscles of the chin and lower lip ramify. After making a curved incision along the angle of the jaw, the dissection must be continued cautiously, and care must be taken to draw downwards the supramaxillary branch of the facial nerve (compare the posterior part of the normal incision for the anterior triangle). The tendinous fibres of the masseter are separated

upwards from the jaw with the knife and periosteum elevator, the muscle is retracted upwards as far as the upper edge of the wound, and a piece of bone is chiselled out from exactly the centre of the ascending ramus (Velpeau and Linhardt). In this way the nerve is exposed as it enters the inferior dental canal. This method is a very precise one, and is sure to strike the nerve. It is less severe than Bruns' method of chiselling out a piece of bone from the posterior border of the ramus; and it is easier than the Sonnenburg-Lücke operation, which consists in detaching the periosteum along with the internal pterygoid muscle from the inner surface of the ramus as far as the lingula. If primary healing occurs there is no interference with the function of the jaw.

(*b*) Paravicini's method. The mouth having been widely opened by means of a White's gag, the sharp inner edge of the anterior border of the ascending ramus is felt for, and an incision made along it through mucous membrane and periosteum down to the bone. The inner edge of the wound is now separated subperiosteally from the inner surface of the ramus by a blunt instrument until the spine is felt at the inner edge of the opening into the inferior dental canal. The nerve is found with certainty behind the spine. The operation is exceedingly simple, and does much less injury than operations from the outside, but has the disadvantage of producing a wound in the mouth from which infection may proceed. Moreover, the slower healing of an infected wound, combined with the fact that the internal lateral ligament is attached to the spine, entails a longer hindrance to the opening of the mouth.

(4) Mental Branch of the Inferior Dental Nerve. The terminal portion of the above nerve, namely, the mental nerve, is exposed by drawing the lower lip well down from the jaw and dividing vertically the mucous membrane at its line of reflection opposite the interval between the first and second bicuspid teeth: the periosteum is then divided, when the nerve will be found emerging from the mental foramen. Generally, however, the seat of neuralgia is more proximal—in connection with the teeth—so that the nerve must be exposed before it enters the inferior dental canal.

(5) The Mylohyoid Branch. This twig may be exposed from below where it lies between the lower jaw and the insertion of the mylohyoid muscle on the inferior surface of the latter.

(6) The Lingual Nerve. The lingual nerve may also be exposed by Paravicini's intrabuccal method (cf. No. 3*b*). The following method, however, is simpler, because the nerve as it passes forwards between the anterior pillar of the fauces and the root of the tongue lies very superficially, indeed just under the mucous membrane. All that is required to expose the nerve is to make a small longitudinal incision through the mucous membrane, but not too near the tongue. The transverse splitting of the cheek by Roser's method is not a necessary preliminary. The disadvantage of the operation is that the wound is inside the mouth.

To avoid this drawback we have sought to expose the nerve from the outside and from below, namely, where it passes above the submaxillary gland. The incision is a part of our normal incision for the superior triangle of the neck. It exposes the lower border of the submaxillary gland, which is turned upwards, and the nerve is then secured where it is connected through the submaxillary ganglion with the submaxillary gland immediately in front of the internal pterygoid muscle. The operation is considerably more difficult than that previously mentioned, but it possesses the advantage that primary healing is obtained with certainty.

Lastly, the nerve may also be secured by trephining the ramus of the lower jaw in the same way as for the inferior dental nerve, or from below (Sonnenburg-Lücke).

Division and avulsion of the nerve may be indicated in lingual neuralgia, especially in connection with cancer of the tongue.

So far as we are aware, there are no special operations connected with the abducens, although the question of nerve-grafting might be considered.

15. Facial Nerve (Figs. 109 and 111). The facial nerve is liable to be injured in any operative interference behind the angle of the jaw (removal of glandular and other tumours) as well as in operations on the parotid (excision of parotid tumours,

and in incision of a phlegmonous parotitis). The nerve is deeply placed and is partly covered by the parotid. In the case of simple tumours it can generally be preserved, but in malignant tumours the nerve has frequently to be sacrificed.

In nerve-grafting, we now possess a means of repairing a nerve injury, and it is especially in connection with the facial nerve that this operation has been most successful.

The results are infinitely better than after the facial nerve is stretched in cases of facial spasm, although the latter operation proves in many cases successful.

We have frequently stretched the facial nerve and would always try its effect before resorting, like Kennedy, to division and nerve anatomosis. We therefore reproduce our description of the operation to expose the facial nerve.

Operation: In partial agreement with Heuter, Löbker, and Kaufmann, we make an incision behind the angle of the jaw along the anterior border of the sterno-mastoid as far as its attachment to the mastoid process: the attachment of the lobule of the ear is then divided by extending the incision upwards in front of the tragus. The tissues to be divided are somewhat dense, consisting of processes of the parotideo-masseteric fascia passing to the cartilage of the ear.

The knife is used cautiously until the lobules of the parotid gland come into view. A blunt hook is inserted, and the lobules are detached forwards with a tissue dissector. The small bleeding vessels must be secured with forceps, otherwise the view is obscured. The tendinous anterior border of the sterno-mastoid is recognised in the floor of the wound, the anterior border of the mastoid process is felt for, and then each strand which passes forwards is irritated mechanically to see if the facial muscles contract. The nerve runs from behind forwards over the posterior border of the digastric, and slightly downwards under the parotid as a fine cord 2 cm. in thickness. It lies at a distance of 2·5 cm. (1 in.) from the surface, fully 1 cm. deeper than the anterior border of the sterno-mastoid and the mastoid process, about midway between the angle of the jaw and the zygoma. (In Fig. 109 it is drawn rather too high.) The posterior auricular artery lies posterior to the wound, while the external carotid lies under the digastric muscle.

In exposing the nerve for the purpose of stretching it in facial spasm a general anæsthetic must not be employed, because the stretching must be so measured that it produces a distinct, but not a total paresis, which can readily be brought about by slight traction with an aneurysm needle. Even if at first some spasm continues this soon completely disappears. An old lady operated on by us in this way recovered completely within fourteen days after having complained of the spasm for six years. The paresis gradually disappears.

Important contributions to the subject of nerve-grafting or nerve-anastomosis have been made by Harvey Cushing,[1] Frazier and Spiller,[2] and Destelle,[3] while Manasse and Barrago have studied it from the experimental point of view.

Up to 1905 the facial nerve had been grafted on twenty-two occasions (Destelle), the anastomosis being made with the posterior branch of the spinal accessory fifteen times, and seven times with the hypoglossal. Although very different opinions are held regarding His's view that every nerve is an outgrowth of a nerve-cell, and that regeneration only takes place by a downgrowth of fibres from the central into the peripheral end, and also regarding the views held by Bethe and Nissl, Ballance and Stewart and other investigators, that regeneration can take place in the peripheral portion of the nerve, the fact remains that nerve impulses can be re-established by anastomosing two different divided nerves. According to Cushing, the credit of having demonstrated experimentally the truth of this nerve-crossing is due to Langley.

Cushing maintains that one must assume from Harrison's researches that there is in the central end of a divided nerve an inherent tendency to re-establish its peripheral connection by some sort of chemiotactic influence, so long as all mechanical obstruction has been removed, irrespective of whether the peripheral portion con-

[1] *Annals of Surgery*, 1903; *vide* also *Cleveland Med. Journ.*, Jan. 1905.
[2] *Univ. of Pennsylvania, Med. Bull.*, 1903.
[3] *Thèse de Bordeaux*, 1905; *vide* also Bréaroisse, *Thèse de Paris*, 1901.

tributes to the process by autoregeneration or not. We have therefore to aid this natural tendency by the removal of all obstructions. We know that when the edges of a wound are accurately sutured, divided nerves heal of their own accord, and also that it is difficult in the case of sensory nerves to prevent regeneration occurring, if there is no obstacle to the subsequent outgrowth in the case of sensory nerves, *e.g.* the trigeminal.

Union of the distal end of the nerve (or as in Lynn Thomas's case, of the main branches) with the spinal accessory or hypoglossal nerve, has been introduced as a method for the relief of facial paralysis. Ballance and Stewart first performed the operation on man in 1895. The effects of the anastomosis are that the nerve-ends unite and there is re-establishment of muscular tone and voluntary muscle power even if the paralysis has existed for a long time, provided the muscles are not quite

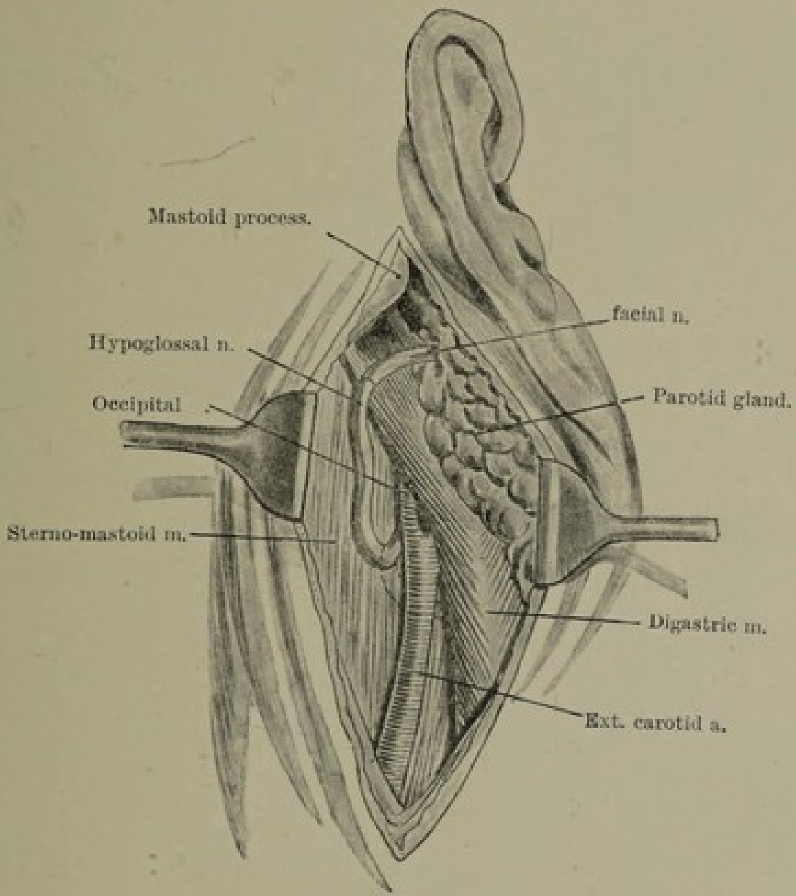


FIG. 111.—Facio-hypoglossal anastomosis. Frazier's operation.

atrophied. In facio-accessory anastomosis an active and independent innervation of the muscles of the face is obtained, but the face twitches with every voluntary movement of the shoulder.

Ballance, Körte, and Frazier therefore prefer to utilise the hypoglossal, because, firstly, the nerve-centres are closer to one another, and secondly, because it is easier to improve the effect by educative methods.

As regards the method of anastomosis to be employed, it has been proved that end-to-end, and end-to-side union afford equally satisfactory results. The former appears to be more certain, and is applicable to extreme cases where everything depends on conduction through the new union; end-to-side union, on the other hand, is reserved for those cases where, in the case of failure, one is unwilling to risk paralysis of the healthy nerve used for grafting.

Technique: An incision, 10 cm. long (*i.e.* longer than that required for simple exposure of the facial nerve), is made along the anterior border of the sterno-mastoid

extending up on to the mastoid process. The posterior border of the parotid is exposed and displaced forwards. According to Frazier, the nerve enters the gland by passing forwards on the outer surface of the styloid process and the digastric muscle 1 cm. above and the same distance internal to the tip of the mastoid process. When the lesion is situated higher up, as is the case in diseases of the middle ear, and in chills in which degenerative neuritis has been proved to exist right up to the geniculate ganglion (Spiller), the nerve must be followed to the styloid foramen and divided as close to it as possible.

The hypoglossal nerve is then isolated at the point where it hooks round the commencement of the external carotid artery. If the spinal accessory nerve is selected, it must be followed from the front of the transverse process of the atlas (which is always easily felt) to the under surface of the sterno-mastoid. By drawing the muscle outwards the nerve can be rendered distinctly visible.

The distal end of the facial nerve is now either implanted in a lateral slit in the hypoglossal or the spinal accessory nerve, or the latter nerve is cut across and its central end united to the peripheral end of the facial nerve, with fine sutures including as far as possible only the nerve-sheaths. By division of the nerve obliquely, a broader surface of contact is obtained. Fine catgut should always be used, so that as little cicatricial tissue as possible may be produced from the long-continued presence of a foreign body.

16. Acoustic Nerve. Tumours not infrequently occur in connection with the eighth cranial nerve and give rise to serious pressure symptoms although they are generally small and easily removed. The question is merely one of correct diagnosis.

The dissection to expose the auditory nerve at the base of the skull is an extensive and severe undertaking, and is the same as that for exposure of the cerebello-pontine angle.

In describing the surgery of the cerebellum, we gave an illustration from Frazier's work (Fig. 90) which shows how the posterior aspect of the petrous temporal with the entering auditory nerve can be exposed by trephining the occipital bone and depressing the cerebellum downwards and inwards.

The glosso-pharyngeal nerve has not yet been made the object of surgical interference.

17. Vagus Nerve. The surgery of the tenth cranial nerve is important firstly on account of its laryngeal branches and secondly on account of its cardiac and pulmonary branches.

In the removal of malignant tumours in the neck, it is not uncommon to be under the necessity of resecting the vagus on one side. As this, however, produces paralysis of the recurrent laryngeal it is desirable that the nerve-ends should be united. This may require a plastic operation, *e.g.* lengthening the nerve, and if the gap between the ends is extensive an anastomosis may be found necessary, *e.g.* with the spinal accessory, provided the latter is available.

(*a*) *Superior Laryngeal Nerve.* This branch of the vagus, which is essentially the sensory nerve for the larynx, is exposed by drawing downward the lower edge of the hyoid portion of our normal incision. At the point of origin of the facial artery it passes deeply behind the external carotid, then forwards parallel to the great cornu of the hyoid bone across the middle constrictor of the pharynx, and upon the outer surface of the thyro-hyoid membrane, and disappears under the posterior border of the thyro-hyoid muscle. It is of very great importance to bear in mind the course of this nerve, as its injury causes insensibility of the larynx, in consequence of which, in operations upon the larynx and the mouth, the patient is specially liable to die of septic pneumonia (*Schluck pneumonie*).

If the nerve is divided, implantation of its peripheral end into the vagus or a cutaneous sensory nerve is to be considered.

The author has stretched the nerve with permanent benefit in a case of acute neuralgia limited to the superior laryngeal nerve.

(*b*) *Inferior Laryngeal Nerve.* Paralysis of the inferior laryngeal nerve is a common complication in goitre, and occurs still more frequently after excision of the

thyroid, specially if the operation has been performed by a surgeon who has no great experience of this branch of surgery. Fortunately the hoarseness which results from unilateral paralysis of the laryngeal muscles is generally only temporary, since the other vocal cord comes in contact with the paralysed cord across the middle line in phonation.

Still in some cases the hoarseness may prove persistent, when the question has to be considered of implanting the peripheral end into the trunk of the vagus or of uniting it to the central part of the spinal accessory after the latter has been divided.

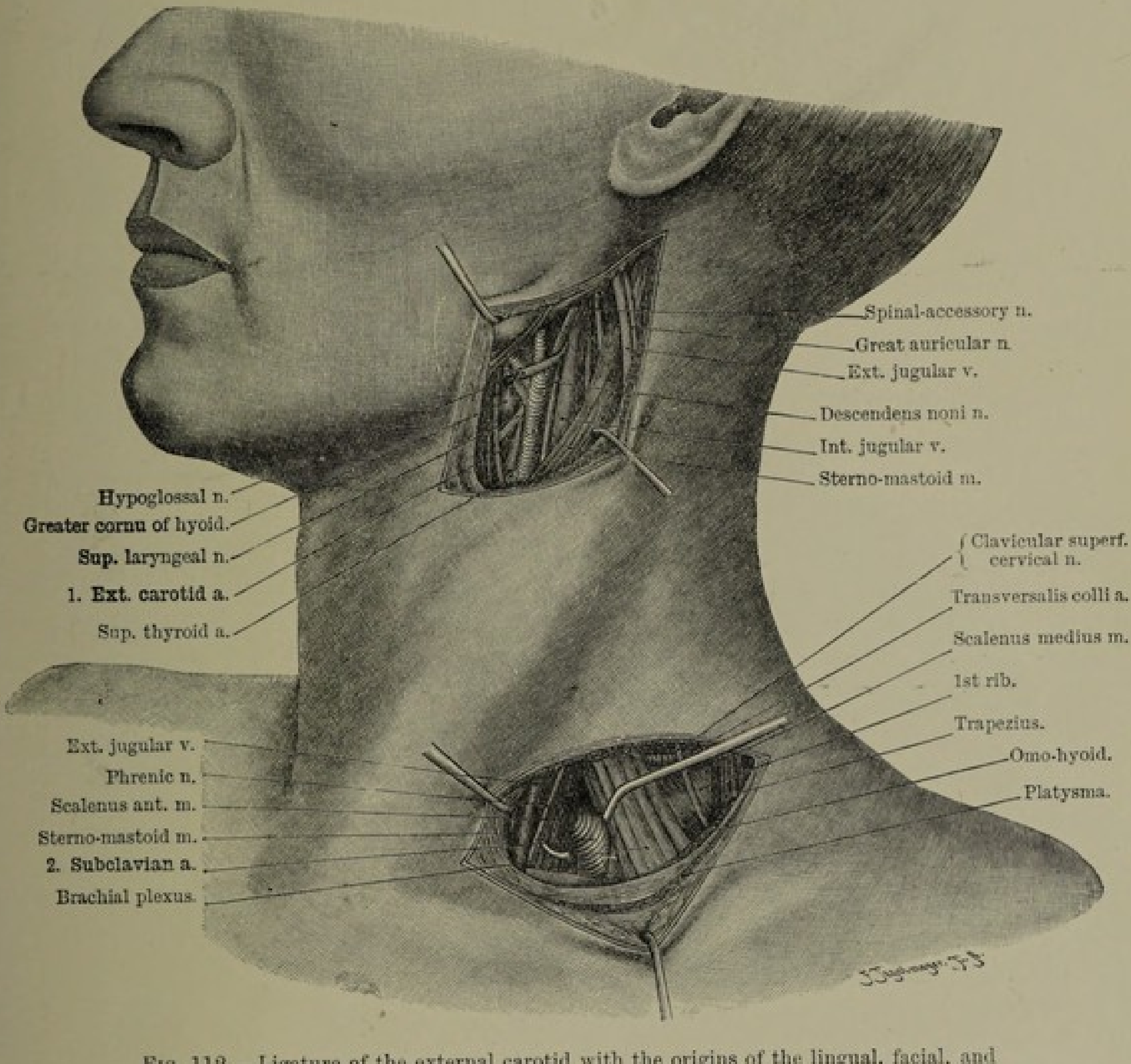


FIG. 112.—Ligature of the external carotid with the origins of the lingual, facial, and occipital arteries. Ligature of the subclavian artery.

18. Spinal Accessory Nerve (Figs. 112, 113). The eleventh cranial nerve supplies through its posterior branch the sterno-mastoid and trapezius. It is very liable to be injured in the removal of tumours in the neck, and is intentionally exposed and divided in facio-accessory anastomosis, since its division, beyond causing drooping of the shoulder and atrophy of the trapezius, results in no serious loss of function. Even after section of the spinal accessory the head can be rotated and the arm can be raised to the horizontal position.

The spinal-accessory nerve (Fig. 112) passes downwards and backwards in front of the internal jugular vein, beneath the upper third of the sterno-cleido-mastoid muscle.

It gives branches to the sterno-cleido-mastoid and trapezius muscles. In spasmodic conditions which are limited to these two muscles, the stretching or tearing out of the nerve gives good results. The nerve is to be avoided, however, in operations in the neighbourhood of the upper end of the sterno-mastoid, especially in excising the lymphatic glands in this region. To expose the nerve we employ the mastoid portion of our normal incision, viz. from the apex of the mastoid process to below the angle of the jaw. The external jugular vein and the great auricular nerve having been freed, the sterno-mastoid muscle is drawn forcibly backwards. The spinal-accessory nerve

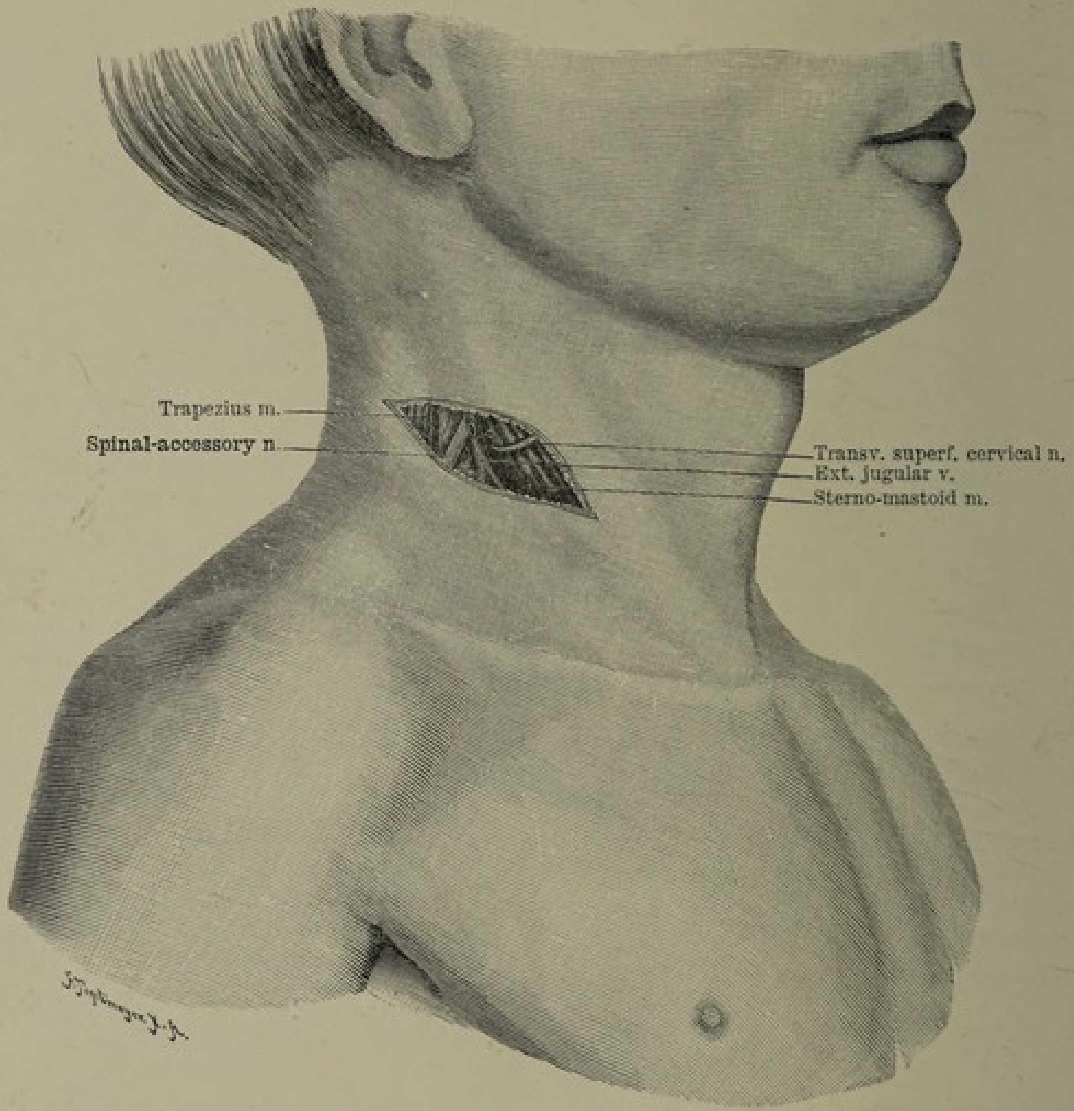


FIG. 113.—Exposure of the spinal-accessory nerve in the middle of the neck.

has a definite course downwards and backwards under the sterno-mastoid in front of the prominent transverse process of the atlas. It lies close to the under surface of the muscle. The occipital artery passes backwards over the nerve. The lowest branch of the facial nerve to the muscles of the chin may come into view at the upper edge of the wound, and is to be avoided. Higher up, the nerve is covered by the posterior belly of the digastric muscle. Anteriorly it is accompanied by the artery to the sterno-cleido-mastoid muscle from the external carotid.

It is easier to expose the nerve lower down, *i.e.* at the posterior border of the sterno-mastoid. Fig. 113 shows the transverse incision made through skin and platysma, rather below the middle of the sterno-mastoid. The external jugular vein,

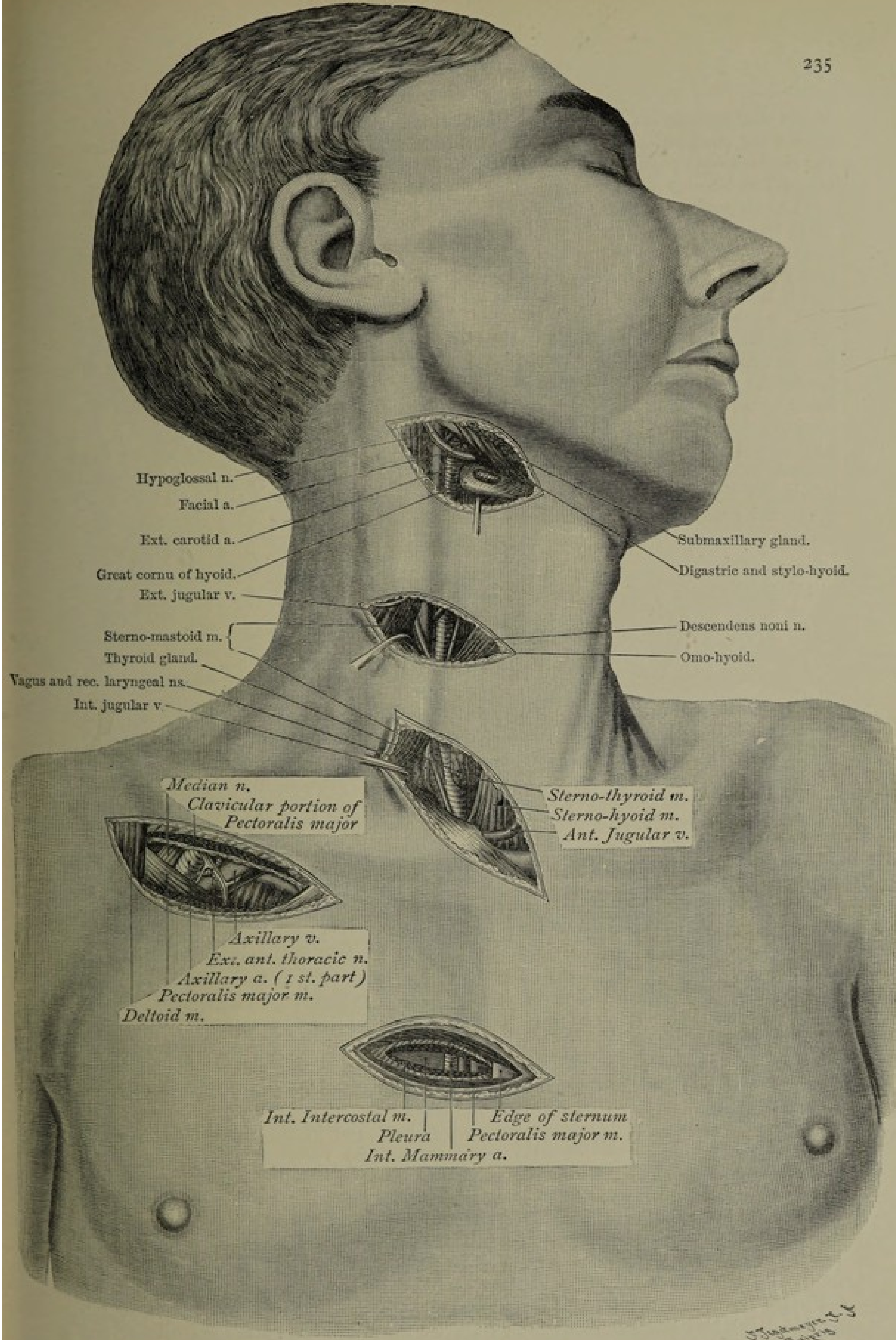


FIG. 114.—Ligature of the lingual artery above the greater cornu of the hyoid. Ligature of the common carotid at the level of the cricoid cartilage. Ligature of the innominate artery. Ligature of the first part of the axillary artery. Ligature of the internal mammary artery.

which descends across it, is drawn forward and the superficial cervical nerve, which crosses the sterno-mastoid muscle, is not interfered with. After division of the fascia, the nerve is seen passing obliquely backwards from the posterior border of the sterno-mastoid to beneath the anterior border of the trapezius.

19. Hypoglossal Nerve (Fig. 114). As already mentioned, the hypoglossal nerve has recently been preferred for nerve-anastomosis in facial palsy.

It is looked for at the outer side of the commencement of the external carotid artery (round which it hooks), from which point it should be followed up and dissected out, if there is danger of its being injured during the removal of a tumour.

The incision to expose it corresponds to the middle third of our normal incision for the superior triangle of the neck, and is the same as that made for ligature of the external carotid (Fig. 114). After we have divided the skin, platysma, and fascia, the anterior border of the sterno-mastoid is freed and retracted backwards, care being taken to avoid the external jugular vein and the great auricular nerve. The common facial vein is drawn backwards and the external carotid exposed. The hypoglossal nerve will be found hooking round the outer side of the artery from behind, before the latter gives off its branches (the superior thyroid artery alone is below the nerve), and then passes underneath the digastric and stylohyoid to reach the anterior surface of the hyoglossus muscle.

H. SPINAL NERVES

(a) The Upper Four Cervical Nerves (Fig. 115)

The upper four cervical nerves may have to be divided in spasmodic contractions of the cervical muscles, particularly spasmodic wry neck, and also in occipital neuralgia. We have described (see p. 443) the method we employ for the treatment of spasmodic torticollis, viz. myotomy, which serves the same purpose as division of the nerve without leaving the muscles of the neck permanently paralysed.

Radical cure in severe cases of muscular spasm or obstinate neuralgia which cannot be localised to the area of one individual nerve, can only be obtained by dividing the nerves where they emerge from the spinal canal. Krause recommends the following operation :—

An incision, beginning below the external occipital protuberance, is carried transversely outwards to the insertion of the sterno-mastoid, from which point it descends along the posterior border of the muscle to the level of a line drawn horizontally through the hyoid bone. In the upper portion of the incision the trapezius, splenius, and complexus are divided at their attachment to the skull, the bleeding at this stage being very considerable. The great and third occipital nerves are also cut across.

This musculo-cutaneous flap is retracted and the deep muscles of the suboccipital triangle are exposed, viz. the rectus capitis anticus major, and obliquus capitis superior and inferior muscles, with the trachelo-mastoid at the outer limit of the wound running obliquely forwards and upwards.

The first cervical (suboccipital) nerve will be found in the suboccipital triangle between the occiput and the atlas lying behind the vertebral artery which runs transversely inwards to the foramen magnum. It is essentially a motor nerve, and has to be divided mainly for spasmodic conditions. According to Krause, its ganglion lies outside the spinal canal.

The great occipital (the posterior primary division of the second cervical nerve) lies below the inferior oblique muscle and furnishes the sensory supply to the whole of the back of the scalp. It is easily recognised by the course it pursues over the posterior surface of the inferior oblique muscle. According to Krause, the ganglion of this nerve also lies extra-vertebral, *i.e.* after the nerve has passed out between the atlas and the axis.

The third cervical nerve runs backwards between the axis and the third cervical vertebra vertically below the second nerve. Internally it gives off the third occipital nerve as its main cutaneous branch, and gives off the small occipital upwards and externally.

The sensory branches of the fourth cervical nerve run downwards and play no part in occipital neuralgia. In spasmodic conditions of the neck the nerve exerts only an indirect action on the cervical vertebra through the longus colli and scalene muscles.

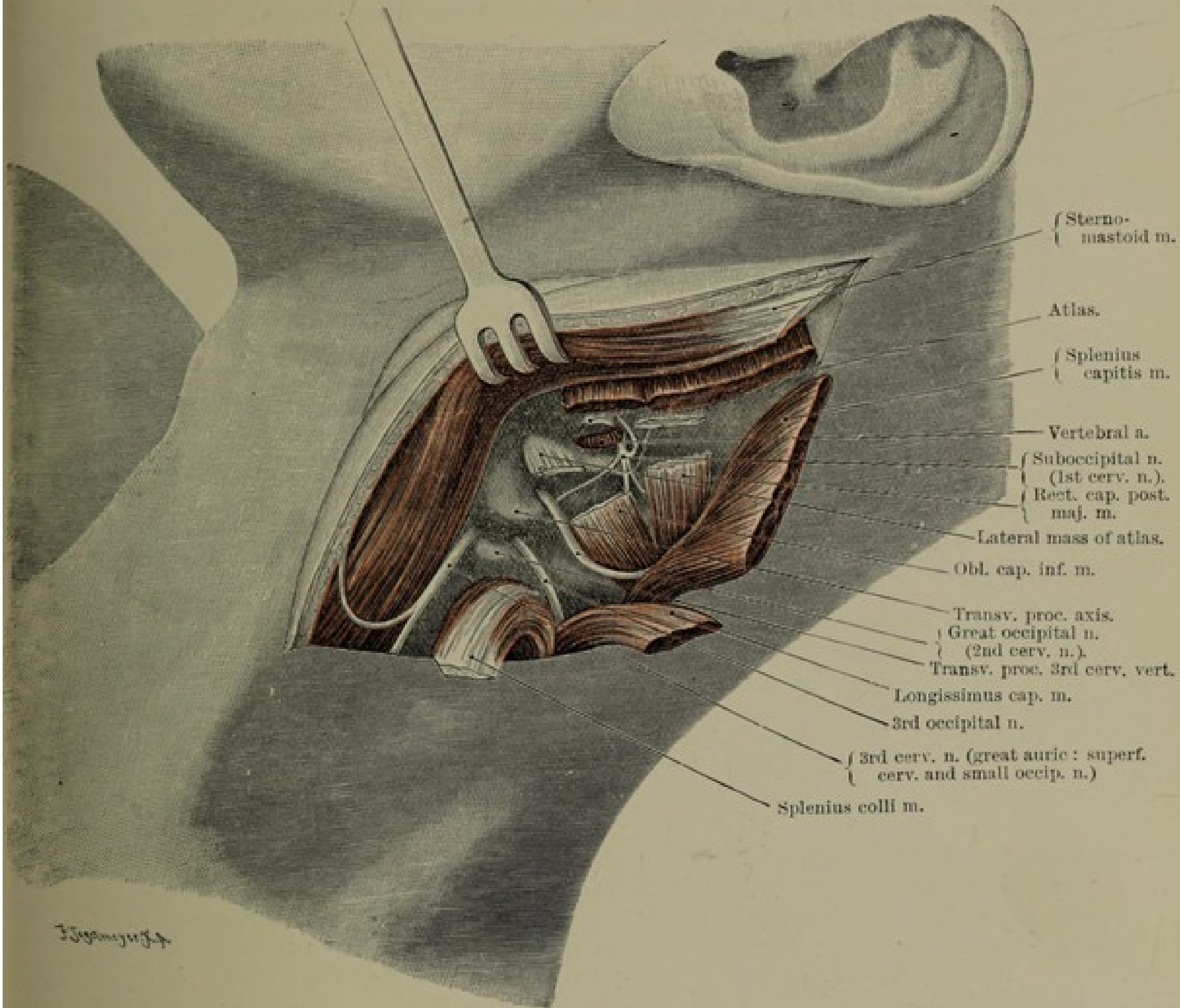


FIG. 115.—Exposure of the upper three cervical nerves through an incision along the posterior border of the sterno-mastoid. The transverse processes of the cervical vertebræ are seen, with the attachments of the muscles.

We regard Krause's operation as difficult and severe. Further, in occipital neuralgia, it is uncommon for all three upper cervical nerves to be involved. The posterior as well as the anterior portion of the suboccipital is purely motor. As a rule, therefore, only the second and third cervical nerves need be exposed. The posterior primary division of the second nerve is the great occipital, and its anterior division takes part in forming the small occipital. The posterior primary division of the third nerve is the third occipital, while the anterior division helps to form the small occipital as well as the great auricular and superficial cervical nerves.

The second and third cervical nerves are exposed as follows:—Incision through

skin and fascia from the mastoid process along the posterior border of the sterno-mastoid muscle from under which various small cutaneous branches emerge. The sterno-mastoid is retracted forwards and the fibres of the splenius capitis and colli which pass obliquely upwards and forwards, are cut across along with the trachelo-mastoid. The strong complexus muscle is drawn backwards and it and the levator anguli scapulæ remain posterior.

By following the nerve-branches already mentioned the trunk of the third cervical nerve is now observed emerging from beneath the projecting transverse process of the axis, and sending its anterior branch downwards over the scalenus medius, and the posterior (small occipital) backwards.

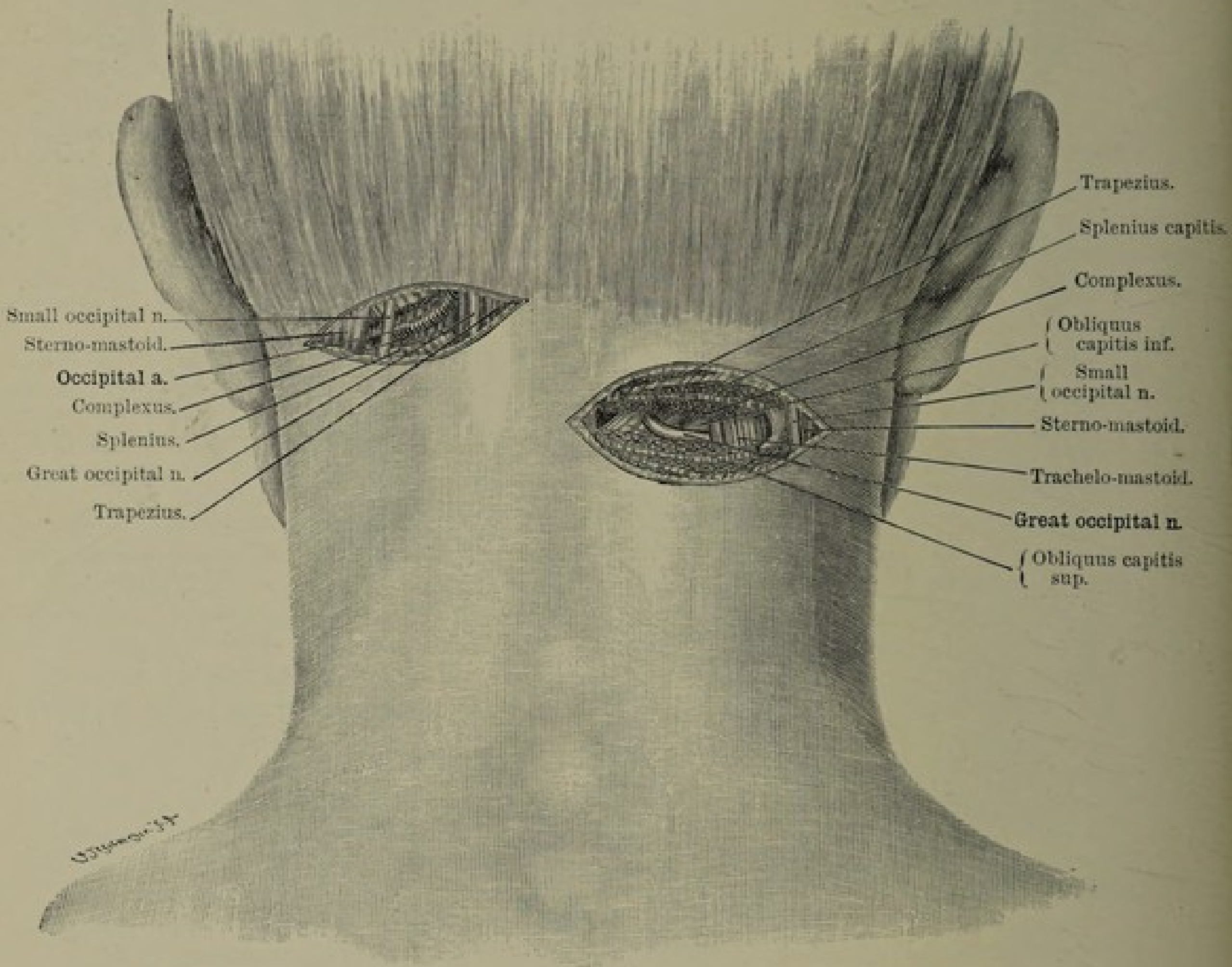


FIG. 116.—Ligature of the occipital artery and exposure of the small occipital nerve. Great occipital nerve.

After dividing the attachments of the levator anguli scapulæ to the transverse processes (and drawing the muscle forwards) we see the short strong belly of the obliquus capitis inferior, round the outer border of which the great occipital nerve hooks. Following up the nerve we find its exit above and behind the transverse process of the axis. The muscle may have to be divided.

If the obliquus capitis superior is also divided, the exit of the first cervical nerve (or suboccipital, the posterior primary division) may be exposed between the arch of the atlas, which can be plainly felt, and the occiput. This, however, is very rarely necessary.

20. Great Occipital Nerve (Figs. 115 and 116). Being the sensory nerve to the

back of the neck and head the great occipital is frequently the seat of neuralgia, for which treatment by isolation and avulsion is justified.

The great occipital nerve (posterior division of second cervical) becomes superficial at the outer border of the trapezius after piercing the complexus muscle. The nerve is found internal to the occipital artery, both structures converging towards one another.

If, for neuralgia, one wishes to find and stretch the nerve *nearer its origin*, the incision must be made deeper (Fig. 116). A transverse incision is carried outwards from the middle line opposite the projecting bifid spine of the axis. At the outer angle of the incision the posterior edge of the sterno-mastoid muscle and the small occipital nerve appear. The comparatively thin trapezius is divided, as also are the fibres of the strong splenius capitis, which ascend obliquely upwards and outwards underneath it; and, lastly, the vertical fibres of the powerful complexus muscle having been divided, the deeply placed fibres of the superior and inferior oblique muscles are exposed. The large nerve curves round the lower border of the latter muscle and passes upwards and inwards across its surface. Here the nerve gives off motor branches to the muscles at the nape of the neck, and is thereafter purely sensory. The trachelo-mastoid muscle extending obliquely downwards at the outer border of the complexus can be spared.

The operation described in the previous section (H, *a*) for exposure of the three upper cervical nerves is, however, preferable.

21. Small Occipital Nerve (Great Auricular, Superficial Cervical Nerves) (Fig. 113). These nerves appear close together from under the posterior border of the sterno-mastoid and radiate upwards and forwards on the side of the neck. They are easily exposed by dividing the skin, platysma and fascia along the middle third of the posterior border of the sterno-mastoid, and defining the border of the muscle. It is here that they are injected in producing "conduction" anæsthesia, and may also be stretched one after the other, as they are purely sensory nerves supplying the whole of the side of the neck.

By drawing forwards the sterno-mastoid and the large underlying vessels, and dissecting deeply at the anterior border of the splenius, trachelo-mastoid, and levator anguli scapulæ, we reach the exit of the third cervical nerve below the attachment of the scalenus medius to the transverse process of the axis. This nerve really belongs to the three branches named, and may thus, along with the third occipital, be made accessible for operation (*vide* description in H, *a*).

The small occipital nerve can also be exposed along with the occipital artery on the occiput as shown in Fig. 116.

22. The Fourth Cervical Nerve (Supraclavicular Nerves and Phrenic Nerve). The fourth cervical nerve (like the third) may call for surgical interference, as it is not infrequently the seat of neuralgia in malignant tumours of the neck, *e.g.* in malignant goitre. Along with the third it contributes largely to the formation of the phrenic nerve, and care must therefore be taken to guard against injury.

The fourth cervical nerve is of chief interest in that it provides an excellent guide to the phrenic nerve, which must be exposed and avoided in operations on the neck.

Fortunately the phrenic pursues a very definite course which makes it possible to isolate it and to deal only with the main sensory branches of the fourth cervical nerve. It runs vertically downwards on the anterior surface of the scalenus anticus (which can easily be felt), and enters the thorax by crossing the insertion of the muscle into the first rib.

The phrenic nerve can be readily exposed, and may be stimulated in cases of arrested respiration with a faradic current. In collapse during long severe operations we have been able to maintain strong enough respiration for twenty minutes by alternate faradic stimulation with a strong current of first one phrenic then the other, till natural breathing was restored, at the same time raising the blood-pressure by saline injections.

(b) The Lower Four Cervical Nerves (Brachial Plexus)

The brachial plexus, which is formed by the lower four cervical nerves (five to eight) and the large first dorsal nerve with twigs from the fourth cervical and second dorsal nerve, occupies a characteristic position and can be readily exposed by an incision in the supraclavicular fossa. The dissection to expose it is the same as that for ligature of the subclavian artery above the clavicle (Fig. 117).

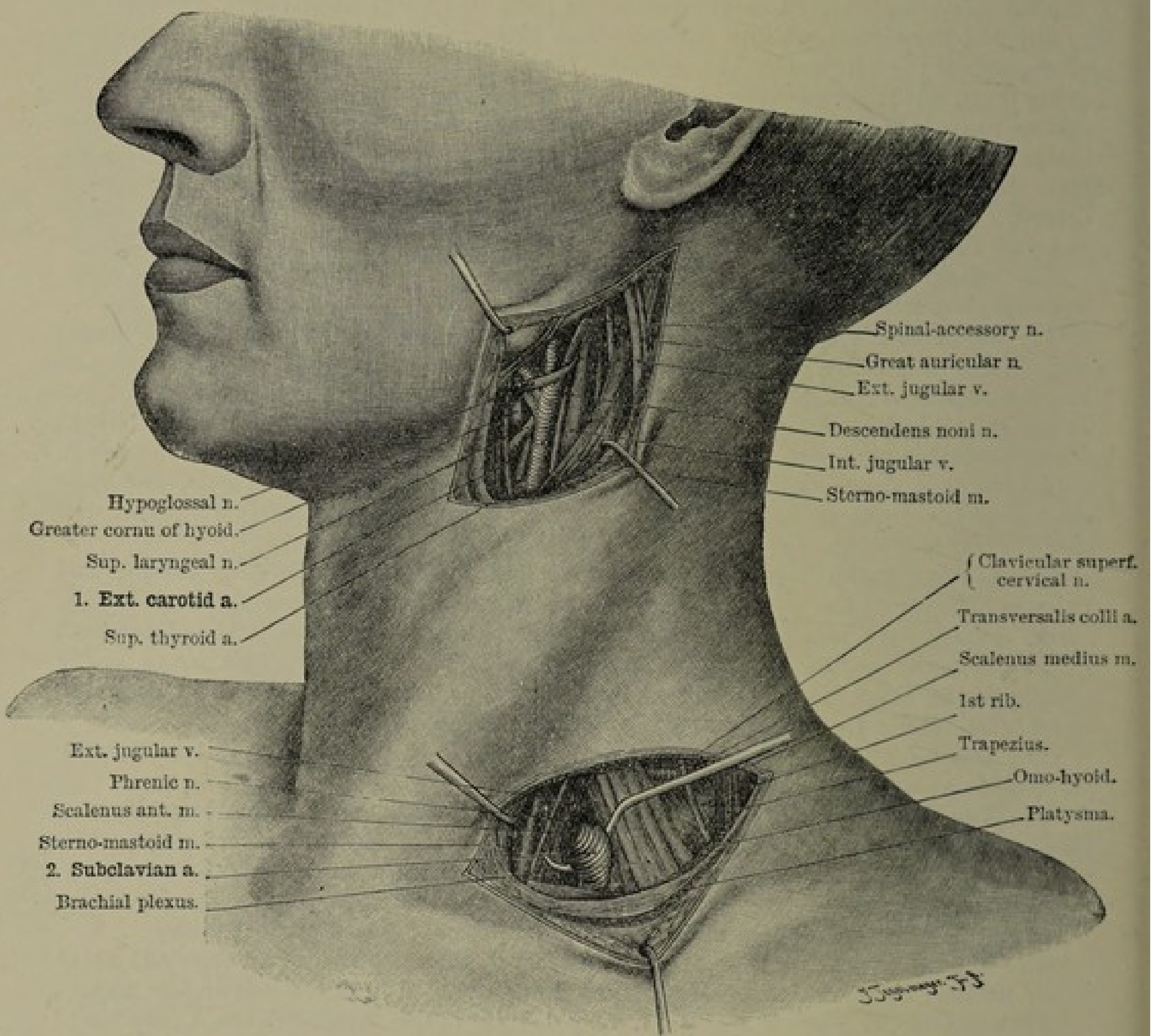


FIG. 117.—Ligature of the external carotid with the origins of the lingual, facial, and occipital arteries. Ligature of the subclavian artery.

Like the subclavian artery, it appears between the scalenus anticus and medius, being situated for the most part above the artery, although the lowest brachial nerve trunk may pass behind it on the first rib. Here the plexus can be stretched for spasmodic conditions in the arm. It was on the brachial plexus that the first experiments in nerve-stretching were made by Nussbaum and Billroth.

The omohyoid muscle lies in front of the plexus, and in the fatty tissue in front of it run the superficial cervical and the suprascapular arteries. The large transversalis colli artery passes between the cords of the plexus.

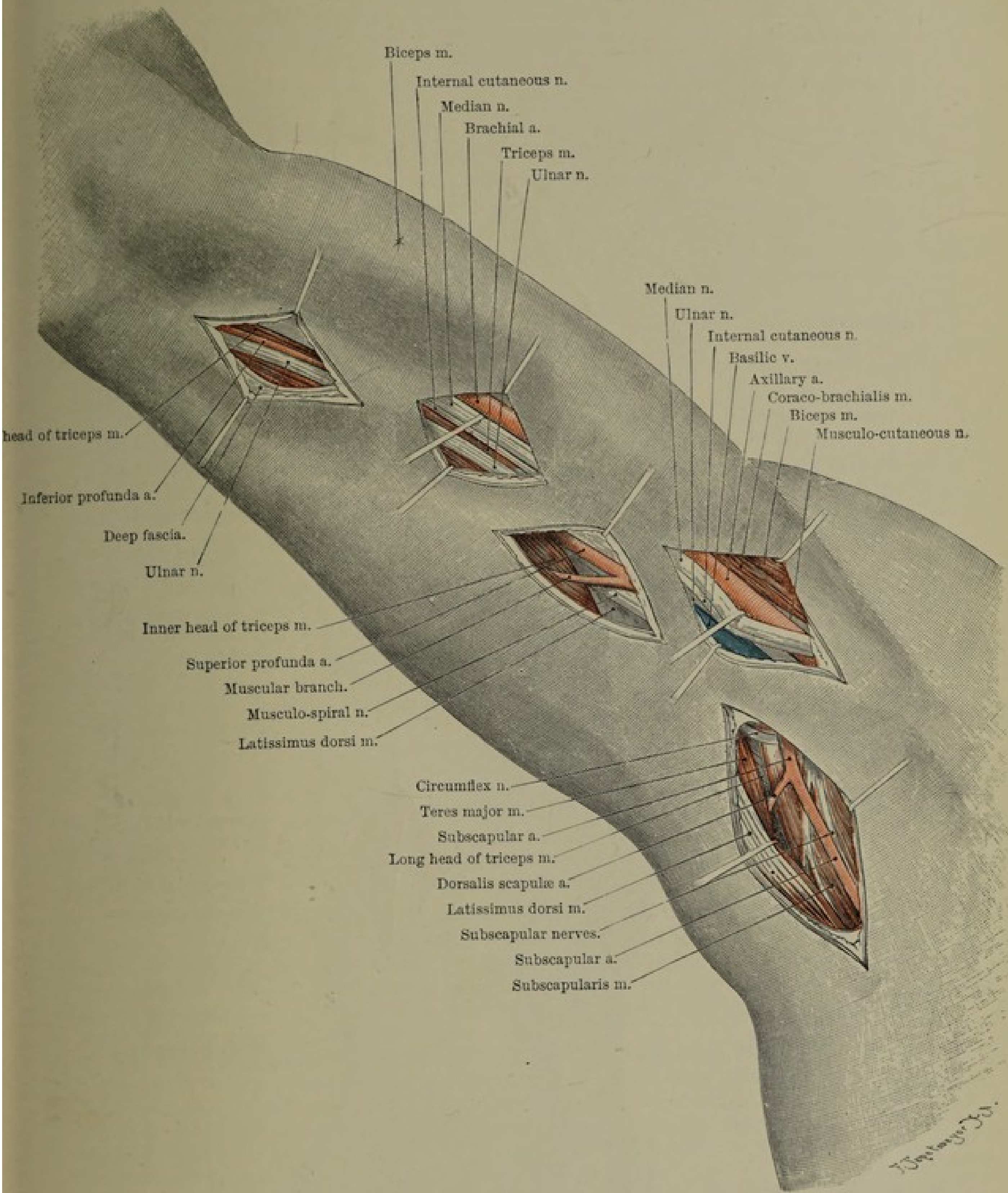


FIG. 118.—Axillary artery, brachial artery, superior profunda artery, subscapular artery, median, subscapular, musculo-spiral, and circumflex nerves.

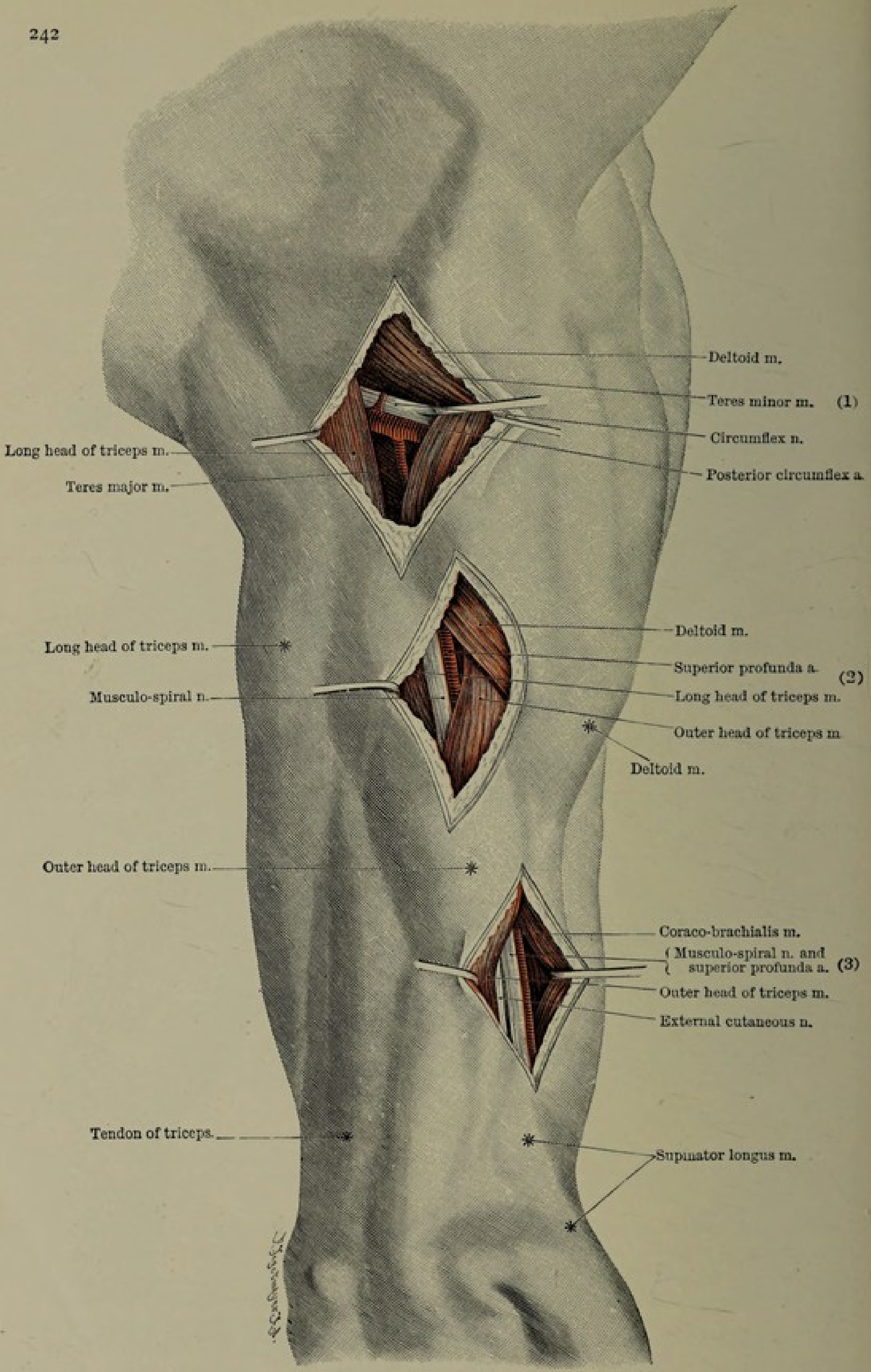


FIG. 119.—(1) Ligature of posterior circumflex artery, circumflex nerve. (2) and (3) Musculo-spiral nerve and superior profunda artery.

The numerous short muscular twigs to the scaleni, levator anguli scapulæ, serratus magnus and subclavius muscles are of no surgical interest, as only those branches which can be separated and recognised are worthy of mention.

23. Anterior Thoracic Nerves. These nerves which supply the pectoralis major and minor must be remembered by the operator when ligaturing the axillary artery immediately below the clavicle, as they cross the artery at this point (*vide* Ligature of the Axillary Artery).

24. Short and Long Subscapular Nerves. Supplying the subscapular and latissimus dorsi muscles, these nerves must be borne in mind when clearing the axilla of malignant glands. Their relations are shown in Fig. 118, and they are exposed by a similar method to that for the arteries of the same name which they accompany.

25. Long Thoracic Nerve. The nerve to the serratus magnus is seen in exposure of the long thoracic artery. It runs vertically downwards on the serratus magnus, and is to be avoided in the removal of axillary tumours (*vide* Ligature of the Long Thoracic Artery).

26. The Circumflex Nerve (N. Axillaris). The circumflex nerve is of importance because from its position it is specially exposed to damage when the arm is abducted and forcibly stretched. It may also be injured from pressure in the axilla (*e.g.* from a crutch or in a case of dislocation of the head of the humerus). Injury to it gives rise to paralysis of the deltoid and may also produce neuralgia from involvement of the lateral cutaneous branch behind and on the outer side of the deltoid.

The reader is referred to the description of ligature of the axillary artery and of the posterior circumflex artery, the illustrations in connection with which we here reproduce. The main branch of the circumflex nerve may be exposed for neuralgia or for local anæsthesia at the middle of the posterior border of the deltoid muscle (*vide* chapter on Local Anæsthesia).

27. Suprascapular Nerve. The suprascapular nerve is liable to injury in the supraspinous fossa where it passes under the suprascapular ligament (lig. transversum scapulæ superius) and especially where it enters the infraspinous fossa behind the neck of the scapula beneath the spinoglenoid ligament (lig. transversum scapulæ inferius). The nerve is exposed by an incision along the outer third of the spine of the scapula, dividing the tendon of the trapezius, and dissecting up the supraspinatus muscle.

The nerve is to be avoided in our posterior osteoplastic resection of the shoulder-joint.

28. Nerve to the Rhomboids (Dorsalis Scapulæ). The nerve to the levator anguli scapulæ and the rhomboid muscles is closely associated with the dorsalis scapulæ artery (*vide* Ligature of this Artery).

The long cutaneous branches of the brachial plexus to the arm are frequently the seat of neuralgia.

29. Lesser Internal Cutaneous Nerve (N. Cutaneus Brachii Medialis). In disease of the axillary glands, etc., this nerve is frequently the seat of a neuralgia which radiates down to the internal condyle of the humerus, for it has a series of connections with the upper intercostal nerves which specially expose it to irritation. In the description of ligature of the axillary artery it is recognised as the smallest nerve in the neuro-vascular bundle.

30. Internal Cutaneous Nerve (N. Cutaneus Antebrachii Medialis). This nerve, which is larger than, and in close apposition with, the lesser internal cutaneous, is also exposed in ligaturing the axillary artery at its termination. It pierces the fascia at the point in the middle of the arm where the basilic vein dips into the internal bicipital sulcus (*vide* Fig. 4, p. 19), and supplies the skin on the palmar and ulnar side of the forearm.

31. Musculo-Cutaneous Nerve. In the exposure of the terminations of the axillary artery (Fig. 118) the musculo-cutaneous nerve will be found in the antero-external bundle of nerves in front of the artery, behind, and external to the median nerve. It is easily recognised by its relatively-small size, and is reached with accuracy between the biceps and the brachialis anticus in the middle of the arm.

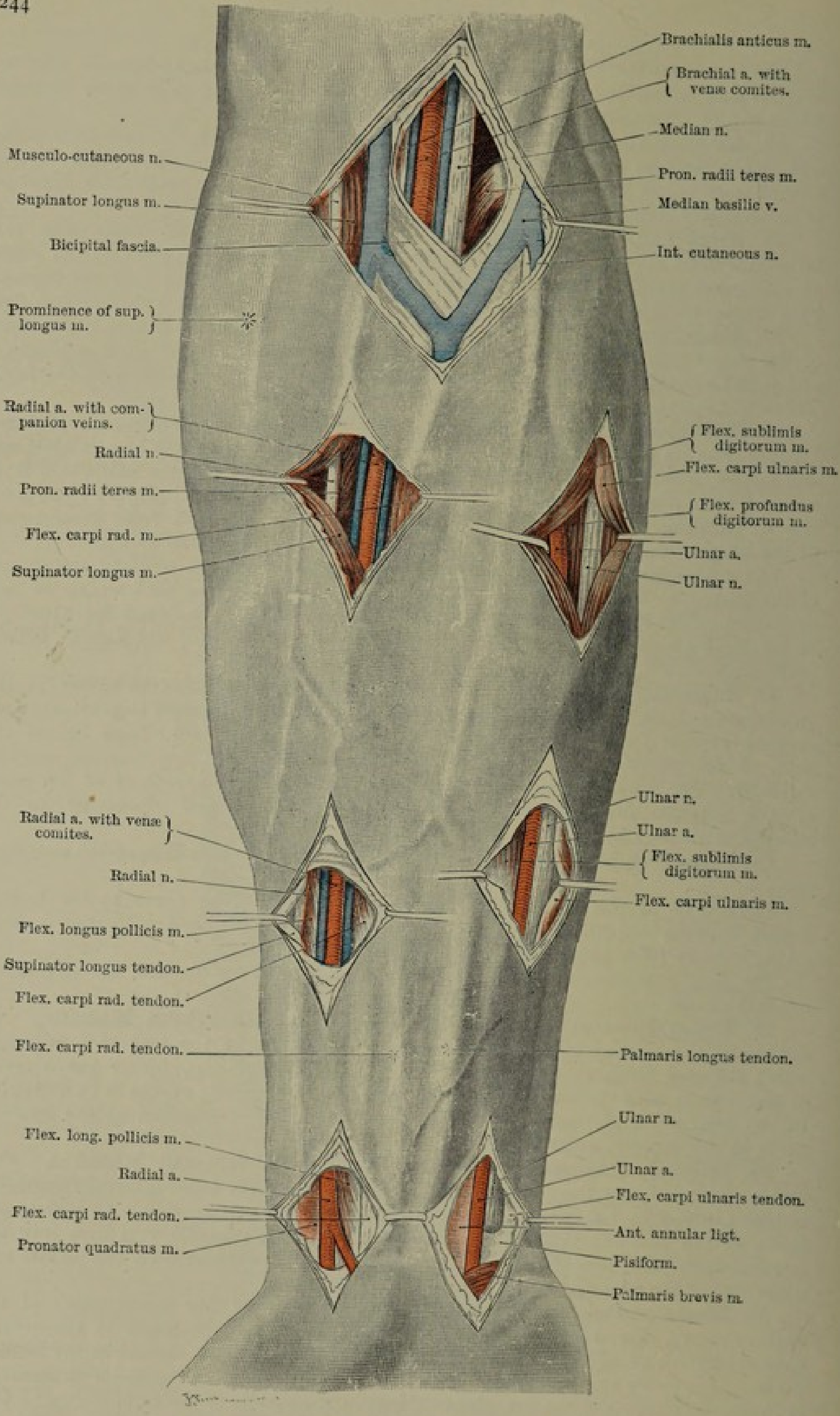


FIG. 120.—Brachial artery. Radial and ulnar arteries.

Above the middle of the upper arm. The incision descends along the internal bicipital sulcus from the lower part of the prominence of the coraco-brachialis. The muscular fibres of the biceps are exposed, and the muscle drawn outwards. The nerve lies, covered by the biceps, upon the outer border of the coraco-brachialis muscle, through which it penetrates in order to reach the anterior surface of the brachialis anticus muscle.

Higher up, the nerve may be found by making an incision over the prominence of the coraco-brachialis, and passing between this muscle and the short head of the biceps.

Below the middle of the upper arm. An incision is made along the outer edge of the biceps a finger's-breadth in front of the external bicipital sulcus; it is carried through the fascia down to the muscular fibres. The cephalic vein is avoided. After raising the biceps from the brachialis anticus, the finger is introduced between them and the nerve found towards the middle of the brachialis anticus lying under the thin fascia covering it. Care must be taken that the outer border of the brachialis anticus is not exposed instead of the biceps.

The cutaneous branch (N. cutaneus antibrachii lateralis) of the musculo-cutaneous which supplies the radial side of the forearm as far as the base of the thumb is reached with certainty at the point where it pierces the fascia (Fig. 120). An incision is made between the cephalic vein and the tendon of the biceps, the latter being easily felt in the fold of the elbow.

32. Median Nerve. The median nerve can be readily exposed in its whole length. In the axilla it lies to the outer side of the axillary artery (*vide* Ligature of the Axillary Artery).

It can also be easily exposed in the middle of the upper arm, where it lies in the internal bicipital sulcus, and crosses from without inwards in front of the brachial artery (Fig. 118). The nerve accompanies the brachial artery in its whole length, lying external to the artery above, and internal to it below.

In the bend of the elbow the nerve lies considerably to the inner side of the artery.

The median nerve (Fig. 120) lies half a centimetre internal to the brachial artery at the outer edge of the pronator teres muscle. The vessels and nerve are supported posteriorly by the brachialis anticus muscle. In this operation it is to be borne in mind that the artery and nerve descend from the internal bicipital sulcus, and therefore one must not pass to the outer side of the biceps tendon. The *musculo-cutaneous nerve* pierces the fascia external to the biceps tendon in the groove between it and the supinator longus.

On the front of the forearm the nerve lies between the flexor sublimus and flexor profundus digitorum muscles (Fig. 122).

In the upper third. Incision in the interval between the supinator longus and flexors, as in ligature of the radial artery. The pronator radii teres, which here covers the nerve, is divided internal to the above vessel. In the upper third of the incision the tendinous arch of the flexor sublimis digitorum is seen with the nerve descending behind it: it must be divided when the nerve is to be exposed farther down. At first the ulnar artery lies to the radial side of the nerve, and then passes almost at once under it as it arches downwards and inwards towards the ulnar side of the forearm. The interosseous artery passes directly downwards to lie deeply upon the interosseous membrane.

Below the middle. Incision in the middle of the forearm between the flexor carpi radialis and the palmaris longus. The muscular fibres of the flexor sublimis appear in the interval between these tendons, and its radial border having been exposed, the muscle is drawn inwards. The large nerve lies upon the flexor profundus digitorum muscle, accompanied by the median artery.

Above the wrist-joint. Incision through the skin and fascia along the radial side of the palmaris longus tendon.

On the radial side of the palmaris longus, farther down, the nerve becomes superficial between the tendons of the flexor digitorum sublimis.

Of the branches of the median the following are to be considered:—

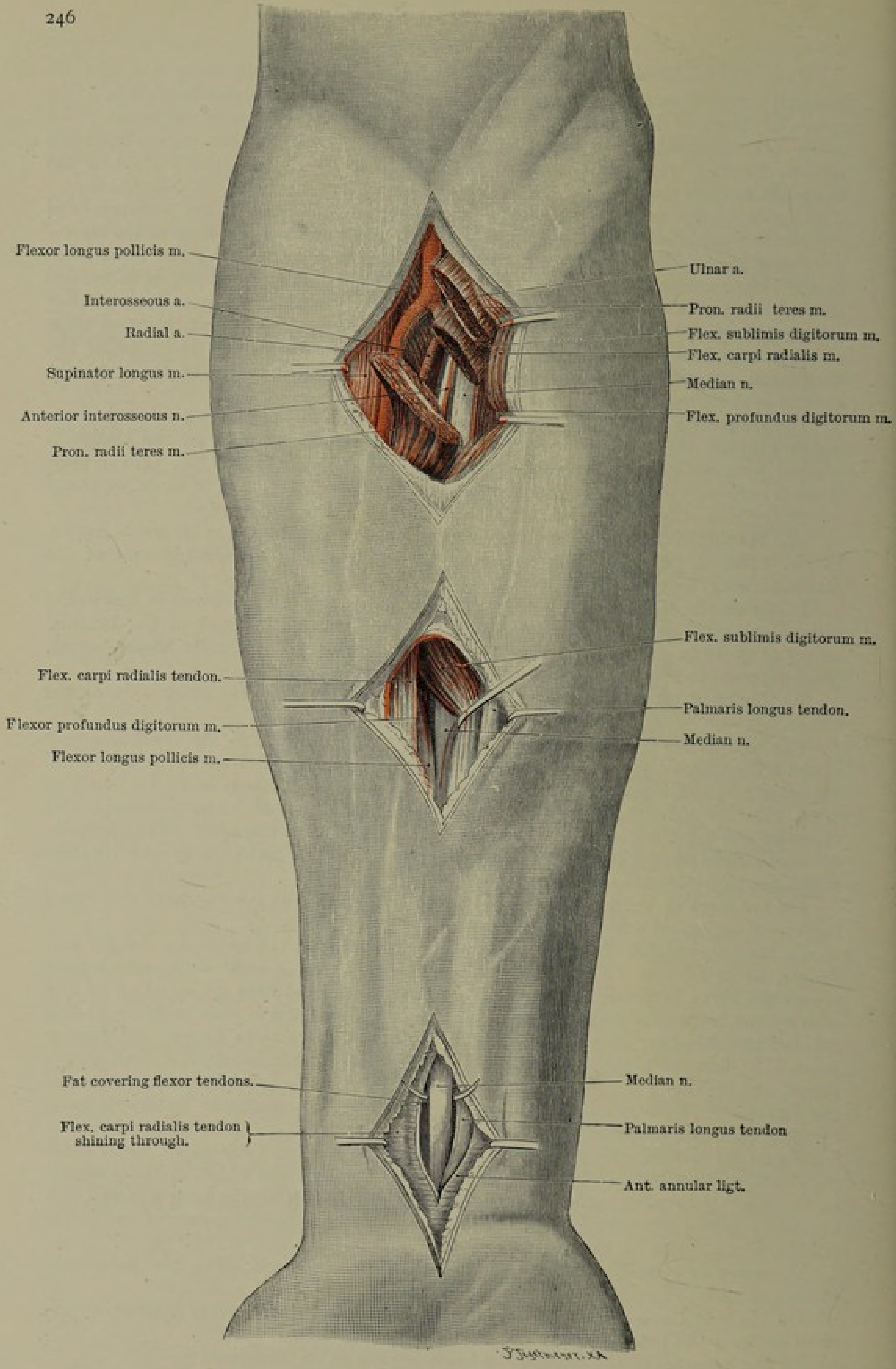


FIG. 121.—Median nerve, anterior interosseous nerve, interosseous artery.

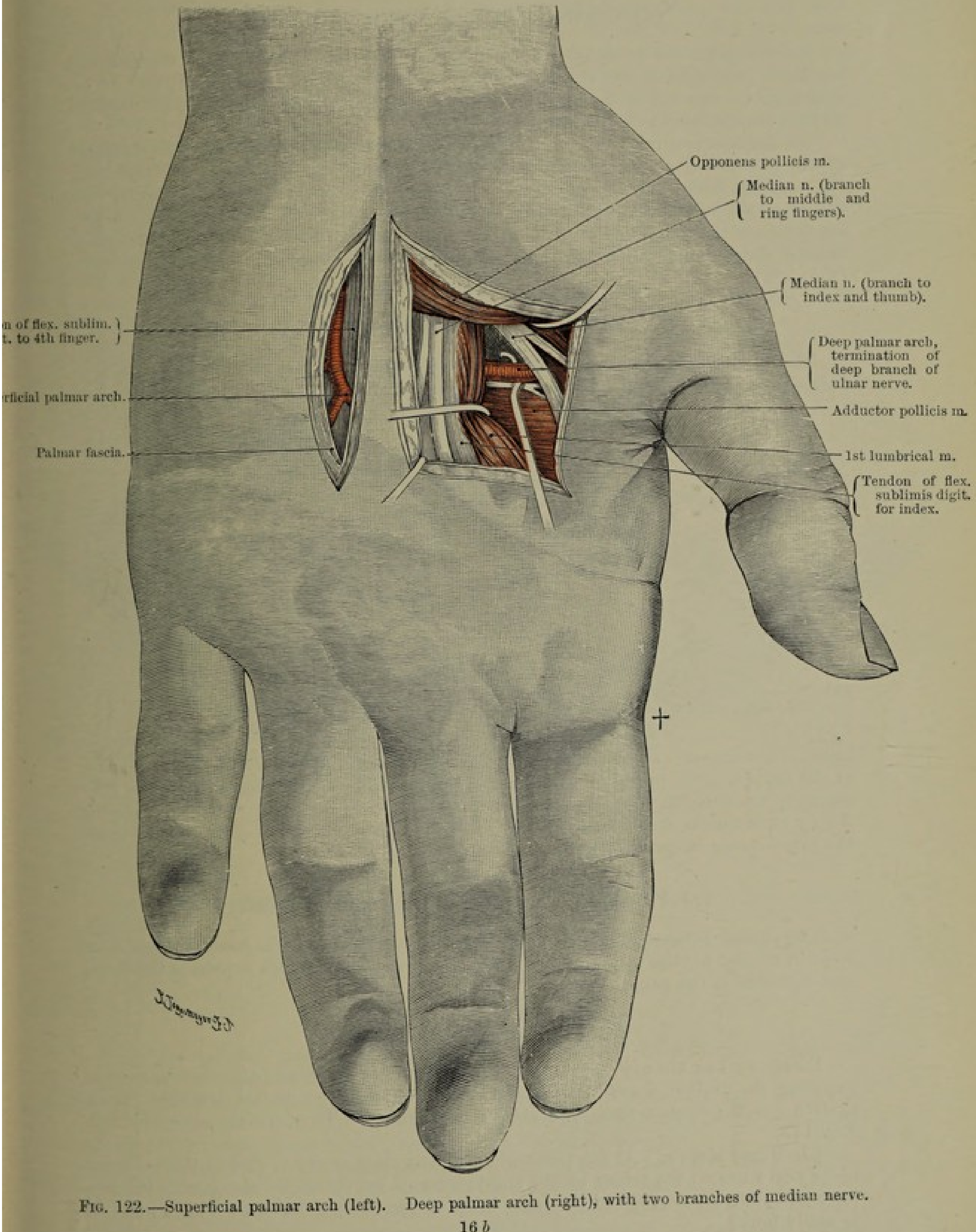


FIG. 122.—Superficial palmar arch (left). Deep palmar arch (right), with two branches of median nerve.

(c) Common Palmar Digital Branches

In the palm the branches of the median nerve lie on the flexor tendons immediately underneath the strong palmar fascia. The two divisions of the nerve, which are distributed to the first four fingers, may be exposed by the same incision as that for the deep palmar arch.

An incision is carried through the skin and the strong anterior annular ligament at the junction of the thenar and hypo-thenar eminences. The large nerve lies upon the common flexor sheath and divides into two divisions, the outer supplying the thenar muscles (with the exception of the adductor), both sides of the thumb, and the outer side of the index finger; the inner supplying the two outer lumbricals, the ulnar side of the index, both sides of the middle and the radial side of the ring finger (Fig. 122).

(d) Anterior Interosseous Nerve

The Anterior Interosseous Branch of the Median Nerve (Fig. 121) is seen passing outwards from the median in exposing the latter in its upper third. The

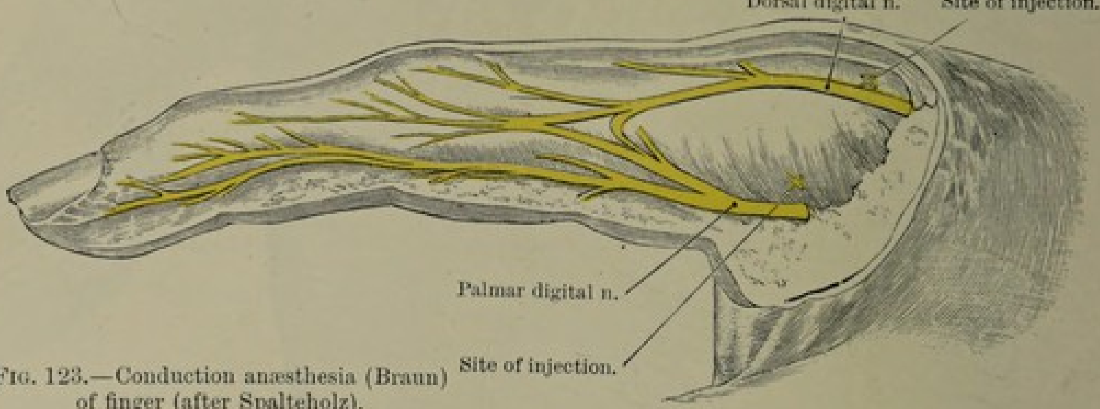


FIG. 123.—Conduction anæsthesia (Braun) of finger (after Spalteholz).

anterior interosseous nerve (with the artery) is exposed in exactly the same manner as the median nerve in the middle third of the forearm. After the median has been exposed, the anterior interosseous branch may be seen upon its outer side passing deeply between the flexor longus pollicis and the flexor profundus digitorum to reach the interosseous membrane.

(e) Palmar Cutaneous Branch of the Median

The palmar cutaneous branch of the median nerve may be exposed by the same incision as that for the median itself above the wrist-joint, where it pierces the fascia and descends to the palm.

(f) Palmar Digital Branches

Reference has already been made to the common palmar digital branches in exposing the median nerve in the palm of the hand. The digital branches of the median are the largest sensory nerves of the fingers. They are shown exposed in Fig. 123.

33. Ulnar Nerve. At the point where the axillary artery is tied in the arm, the ulnar nerve lies on the artery in the antero-internal nerve-bundle along with the two internal cutaneous nerves and the inner head of the median nerve, at which point it is easily found.

Lower down in the arm it lies in the internal bicipital sulcus.

Incision over the inner head of the triceps along a line ascending vertically from the internal epicondyle. The strong fascia is divided behind the white line corresponding to the internal intermuscular septum. This exposes the muscular substance of the inner head of the triceps, in the most superficial fibres of which lie the ulnar nerve and the inferior profunda artery.

Behind the internal condyle of the humerus at the elbow, the ulnar nerve again occupies an absolutely definite position (Fig. 124).

Incision through skin and fascia upon the posterior surface of the base of the internal epicondyle. The nerve lies close to the bone along the inner edge of the triceps, disappears below between the two heads of origin of the flexor carpi ulnaris which spring from the epicondyle and the olecranon respectively, and rests upon the flexor profundus digitorum. The terminal branch of the inferior profunda artery lies alongside the nerve.

In the upper third of the forearm the ulnar nerve furnishes the guide to the ulnar

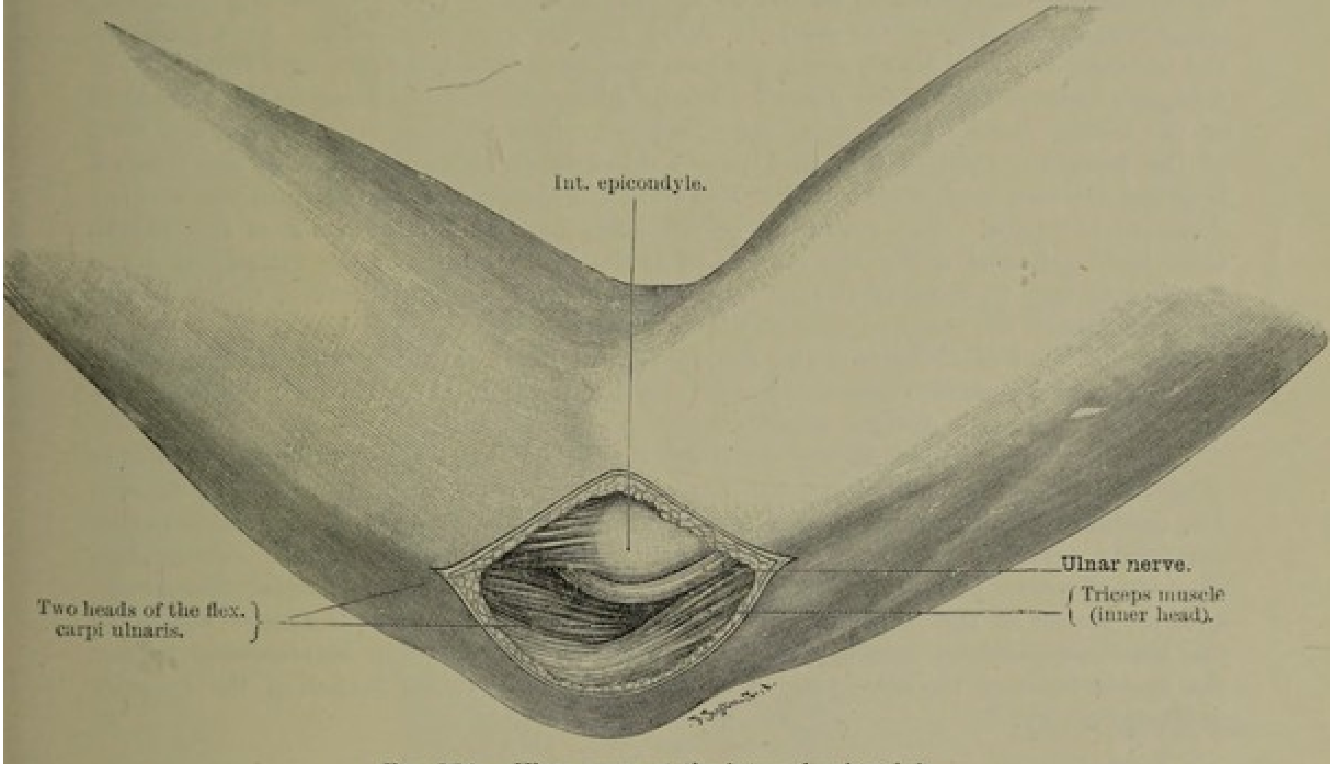


Fig. 124.—Ulnar nerve at the internal epicondyle.

artery between the flexor sublimis and profundus (*vide* Ligature of Ulnar Artery, Fig. 120).

The ulnar nerve is exposed in the same way as the artery in the lower third of the forearm and at the pisiform bone.

Branches of the Ulnar Nerve

(*a*) The palmar cutaneous branch to the ball of the little finger is only of importance in regard to the production of local anæsthesia.

(*b*) The dorsal cutaneous branch which supplies sensation on the back of two and a half fingers passes on to the dorsum of the hand a finger's-breadth below the styloid process of the ulna, which is easily felt through the skin.

(*c*) The palmar branch divides in the palm of the hand a finger's-breadth below the pisiform, above and to the ulnar side of the hook of the unciform (which can be distinctly felt) into a superficial branch which passes beneath the palmar fascia on the muscles of the hypothenar eminence to give digital branches to one and a half fingers

and into a deep branch which dips down on to the interossei, which it supplies along with the lumbricals and the adductor pollicis.

These branches can be exposed at the point mentioned above, and to the ulnar side of the hook of the unciform. The terminal branch of the deep division is seen in ligature of the deep palmar arch (*vide* Fig. 122).

34. Musculo-spiral Nerve (N. Radialis). In the axilla, at the point where the terminal portion of the axillary artery is ligatured, the musculo-spiral nerve lies along with the circumflex nerve posterior to the artery.

In the upper third of the arm. The musculo-spiral nerve in the upper third of the arm is exposed in the same manner as for ligature of the superior profunda artery on the inner side of the arm (Fig. 118). The nerve lies behind the artery, descending on the tendon of the latissimus dorsi and then passing towards the back of the humerus between the inner and long heads of the triceps. In looking for it care must be taken not to go too far back, as otherwise one gets behind the nerve and artery which are here in relation to the bone in the internal bicipital sulcus. The nerve is recognised by its characteristic position on the latissimus dorsi.

Above the middle of the posterior surface of the arm (Fig. 125). As a guide to the incision, a line is drawn along the posterior surface of the upper arm from a point a finger's-breadth behind the posterior border of the deltoid and close to the long head of the triceps down to the tip of the olecranon. The incision begins below the level of the posterior axillary fold, and passes downwards along this line in the interval between the long and outer heads of the triceps, which are separated from one another down to the bone. The nerve lies between the inner and outer heads of the triceps after having passed under the long head at the lower border of the latissimus dorsi. Parallel to and in front of the nerve lies the superior profunda artery, which is also in contact with the inner surface of the humerus.

At the bend of the elbow the musculo-spiral nerve, together with its bifurcation into radial and posterior interosseous nerves, lies in the interval between the supinator longus and brachialis anticus muscles.

An incision is made at the bend of the elbow in a line prolonged from the external bicipital sulcus along the anterior edge of the supinator longus muscle. The median cephalic vein is drawn aside, and after division of the fascia, the musculo-cutaneous nerve appears at the lower part of the incision beside the biceps tendon. The latter nerve pierces the fascia to supply the skin upon the radial side of the anterior aspect of the forearm. By passing towards the bone at the outer border of the brachialis anticus muscle, we find the radial and posterior interosseous nerves, the one in front of the other, and beneath them the terminal branch of the superior profunda artery.

Branches of the Musculo-Spiral Nerve

(*a*) *The upper external cutaneous branch* (*n. cutaneus brachii posterior*) which supplies the skin on the posterior surface of the upper arm is looked for at the point where the musculo-spiral nerve crosses the tendon of the latissimus dorsi (*vide* ligature of the superior profunda artery in the upper third).

(*b*) *The lower external cutaneous branch* (*n. cutaneus antebrachii dorsalis*) which is distributed on the back of the forearm pierces the fascia in the external bicipital sulcus below the middle of the arm (*vide* Fig. 5).

(*c*) *The posterior interosseous nerve* (*ramus profundus*). (Fig. 126.) The posterior interosseous nerve is the motor nerve to the supinators and extensors in the forearm. To expose it an incision is carried vertically downwards from the head of the radius, along the radial aspect of the posterior surface of the forearm, in the interval between the radial extensors and the tendinous extensor communis digitorum. The fascia is divided between the glistening tendinous origin of the extensor communis digitorum and the muscular fibres of the radial extensors, the latter being drawn forwards with blunt hooks. The supinator brevis muscle now appears, the fibres of which pass in a characteristic manner obliquely downwards and forwards. The nerve

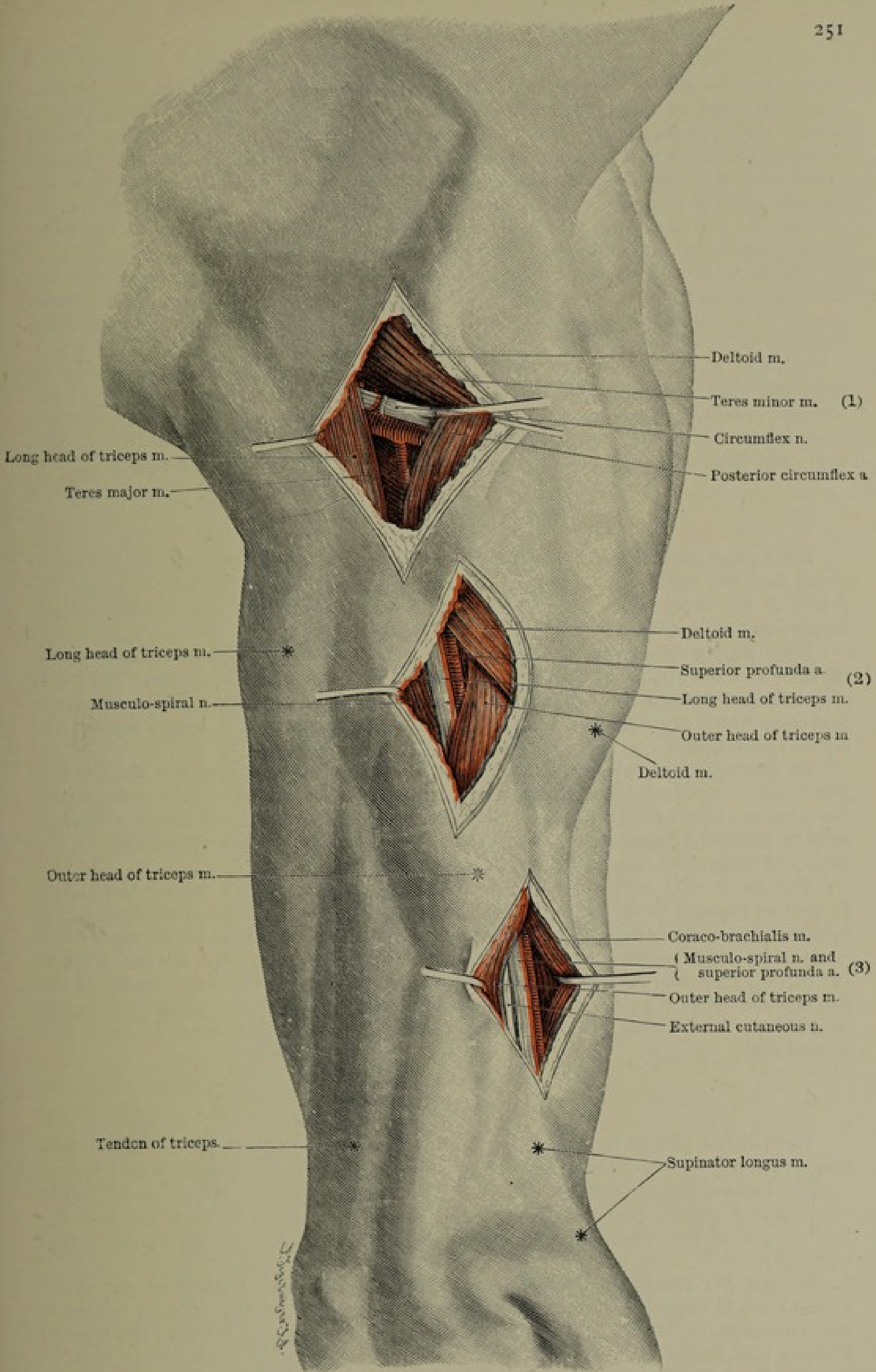


FIG. 125.—(1) Ligature of posterior circumflex artery, circumflex nerve. (2) and (3) Musculo-spiral nerve and superior profunda artery.

issues from the muscle about 5 cm. (2 in.) below the head of the radius, and at once breaks up into several branches. To expose the trunk of the nerve for a greater extent, the supinator brevis muscle is divided in an upward direction. The forearm is flexed and held in a position midway between pronation and supination. Longer branches of the nerve pass between the extensor communis and radial extensors to the extensors of the thumb and index finger, which lie upon the posterior surface of the radius. In the lower third of the arm the terminal branch passes on to the interosseous membrane and ends upon the ligaments of the wrist-joint.

The *posterior interosseous artery* passes backwards above the upper border of the interosseous membrane, appears upon the posterior aspect of the forearm at the lower border of the supinator brevis muscle, and descends between the superficial and deep layers of extensor muscles.

(*d*) *The radial nerve* (*ramus superficialis*). This sensory branch descends on the outer side of the radial artery (*vide* Fig. 120) as far as the lower third of the forearm, where it passes backwards underneath the supinator longus, and pierces the deep fascia. It is distributed to the adjacent margins of the outer four digits. The nerve can be felt through the skin on the back of the lower end of the radius.

(g) Thoracic Nerves

35. Intercostal Nerves. Of the twelve thoracic nerves, eleven are termed intercostal and one subcostal. They run close to the lower border of the rib, below the artery of the same name, and, except at their commencement and termination, lie under cover of the fibres of the external intercostal muscles.

They supply sensation to the whole of the skin of the thorax (including the mamma and the abdomen) through their lateral cutaneous branches (which are given off vertically between the axillary and mammary lines), and their anterior cutaneous branches, which are found in the anterior ends of the intercostal spaces and on the rectus abdominis.

By exposing the intercostal nerves on the posterior surface of the thorax, and stretching or dividing them in cases of neuralgia (in the thorax or abdomen) all the branches are affected with the exception of the posterior primary divisions, which can only be reached by dissecting the muscles of the back off the posterior surfaces of the vertebral arches and transverse processes.

The intercostal nerve lies between the intercostal muscles below the artery. It may be exposed in the same way as the artery—for the purpose of stretching it in intercostal neuralgia (Fig. 127). If one has only to do with a single nerve, the incision is made from the prominence of the erector spinæ muscle along the rib and down to the bone. The external intercostal muscle is separated from the lower border of the rib, and the nerve is pulled forwards by a blunt hook from beneath the overhanging rib above. Where more than one nerve is involved, a vertical incision is made over several ribs.

(h) The Lumbar Plexus

The lumbar plexus is formed by the first, second, third, and part of the fourth lumbar nerves, receiving also a twig of communication from the twelfth dorsal nerve.

The sensory branches derived from it are distributed not to the abdomen, but to the inguinal region, the outer, inner, and anterior aspects of the thigh, and the upper part of the pudenda. Pain in these regions may therefore be dealt with surgically.

36 and 37. Ilio-hypogastric and Ilio-inguinal Nerves. Both these nerves are encountered in exposing the kidney from behind; they lie on the anterior surface of the quadratus lumborum, at the outer border of which they pass between the internal oblique and transversalis. (The continuations of the intercostal nerves also lie in this layer.) They can be easily exposed in this situation (*vide* chapter on Nephrotomy).

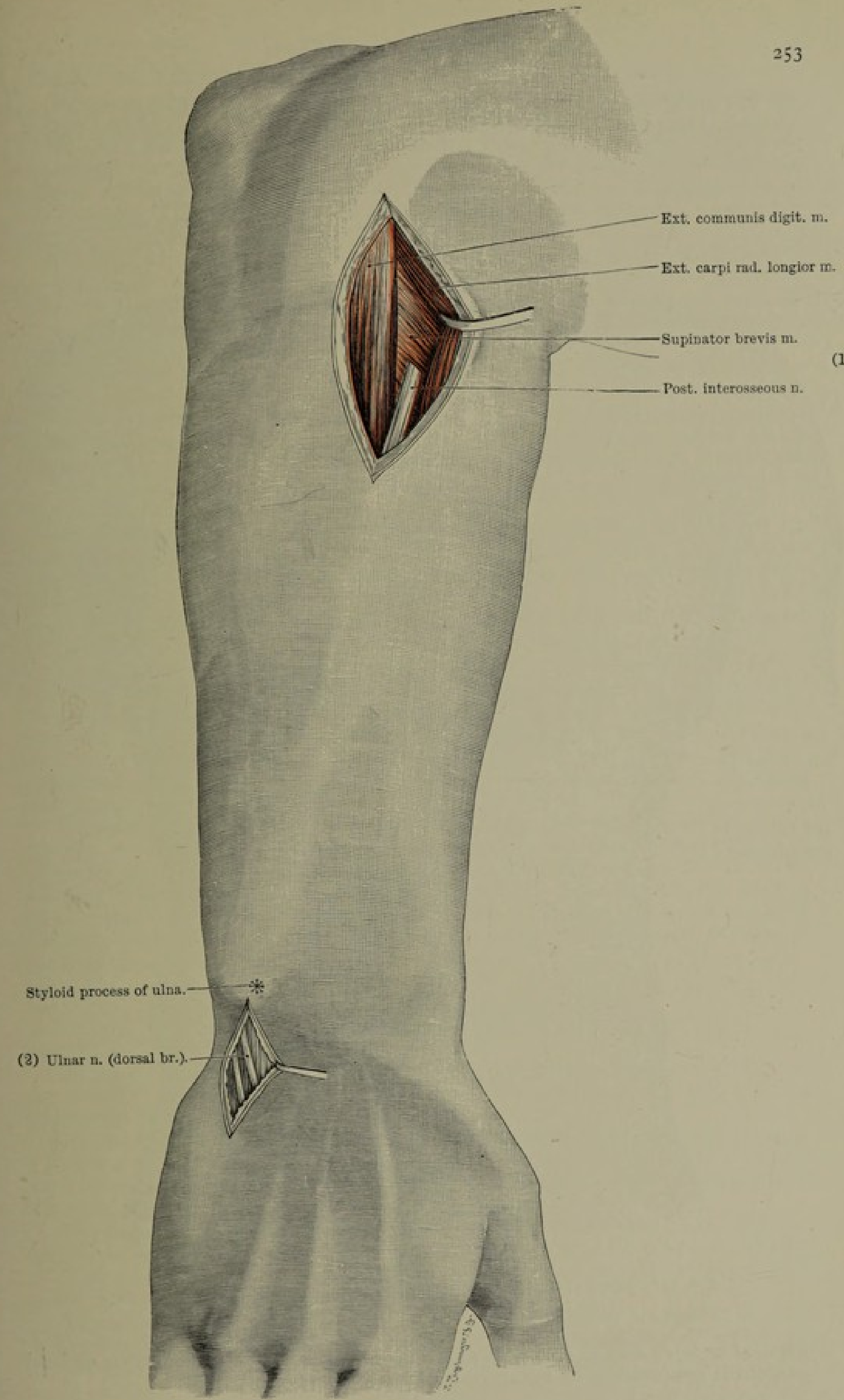


FIG. 126.—(1) Posterior interosseous nerve, below the head of the radius.
(2) Dorsal branch of ulnar nerve at the wrist.

The ilio-hypogastric nerve runs above, and the ilio-inguinal through the external abdominal ring to the mons veneris and the upper part of the pudenda. The ilio-

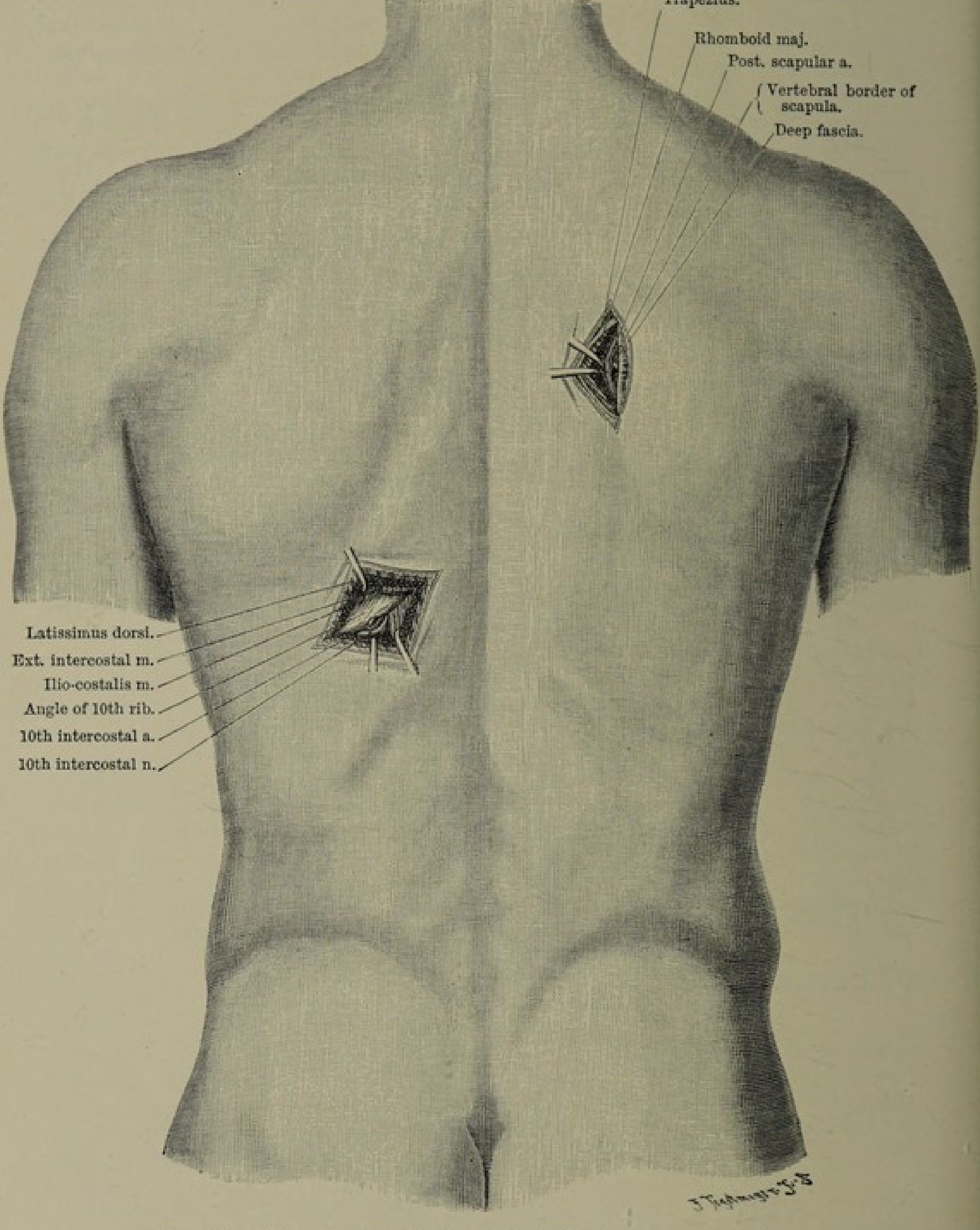


Fig. 127.—Exposure of the 10th rib and the 10th intercostal artery and nerve. Ligature of the posterior scapular artery.

inguinal is more easy to recognise and can be injected for the production of local anæsthesia in operations on the spermatic cord or round ligament.

The ilio-hypogastric supplies the upper and outer part of the skin of the thigh, the ilio-inguinal the upper part of the inner side of the thigh.

38. External Cutaneous Nerve (N. Cutaneus Femoralis Lateralis). This nerve supplies the skin on the outer side of the thigh as far as the knee. In the iliac fossa it lies on the iliacus muscle (*vide* Fig. 53, Ligature of the Common Iliac Artery), when it is readily seen and may be exposed after it has crossed the circumflex iliac artery on to the origin of the sartorius, at which point it pierces the deep fascia.

Incision (Fig. 128) through skin and fascia parallel to Poupart's ligament a finger's-breadth below the anterior superior iliac spine. The nerve lies under the fascia, 2 cm. ($\frac{3}{4}$ in.) below the spine, and descends obliquely downwards and outwards either at the outer edge of the origin of the sartorius, or over its anterior surface. The operation may be indicated in Bernhardt's meralgia paræsthetica.

39. Genito-crural Nerve (N. Genito-femoralis). This nerve divides into a crural and a genital branch, the former of which descends on the outer side of the femoral artery to supply the skin on the anterior surface of the thigh, while the latter enters the internal abdominal ring and is distributed to the spermatic cord, the dartos and the scrotum (or labium). Both branches can be readily injected during operations in the region of the femoral vessels (*vide* Fig. 128), or on the spermatic cord in the inguinal canal for the production of local anæsthesia.

40. Anterior Crural Nerve (N. Femoralis). This, the principal nerve for the thigh, receives fibres from all the four nerves of the lumbar plexus. It is often cut down upon and injected for the production of conduction anæsthesia, or in order to block the nerve in tetanus.

The nerve supplies the lower part of the front of the thigh with common sensation, and also the region below the patella through the long saphenous nerve.

To expose the nerve at Poupart's ligament (Fig. 128) a transverse incision is made below and parallel to the middle third of Poupart's ligament. The superficial epigastric artery is ligatured and the superficial layer of the fascia lata, which forms the sheath of the ilio-psoas, is opened. The nerve lies immediately under this to the inner side of the muscle, having already broken up into several branches, and being separated from the artery by the deep layer of the ilio-psoas fascia which divides off the vascular from the muscular compartment.

Exposure in the upper third of the thigh (*vide* Ligature of the External Circumflex Artery). A vertical incision is made 1 cm. external to the middle of Poupart's ligament, beginning two fingers'-breadth below the ligament, the centre of the incision corresponding to the level of the root of the great trochanter. After dividing the skin and dense fascia lata, the inner border of the sartorius is exposed and retracted outwards. The inner border of the rectus femoris is then recognised and the nerve is found in the fatty tissue covering the lower end of the ilio-psoas.

Branches of the Anterior Crural Nerve

(*a*) *Anterior Cutaneous Nerves.* The points at which these nerves pierce the fascia and at which they can be injected to produce local anæsthesia are shown in the illustrations in the chapter on local anæsthesia.

(*b*) *The Long Saphenous Nerve.* This sensory branch is distributed to the skin on the inner side of the thigh: by one terminal branch (ramus infrapatellaris) it supplies the area in front of and below the patella, by the other it supplies the inner side of the leg and foot.

The nerve accompanies the femoral artery as far as the opening in the adductor magnus, and follows the course of the internal saphenous vein at the knee and in the leg.

Exposure in the thigh. Vide ligature of the femoral artery in the upper third of the thigh and in Hunter's canal (Fig. 128).

To expose the nerve *above the internal condyle of the femur* an incision is made in front of the sartorius, under which the nerve passes downwards and backwards; the nerve lies at the edge of the tendon of the adductor magnus.

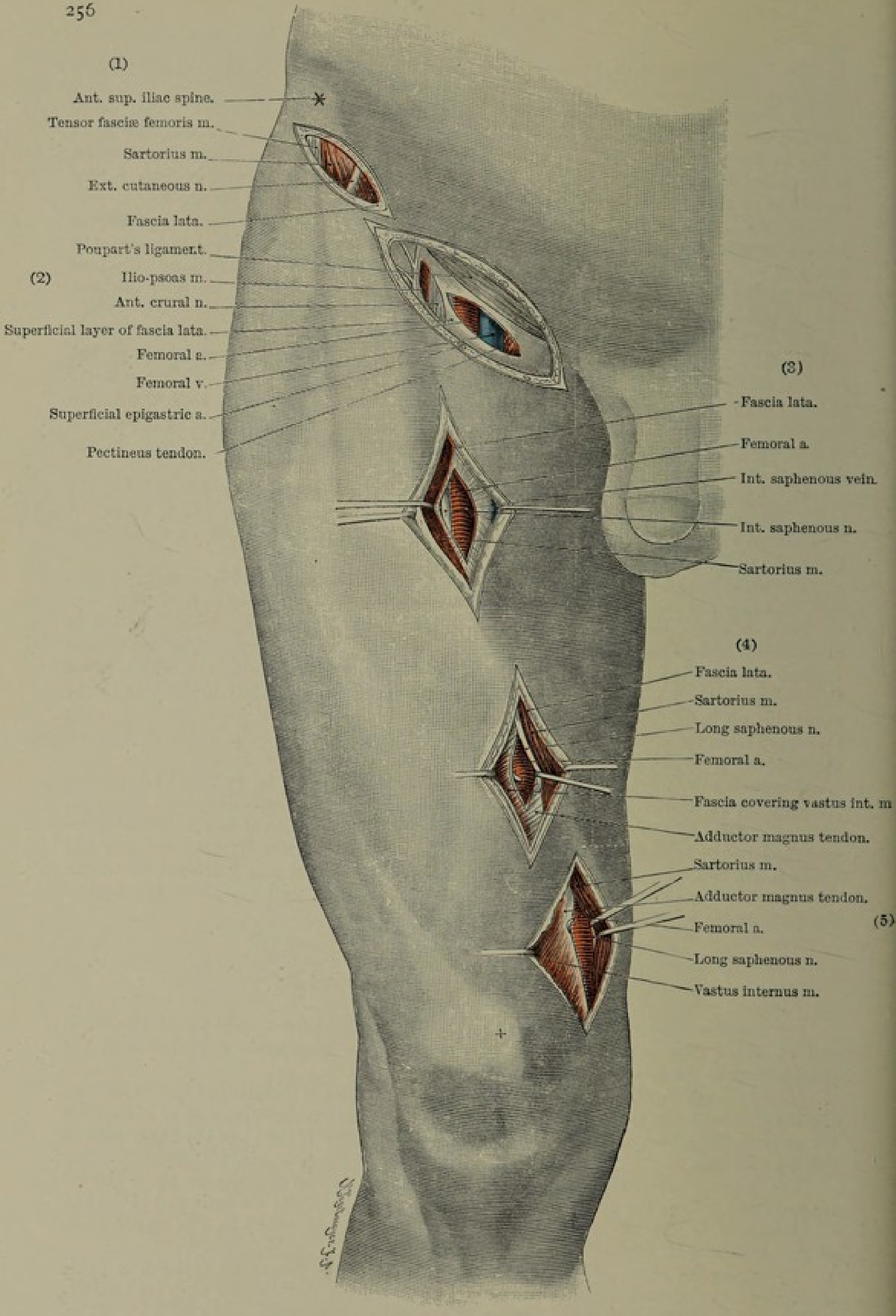


FIG. 128.—(1) External cutaneous nerve. (2) Common femoral artery. (3) Femoral artery. (4) Femoral artery at the opening in the adductor magnus. (5) Femoral artery at the lower end of the femur.

At the knee. An incision is made immediately behind the inner tuberosity of the tibia at the posterior edge of the sartorius, beneath which the nerve descends, in the groove between it and the tendon of the gracilis. The internal saphenous vein, which can be felt through the skin, lies upon the fascia in front of the nerve.

In the leg. The nerve, accompanied by the internal saphenous vein, runs for its whole length along the inner border of the tibia, and in the line of the incisions for ligaturing the posterior tibial artery. Cf. Ligature of posterior tibial artery.

At the ankle-joint. The nerve along with the internal saphenous vein can be felt at the anterior border of the internal malleolus.

41. Obturator Nerve. The lowest nerve of the lumbar plexus crosses over the brim of the pelvis and reaches the inner side of the thigh by passing through the obturator groove of the thyroid foramen, where it gives off branches to the strong adductor muscles. Its sensory portion is of importance in the diagnosis of obturator hernia, giving rise to neuralgic pain on the inner side of the thigh.

The incision—the same as for ligature of the internal circumflex branch of the profunda femoris—descends vertically from a point a finger's-breadth internal to the middle of Poupart's ligament. The skin, superficial fascia, and superficial layer of the fascia lata are divided. The internal saphenous vein which lies upon the fascia is drawn outwards. The strong pectineal fascia is divided just internal to the femoral vein. After defining the outer border of the pectineus muscle, the latter is separated from the os pubis and fascia over the obturator externus, and is drawn well inwards. The strong transversely-striated fascia over the obturator externus muscle is now divided, and the finger, passed above the upper border of the muscle, feels for the under surface of the horizontal ramus of the pubis, below which the artery leaves the obturator foramen on the anterior surface of the external obturator muscle accompanied by the obturator nerve, which lies above it.

(i) Sacral Plexus

The sacral plexus is formed by the greater part of the fourth lumbar nerve, the fifth lumbar, and the first three sacral nerves. Lying on the postero-lateral wall of the pelvis (in front of the pyriformis and behind the pelvic fascia and peritoneum, to the side of the rectum and the contents of Douglas's pouch), it is not infrequently involved in diseases of the pelvic organs. There is no doubt that in many cases of pelvic neuralgia and sciatica, surgeons fail to discover the source of the mischief in the pelvis itself and are too backward in undertaking freeing of the nerve-roots and the plexus from pressure and adhesions.

In operations of this sort, it must be remembered that the internal iliac artery lies in front of the upper part of the plexus and gives off the gluteal artery, which runs backwards between the lumbo-sacral cord and the first sacral root, and the sciatic artery between the second and third sacral roots.

42 and 43. Superior and Inferior Gluteal Nerves. These are the motor nerves to the muscles of the buttock, and accompany the corresponding arteries (gluteal and sciatic), *q.v.*

44. Small Sciatic Nerve. This nerve can be easily exposed. It accompanies the sciatic artery and the great sciatic nerve in the buttock, and through its gluteal and perineal branches supplies the lower part of the buttock and perineum, while its main division is distributed on the posterior aspect of the thigh.

In the buttock it is exposed by the method described for ligature of the sciatic artery (*q.v.*). In the thigh the small sciatic nerve is reached by the same incision as serves to expose the great sciatic nerve (see Fig. 129). The nerve lies underneath the fascia but much more superficial than the great sciatic nerve.

45. Great Sciatic Nerve. From its position and size the great sciatic ranks next to the trigeminal nerve in surgical importance. It is often the seat of neuralgia, which may be either traumatic in origin or more often due to pelvic and spinal disease.

It is the largest branch of the plexus, and leaves the pelvis through the great

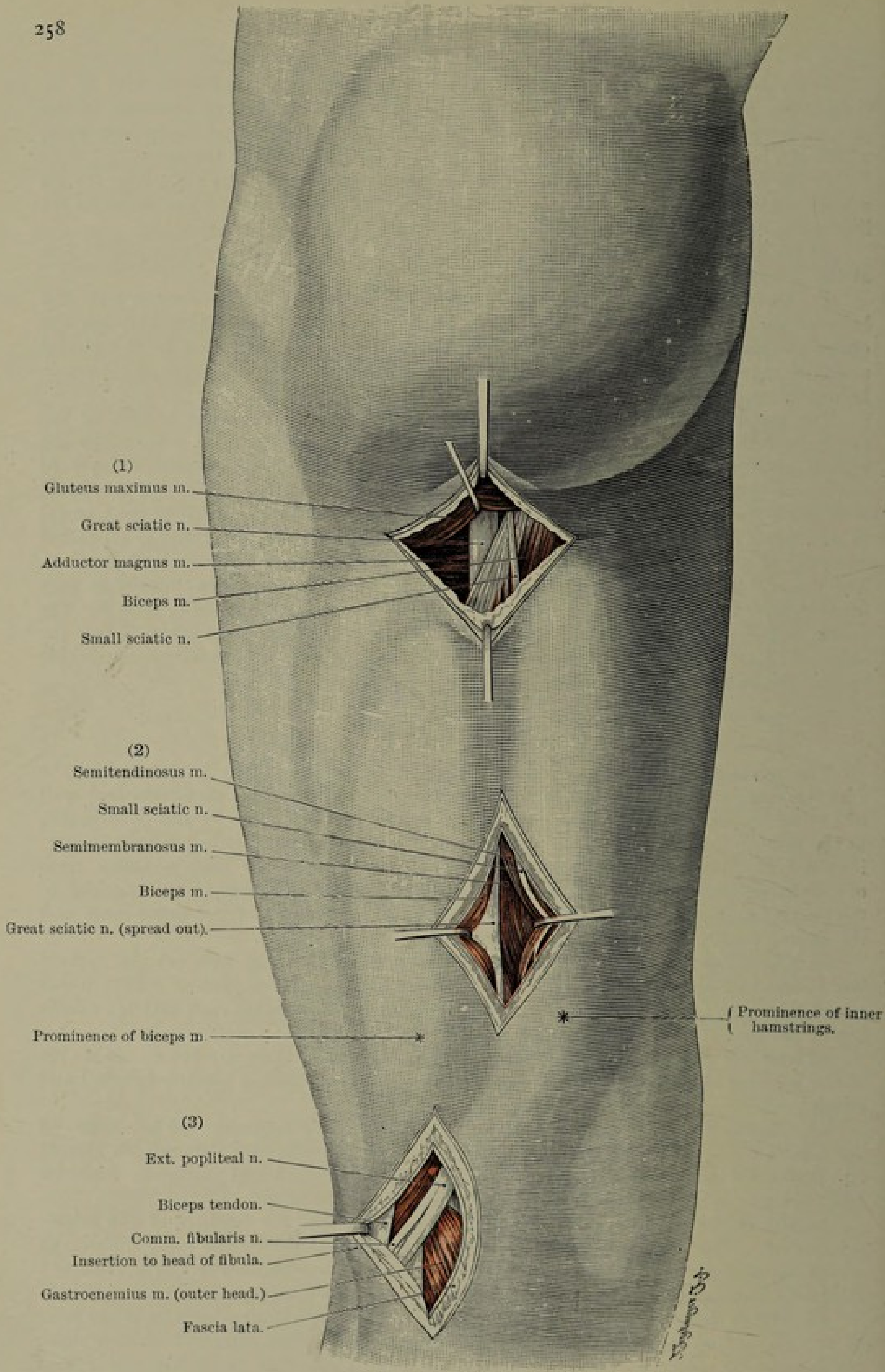


FIG. 129.—(1) Great sciatic nerve at the fold of the buttock. (2) The same in the middle of the thigh. (3) External popliteal and musculo-cutaneous nerves.

sacro-sciatic notch, at the lower border of the pyriformis, at which point it is easily accessible for surgical interference.

In the buttock the trunk of the great sciatic nerve is exposed in the same way as the sciatic artery. Even in the rare cases in which it divides high up, the external and internal popliteal nerves lie close to one another as far as the lower third of the thigh. The nerve is found midway between the tuber ischii and the great trochanter covered by the gluteus maximus, and lying on the obturator internus and gemelli above, and on the quadratus femoris lower down.

Incision corresponding to the middle two-thirds of a line from the postero-inferior spine of the ilium to the root of the great trochanter, parallel to the incision for ligature of the sciatic artery. The skin, dense subcutaneous fat, and fascia are incised, the fibres of the gluteus maximus are separated by blunt dissection, and the lower border of the pyriformis exposed. The sciatic artery accompanied by the inferior gluteal nerve emerges from below the inner end of the latter muscle, and while both give off large branches to the gluteus maximus, the nerve sends off a branch which joins lower down with the small sciatic nerve. The ischial spine and the small sacro sciatic ligament, the latter of which passes inwards from the tip of the ischial spine, afford a good guide to the point at which the artery leaves the pelvis. The lower border of the great sacro-sciatic notch over which the artery runs, is felt above the ischial spine.

The course of the small sciatic nerve corresponds to the continuation of the trunk of the artery (Fig. 129). At a deeper level and more external the broad, easily-palpable trunk of the great sciatic nerve can be felt running downwards on the bone over the base of the ischial spine and the obturator internus muscle (Fig. 129).

In the thigh. The trunk (*i.e.* before it divides into internal and external popliteal nerves) extends only to the lower third of the thigh, in which position it can be readily exposed (Fig. 129).

To expose it in the *upper part of the thigh*, a vertical incision is made descending from the fold of the buttock from a point midway between the tuber ischii and the posterior border of the great trochanter. After division of the skin and fascia, the lower border of the gluteus maximus is exposed and drawn upwards so as to expose the outer edge of the biceps, which runs obliquely downwards and outwards. Between the fascia lata and the biceps is the small sciatic nerve. The large trunk of the great sciatic nerve lies deeper under the outer edge of the biceps, which is to be drawn inwards. In the same region, but deeper and more internal, is a branch of the sciatic artery, which may be ligatured where it lies upon the adductor magnus muscle.

Below the middle of the thigh. Incision upon the posterior aspect of the thigh midway between the semitendinosus and semimembranosus internally and the biceps externally. On the skin being divided, the small sciatic nerve appears either upon or under the fascia. On passing deeply between the above muscles we find the great sciatic nerve lying upon the posterior surface of the bone, having already frequently divided into its two main branches.

(a) The Internal Popliteal Nerve with its Branches. The internal popliteal nerve is the continuation of the trunk of the great sciatic and runs vertically down the middle of the popliteal space.

In the popliteal space. A vertical incision is made over the middle of the popliteal space opposite the knee-joint. The short saphenous vein is to be avoided at the lower part of the incision. It ascends between the two heads of the gastrocnemius and opens into the popliteal vein. To its outer side is the nervus communicans tibialis. The dissection is continued through the fat to the inner side of these structures and between the heads of the gastrocnemius. The internal popliteal nerve is the first structure to appear. When this is drawn outwards the popliteal vein comes into view, closely bound down by a strong sheath to the subjacent popliteal artery, which lies above upon the fat covering the femoral trigone, and below upon the popliteus muscle.

In the leg. The posterior tibial nerve lies close to the outer side of the posterior tibial artery: it is therefore exposed in the same way as the artery (Fig. 131).

(*a*) *Ramus Communicans Tibialis* (*N. Cutaneus Suræ Medialis*). This nerve

has a very definite course and accompanies the short saphenous vein. It lies on the outer side of the vein in the middle of the calf of the leg between the two heads of the gastrocnemius and under cover of the deep fascia which it pierces below the prominence of the calf (Fig. 130).

Behind the external malleolus the short saphenous nerve, which is formed by the union of the nervus communicans tibialis with the nervus communicans fibularis, lies

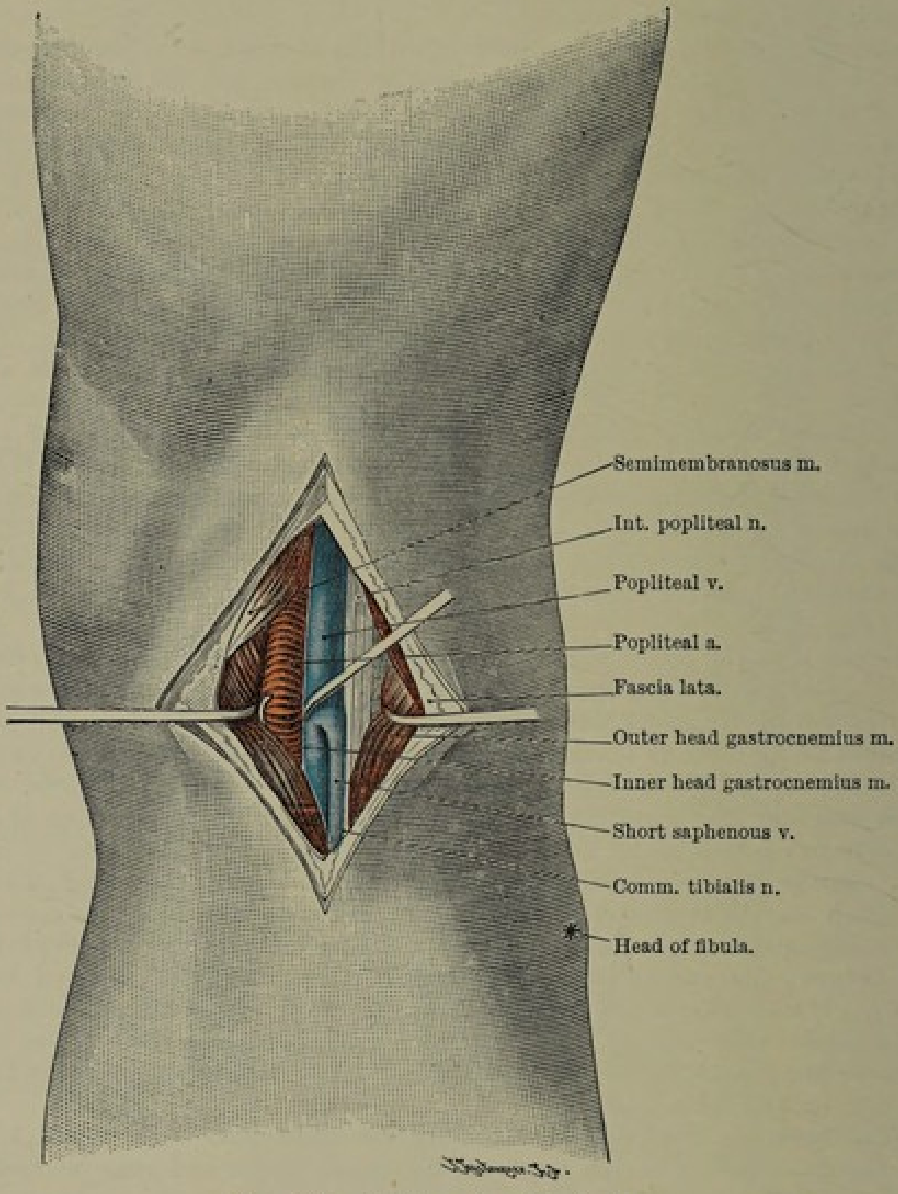


FIG. 130.—Ligature of popliteal artery.

on the fascia close to the vein midway between the tendo Achillis and the malleolus. It is distributed to the outer border of the foot.

(*b*) *Internal Plantar Nerve. At the inner border of the foot.* An incision beginning a finger's-breadth below and in front of the sustentaculum tali is carried horizontally backwards along the inner border of the foot above the prominence of the abductor hallucis muscle. After division of the skin and fascia the abductor hallucis is exposed, and separated downwards from the subjacent deep fascia. On dividing the latter we find the plantar vessels opposite a line continued downwards from the posterior border of the internal malleolus. The posterior tibial nerve lies immediately below the artery.

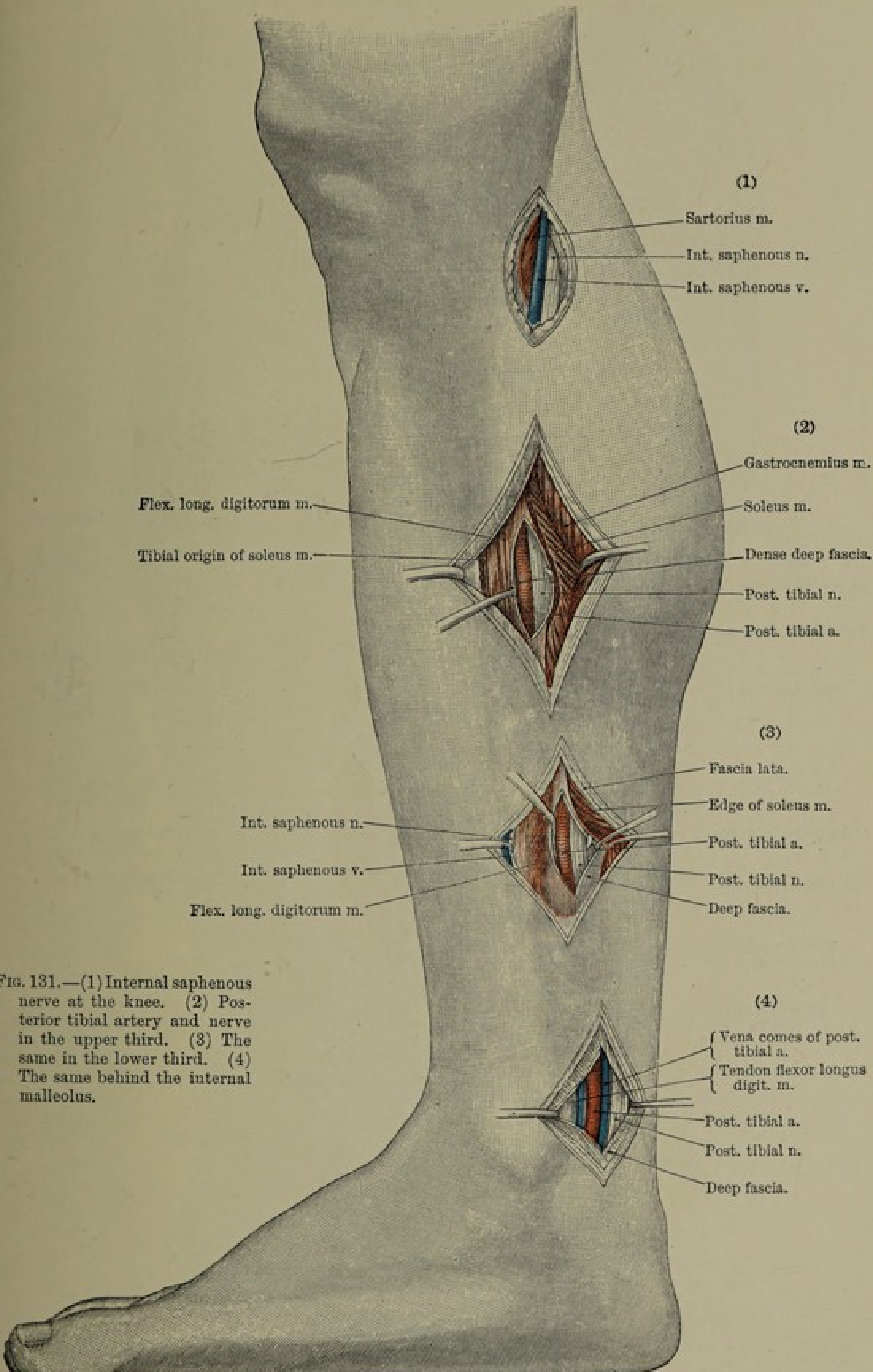


FIG. 131.—(1) Internal saphenous nerve at the knee. (2) Posterior tibial artery and nerve in the upper third. (3) The same in the lower third. (4) The same behind the internal malleolus.

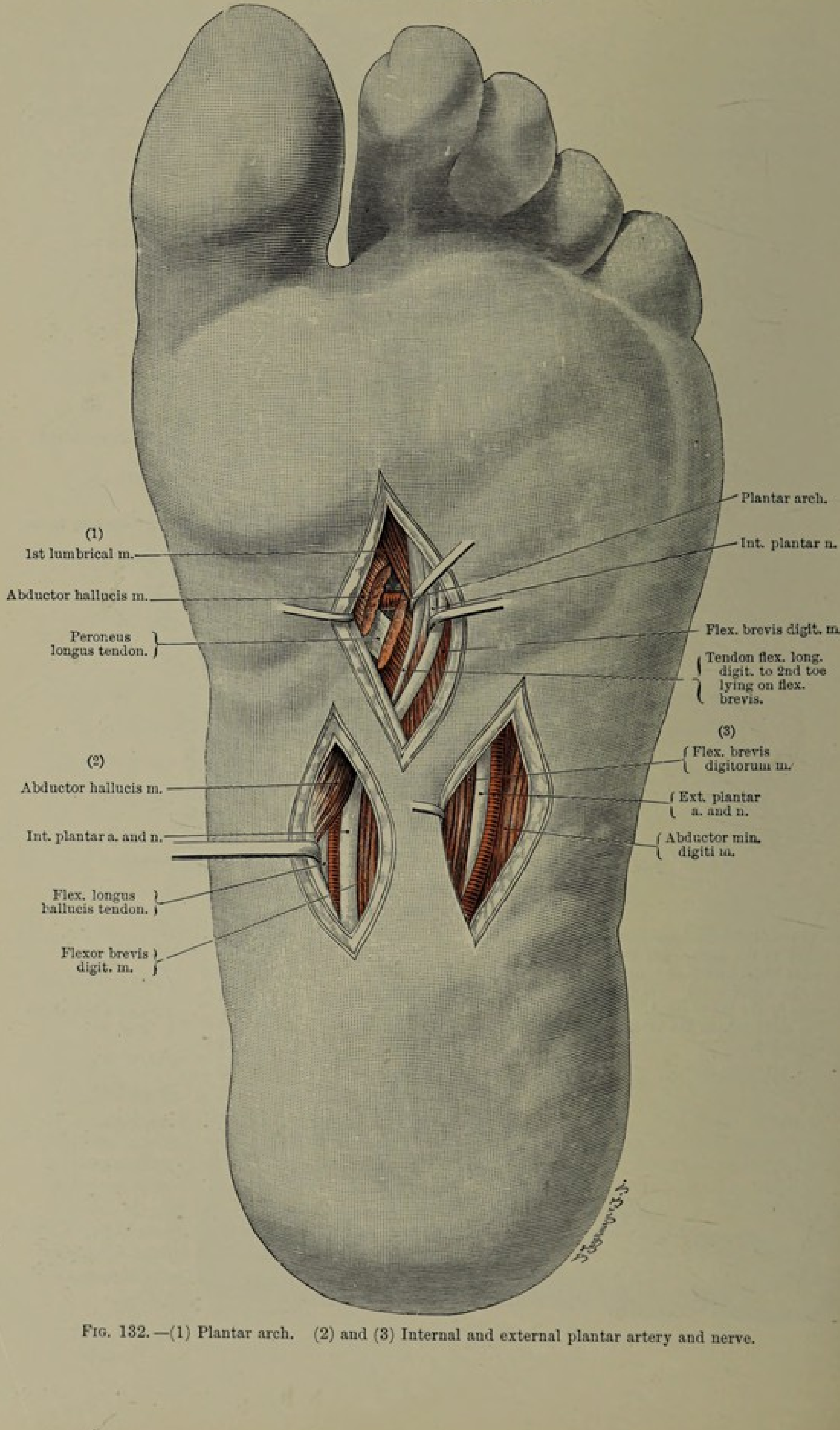


FIG. 132.—(1) Plantar arch. (2) and (3) Internal and external plantar artery and nerve.

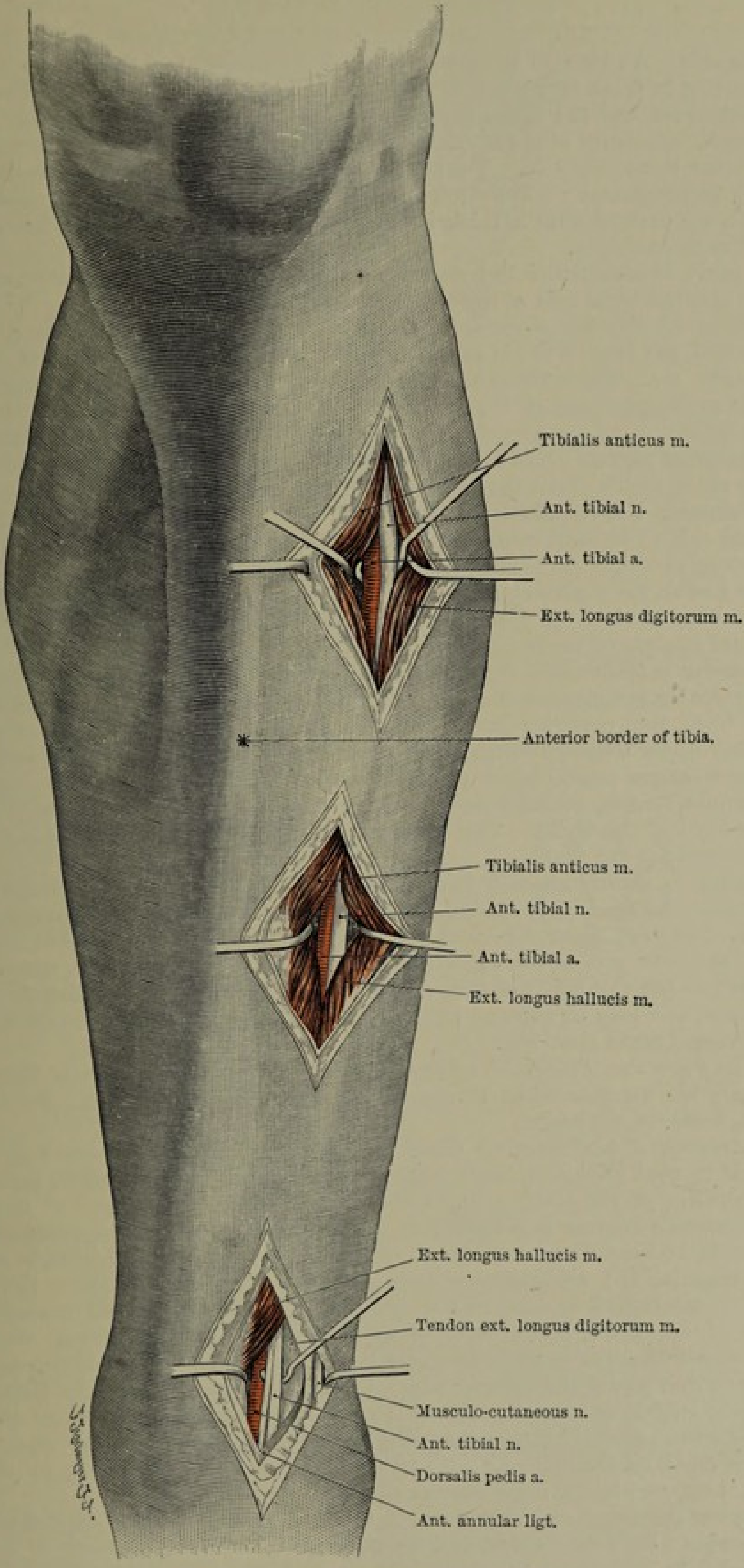


FIG. 133.—Anterior tibial artery and nerve.

In the sole. An incision is made in a line from the point of the heel to the great toe, beginning in front of the ball of the heel and extending forwards. The skin, a thick layer of fat, and the dense logitudinal fibres of the plantar fascia are divided. The muscular substance of the abductor hallucis is exposed, and the artery is found passing under it into the sole. The flexor brevis digitorum lies external to the artery.

The internal plantar nerve accompanies the artery, the latter being of smaller size, while both are covered with a thick layer of fat. The tendon of the flexor longus hallucis lies more deeply.

The nerve is distributed to both sides of the hallux, and of the second and third toes, and also the tibial side of the fourth toe on their plantar aspect.

(*c*) *External Plantar Nerve* (*vide* Fig. 132). Incision from immediately in front of the ball of the heel forwards in the direction of a line from the point of the heel to the fourth toe. On division of the skin, abundant fat, and the strong plantar fascia, the muscular fibres of the adjacent edges of the flexor brevis digitorum and abductor minimi digiti are exposed, and the artery is found lying between them.

The external plantar nerve lies beside the corresponding artery, the former being relatively much smaller than the latter.

(b) Peroneal Nerve (External Popliteal) with Branches. This nerve, which winds from behind forward round the neck of the fibula, is specially liable to injury, and radiating neuralgic pains are produced along its course.

Above and in the popliteal space. The trunk of the nerve can be felt and indeed seen behind the head of the fibula; it is still more distinct on the posterior surface of the external condyle of the femur.

An incision is made along the posterior edge of the tendon of the biceps, superiorly over the palpable prominence of the external condyle, inferiorly along a line extending upwards from the posterior border of the head of the fibula. The nerve lies immediately under the deep fascia at the outer edge of the gastrocnemius, and pierces the peroneus longus muscle below the head of the fibula.

The communicating peroneal nerve is given off from the external popliteal (Fig. 129) above the head of the fibula. This nerve may also be felt through the skin upon the external condyle of the femur.

The nerve is readily exposed behind the head of the fibula by dividing the deep fascia between the head of the fibula and the outer border of the gastrocnemius.

(*a*) *N. Cutaneus Suræ Lateralis* (*N. Communicans Fibularis*). The cutaneous branch to the outer side of the leg, which unites lower down with the n. communicans tibialis, can be felt through the skin on the posterior surface of the external condyle of the femur, and may be exposed in the popliteal space by the same incision as that for the peroneal nerve (*vide* Fig. 129).

(*b*) *The Peroneous Profundus* (*Anterior Tibial Nerve*). The anterior tibial nerve accompanies the anterior tibial artery on the interosseous ligament. Its relations above are, however, different.

The Anterior Tibial near its Commencement (Fig. 134). The incision extends downwards through skin and fascia from a point opposite the outermost part of the outer tuberosity of the tibia, a finger's-breadth in front of the head of the fibula. The intermuscular septum is indicated by a white line extending obliquely downwards and forwards, and the dissection is continued along it between the tendinous extensor longus digitorum and the peroneus longus. The anterior tibial nerve lies deeply in the above-mentioned septum, and passes obliquely downwards and inwards below the head of the fibula under cover of the extensor longus digitorum, whilst the musculo-cutaneous nerve extends vertically downwards along the same interval.

In its further course the anterior tibial nerve accompanies the anterior tibial artery in its entire length, and can be exposed by the same incisions. It lies to the outer side of the artery, except below, where it lies upon its anterior and inner aspect.

On the front of the leg. As the nerve here accompanies the artery in its whole length, it is exposed in the same manner as the artery (*q.v.*).

To expose the nerve on the dorsum of the foot, *vide* Fig. 135. It is distributed in the interspace between the first and second toes.

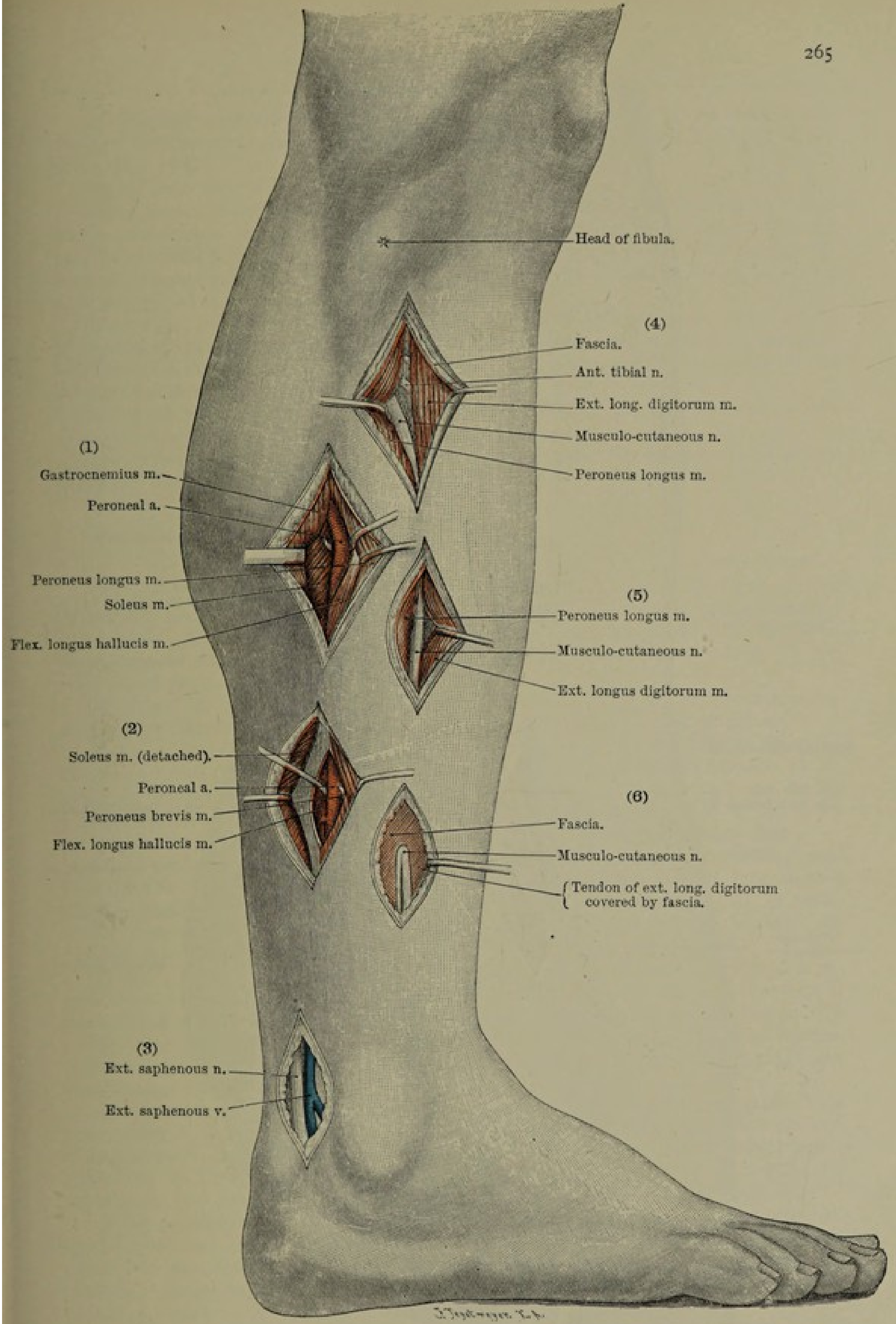


FIG. 134.—(1) Ligature of peroneal artery in its upper part. (2) The same in its lower part. (3) Exposure of external saphenous nerve. (4) Exposure of posterior tibial and musculo-cutaneous nerves below the external condyle of tibia. (5) Exposure of musculo-cutaneous nerve in the middle of the leg. (6) The same in the lower third, where it pierces the fascia.

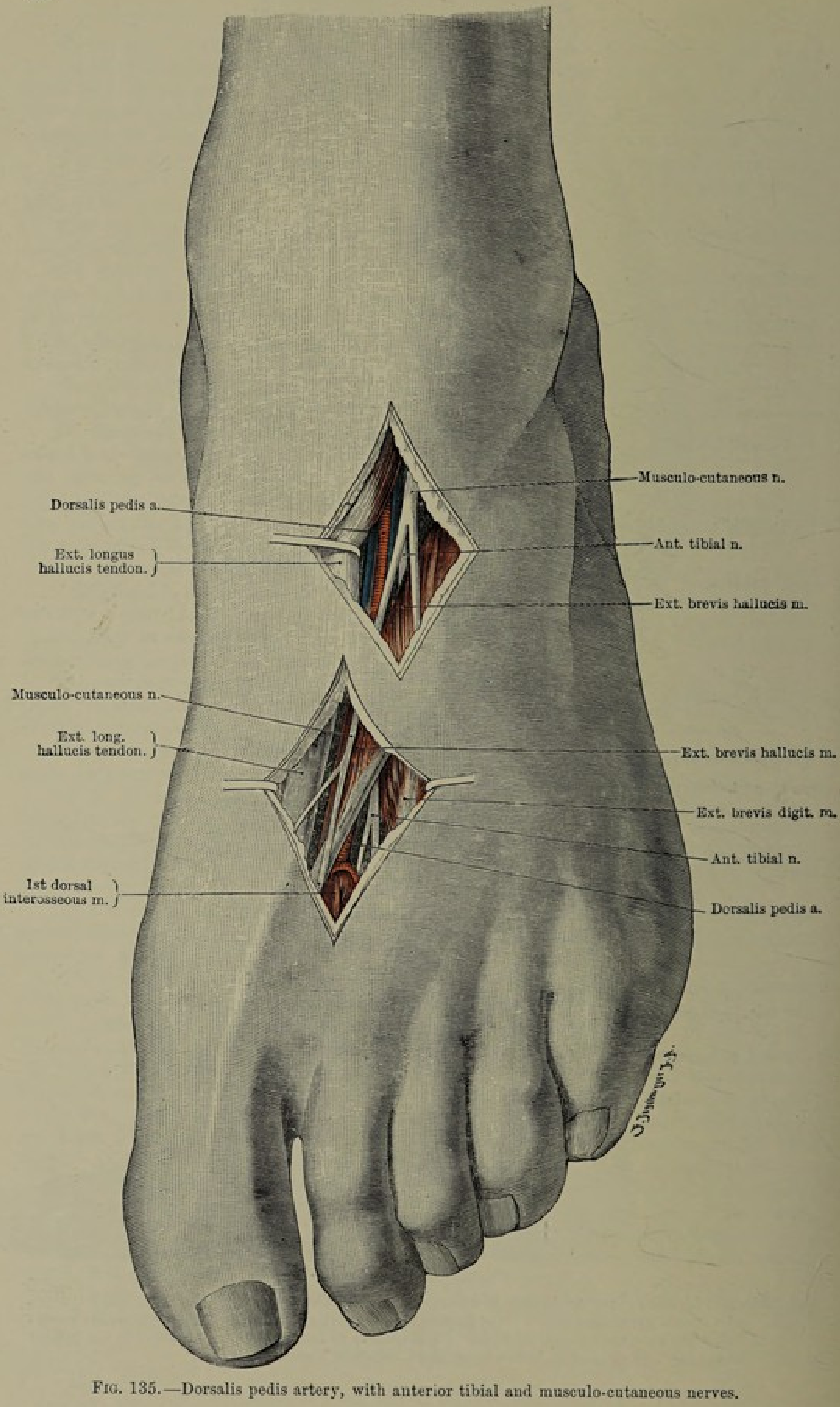


FIG. 135.—Dorsalis pedis artery, with anterior tibial and musculo-cutaneous nerves.

(*c*) *Musculo-cutaneous* (*N. Peroneus Superficialis*). *In front of the head of the fibula.* Compare exposure of the exterior popliteal nerve in front of the head of the fibula, Fig. 134.

On the outer side of the leg (Fig. 134).

In the middle third of the leg. Divide the skin and fascia along the anterior edge of the prominence of the peronei muscles (longus superiorly, brevis inferiorly), and pass in between these muscles and the extensor longus digitorum. On drawing the peroneal muscles outwards, we find the nerve at the bottom of the interspace, becoming more superficial as it descends.

The nerve pierces the fascia *at the junction of the middle and lower thirds of the leg*, where it may be exposed by an incision midway between the anterior border of the tibia and the posterior border of the fibula. The nerve can occasionally be felt through the skin in this situation.

On the dorsum of the foot. Here the nerve supplies all the toes except the adjacent sides of the first and second toes.

The musculo-cutaneous nerve is more superficial than the dorsalis pedis artery which lies underneath the deep fascia accompanied by the anterior tibial nerve.

(j) Pudendal Plexus

The pudendal plexus and its branches is important, in spite of its small size, as it furnishes motor and sensory supply for the perineum, bladder and urethra, rectum and vagina. Neuralgia is also not uncommon in the region supplied by its branches. The plexus is formed by the third sacral nerve with communications from all the other sacral nerves.

(*a*) *The Pudic Nerve.* This is the largest nerve of the plexus, and is occasionally of operative interest. Tavel has made a detailed study of its surgical treatment.

Professor Strasser, who has made careful investigation of its distribution describes the pudic nerve (with the artery) as enclosed in a sheath of fascia (Alcock's canal) which is derived from the fascia covering the obturator internus, and which lies a finger's-breadth below the junction of the obturator fascia with that of the lower part of fascia covering the levator ani at the upper limit of the ischio-rectal fossa.

It is very important that the twigs innervating the anus should be differentiated from the other fibres of the internal pudic, because if they are divided, incontinence is apt to result. Hence, if the nerve is divided on account of neuralgic pain, or spasm in the perineum, the pudenda (vaginismus), urethra, or neck of the bladder, the division must be made below the point at which these nerves are given off.

In the buttock. The dissection to expose the nerve at the point where it emerges from the lower part of the great sacro-sciatic notch along with the sciatic artery, is the same as that described for ligature of the internal pudic artery. It lies on the posterior surface of the ischial spine internal to the sciatic artery and in close relation to the internal pudic artery along with which it again enters the pelvis through the small sacro-sciatic notch.

In the perineum. Hitherto stretching and division of the internal pudic have been confined to the portion of the nerve in the perineum, as we possess other methods of treatment for spasm of the sphincter ani which involve less risk of incontinence. According to Tavel, it was first successfully performed by Simpson in 1861 for vaginismus, and by Albertin and Rochet for cystalgia and painful urethro-cystitis.

Before entering the perineum the pudic nerve gives off the inferior hæmorrhoidal to the lower end of the rectum. Dividing (or stretching) the nerve therefore only affects the branches to the perineum, vagina, urethra, and genitals (perineal and dorsalis penis nerves). Tavel points out that the deep part of the perineal gives off a recurrent branch to the sphincter, which should not be injured.

It is advisable to follow Tavel's suggestion and first expose the nerves in the perineum, after which they are laid across Kocher's dissector and tested, branch by branch, by mechanical stimulation in order to observe the muscles which they supply

(sphincter ani, transversus perinei superficialis and profundus, sphincter vaginæ, sphincter urethræ, ischio-cavernosus, and bulbo-cavernosus muscles).

The inferior hæmorrhoidal nerve supplies the skin behind the anus, the perineal nerve, the skin in front of the anus, the perineum, posterior portions of scrotum and labia, the labia minora, vulva, and the vaginal and urethral mucous membrane. The dorsalis penis (clitoridis) supplies the penis and clitoris, and to some extent the labia minora.

In the lithotomy position, an incision is made in the sagittal direction along the inner border of the tuber ischii (Tavel's incision is 8 to 10 cm. long midway between the tuber ischii and the anus) dividing skin and subcutaneous fat. The origin of the ischio-cavernosus muscle from the anterior part of the tuber ischii is exposed, and behind it the less distinct superficial transverse perineal muscle. The two divisions of the nerve are found passing forwards from under the great sacro-sciatic ligament. The upper, *i.e.* deeper, branch (measuring from the skin) passes forwards under cover of the transversus perinei muscle, and may be divided. Of the branches which are superficial to the transversus perinei, those going to the labia must often be torn across; their course can easily be recognised by putting the nerve on the stretch. The artery can be felt on the inner surface of the obturator internus and after the fascia has been opened the nerves which are superficial to the vessel can be raised with a dissector. As advised by Tavel and the author, the affected branches can then be twisted on artery forceps from the periphery and torn out by Thiersch's method.

(k) Coccygeal Plexus

Neuralgia of the plexus, coccydinia, may require surgical interference.

The plexus, which is mainly formed by the fifth sacral and the coccygeal nerves, is placed on the front of the origin of the coccygeus muscle, through (or below) which the lowest sensory nerves supplying the region of the coccyx are given off.

46. Ano-coccygeal Nerves. Neuralgia of these nerves is cured by excising the coccyx, as this procedure insures their division.

(l) Sympathetic Cord

Recently endeavours have been made to obtain information regarding the function of the sympathetic nerve by operative measures and to influence pathological conditions by its removal, without possessing adequate knowledge of the physiological effects of interference with the nerve.

The cervical sympathetic has been dealt with surgically in the hope that epilepsy, Basedow's disease, and trigeminal neuralgia might be cured by its total or partial excision. These hopes have been so little fulfilled that it does not seem justifiable to perform a complete excision of the cervical sympathetic, and thus destroy at one stroke all the vasomotor nerves of the head and neck, the sympathetic nerves to the eye, and the three cardiac nerves (superior, middle, and inferior, from the corresponding cervical sympathetic ganglia), without having an exact knowledge of the consequent injurious effects of such a procedure.

Till its effects are better known we refrain from describing total excision, and are satisfied with consideration of excision of the superior cervical ganglion or division of the nerves which ascend from it (carotid and jugular sympathetic), since we have demonstrated that the latter measure exerts a favourable influence on exophthalmos and trigeminal neuralgia.

47. Division of the Cervical Sympathetic above the Superior Cervical Ganglion. The neck being fully extended, an incision is carried downwards through skin and fascia from the tip of the mastoid process, the great auricular nerve and the external jugular vein being retracted or divided, and the anterior border of the sterno-mastoid muscle exposed and hooked backwards. The prominent internal jugular vein is freed posteriorly, and the vagus nerve is recognised from its position between the

vein and the carotid artery, the latter lying farther forward and at a deeper level. Care must be taken not to draw the sympathetic forward along with the vessels.

By dissecting deeply on to the anterior surface of the vertebræ in front of the origin of the levator anguli scapulæ and scalene muscles, the characteristic greyish spindle-shaped ganglion, which measures about 2 cm. in length, and which extends from the second to the fourth transverse process, is exposed lying on the prevertebral fascia and muscles. Its cephalic branches, which are mainly associated with the internal carotid, are given off the upper end of the ganglion, and may be raised on a hook and divided.

The twigs to the external carotid and its branches, as well as those to the larynx (and pharynx), and also the superior cardiac nerves, arise from the lower end of the ganglion, and must not be injured. After a few hours, slight ptosis, contraction of the pupil, and swelling of the cheek are distinctly observable.

SECTION IV

SURGERY OF THE EXTREMITIES

(a) General

THE surgery of the extremities has been partially considered in the previous sections on the exposure of vessels and nerves. The remaining portion of the subject will be treated in a separate section. It may be stated that this branch of surgery is one which can be best practised on the cadaver as a regular course.

It is a field suited to the work of the practitioner, because the operations can be performed without bleeding, expert assistance is not necessary, and local anæsthesia is generally sufficient. It would be unfortunate if this branch of surgery were to be wrested from the practitioner by the specialist.

Surgery of the extremities is no longer limited, as it was till a comparatively recent date, to the ligature of vessels, to excisions and amputations and to the mechanical correction of curvatures. Its range has been greatly extended, and practitioners have even yet to realise fully the advantages of operative interference in certain types of cases.

We no longer confine ourselves to ligature of a vessel for the arrest or prevention of hæmorrhage, for the treatment of an aneurysm, etc., as vessels are now ligatured to improve the flow of blood in a limb (in cases of lymphatic elephantiasis, and varix), and to prevent the dangers of embolism (a proximal ligature or by incision of the vessel and removal of the thrombus); while suture is undertaken in the case of lateral injuries and in the excision of an aneurysm. One even goes the length of transplanting vessels for existing defects (by inserting a portion of a vein into an artery) when the continuity cannot be repaired by the method devised by Payr—the insertion of a magnesium tube. Further, one does not hesitate in cases where gangrene is imminent after severe arterial lesions to completely reverse the circulation (Carel and Guthrie).

The peripheral nerves now possess a surgical importance of their own. It is acknowledged that it is a mistake not to reunite a divided nerve as quickly as possible by suture, and yet this treatment is not invariably adopted. One trusts too much, especially when a nerve has been crushed or torn, to the comfortable policy of *laissez-aller* to remove subsequent thickenings and adhesions.

It was not only the question of nerve suture that led us to consider each individual nerve, but the knowledge that a thorough acquaintance with the course of even the smaller nerves is essential, if the fullest advantages to be derived from local anæsthesia are to be obtained. "Conduction" anæsthesia (Braun) ought to be more extensively utilised than has hitherto been the case, and doubtless it will be more generally adopted when practitioners make themselves more familiar with the anatomical course of the nerve-trunks.

The treatment of tetanus by exposure and blocking of the nerve-trunks has already

produced excellent results, and it is becoming more manifest that the poison of tetanus reaches the central nervous system through the peripheral axis cylinders, and that it can be arrested by dividing or blocking the nerves.

Further, ever since the first edition of this work was published, we have endeavoured to show how the deeper tissues can be extensively exposed without causing injury to the nerves. The normal incisions which we instituted have since that time been greatly extended (Küstner's and Pfannenstiel's abdominal incisions) so that it is now possible to divide tissues freely without producing the slightest permanent injury.

Cushing has recently drawn attention to the importance of accurate suturing of wounds so that the nerve-ends are brought into contact when their division has proved unavoidable, because, depending perhaps on some chemotactic process, there is a tendency for the central end to send processes to unite with the motor end organ in the peripheral portion, as soon as some degree of contact is restored (even without direct suture).

Cushing mentions as an example the regeneration of cutaneous branches and of the spinal accessory nerve after extensive removal of glands in the neck that follows accurate closure of the wound, arrest of hæmorrhage and asepsis.

(b) On Nerve-anastomosis, Nerve-transplantation, and Nerve-grafting

In the foregoing chapter we have already considered the question of nerve-anastomosis, nerve-transplantation, and nerve-grafting in connection with the surgery of the facial nerve. Numerous authorities have, however, observed that one cannot assume when the peripheral and central ends of a nerve are united that corresponding nerve-fibres reunite, and that on this supposition the union of nerve-ends which do not belong to each other is necessarily forced upon us. Experiment has shown that the central nerve organ after some months again sends undiminished nerve impulses into the corresponding peripheral portion of nerve, as well as into a nerve that has been grafted (*i.e.* to absolutely strange end organs).

The attempt has already been made by surgeons with special experience and enterprise in this field, to undertake anastomoses with healthy nerves in suitable cases of infantile paralysis.

In a case of partial paralysis of all four extremities due to poliomyelitis anterior acuta, Cushing divided the spinal accessory and implanted the proximal end into the fifth root, which was the one chiefly affected. Langley and Anderson successfully united preganglionic fibres of the sympathetic in the neck with the peripheral ends of the recurrent laryngeal, phrenic, and spinal accessory.

(c) Surgery of Muscles

The surgery of muscles and tendons deserves special notice. It should be a rule during all operations to avoid as much as possible division of muscles, because in muscle more than in any other tissue necrosis of the cut surface is more likely to occur, and because healing only takes place by the formation of connective tissue, *i.e.* an artificial tendinous inscription. It is of further importance to guard against atrophy occurring by avoiding injury to the motor nerve, a point which has been specially considered in our remarks on normal incisions.

One can best avoid injury to muscles by using either intermuscular or, in the case of broad muscles where this cannot be performed, permuscular incisions in the direction of the fibres, and in this connection we would draw attention to the method of opening the abdomen employed in operations on the appendix (*vide infra*). Here the layers of the abdominal wall are split (not divided) in the direction of their fibres and the lines of division of the layers cross each other in three directions.

When a muscle has to be divided at right angles to the direction of its fibres, it is very important not to leave a peripheral portion which can undergo atrophy,

i.e. the muscle should be divided as far as possible away from the point of entrance of its nerve. In many incisions that are advocated little attention is paid to this point, *e.g.* in laparotomy many surgeons do not hesitate to employ vertical incisions, especially at the outer border of the rectus, quite regardless of the fact that the nerves pass obliquely downwards and inwards. When a larger incision is required, much less harm is done, and less subsequent disturbance of function results if the rectus is cut right across, than by employing a vertical incision which inevitably divides its nerves of supply.

In the neck we have illustrated the incisions which should be employed for the removal of extensive tumours. Here, again, they show how a large muscle like the sterno-mastoid may be cut across without any subsequent harm, if the division is made at a distance from the point of entrance of its nerve.

The same holds good in myotomy for the relief of spasm, and we refer the reader to the description of the operation for spasmodic torticollis (p. 443). By separating its attachment from a bone a muscle may be thrown out of use, and the spasm effectively cured, without the necessity of producing definite atrophy.

Muscle-transplantation is as a rule effected by transplantation of its tendon, *i.e.* a new insertion for the tendon is provided and the function of the muscle is altered without actually displacing the muscle itself.

Transposition of the fleshy part of a muscle is limited practically to the broad muscles of the abdomen and occasionally of the neck. In the case of inguinal and ventral herniæ, instead of the employment of simple fascial sutures, the muscles may be slid over one another. After the peritoneum and deep fasciæ have been united up, the broad abdominal muscles and also the rectus are slid over the line of sutures and fixed with stitches. Muscles capable of contraction furnish a strong protection against hernia.

In the neck we have on several occasions had to undertake transplantations for cosmetic reasons after a previous operation had left a depressed scar. The latter, especially when situated immediately below the lower jaw, can only be cured by careful suture of the platysma after excising the cicatrix. Very satisfactory results as regards appearance can thus be obtained. It is important, therefore, to unite the platysma separately in all those cases.

(d) Surgery of Tendons

Far greater importance is now attached to the surgery of tendons (tenoplasty) than to the surgery of muscles. It is remarkable what can be accomplished since the introduction of asepsis in the way of dividing and displacing tendons without the risk of necrosis. Formerly one had to be content with a subcutaneous tenotomy, but we are now in a position to obtain any desired amount of elongation without trusting to nature's methods.

Let us take as an example the tendo Achillis, the tendon which one is most commonly called upon to lengthen. Instead of simply cutting it across, we divide it in a Z-shaped manner (Bayer's incision, according to Vulpius), the distance between the two horizontal limbs of the Z corresponding to the amount of lengthening required. The two ends of the tendon are then accurately united by sutures (*vide* Fig. 136).

In regard to the method of suturing the ends of the tendon, we have always found ordinary simple stitches sufficient, provided the needle is inserted at a little distance from the cut edge and that there is no tension. The absence of tension is of much more importance than the actual variety of stitch employed. If tension cannot be avoided, the Wilms-Siever stitch will be found very serviceable. In this form of suture the ends of the tendon are first approximated and are held in position by stitches inserted as in Fig. 137.[1] According to Siever, a strain of 5 kilos (11 lbs.)

[1] Taken from Wilms-Siever's article in the *Centralbl. f. Chir.* Bd. 40, 1905.

can be borne for several days, and active movements can be begun at an early stage without risk, a point to which great importance must be attached.

While we must be careful to avoid any tension, there is no necessity to rush to the other extreme and elongate a tendon unnecessarily. If the amount of elongation is accurately gauged, the function of the muscle is quickly restored, in contrast

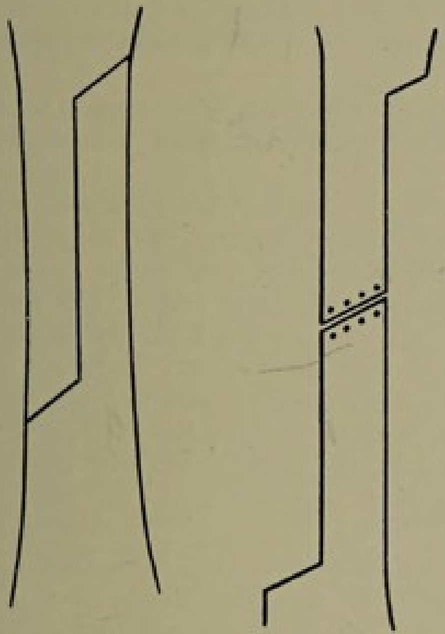


Fig. 136.

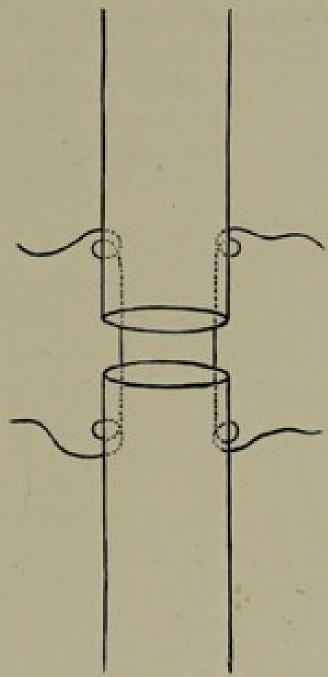


Fig. 137.

to the results obtained after simple tenotomy. We no longer employ rigid dressings in the case of tendo-Achillis, as slight movements produce no harm, and active movements may be permitted with advantage after the first week.

Figs. 136 and 137 illustrate the method of dividing and the method of reuniting the tendon. To expose the tendo-Achillis, a long posterior incision is made. It is then split longitudinally into two lateral halves, which are cut obliquely above and below (by cutting obliquely one gets broader surfaces to suture).

If it is split in the frontal (coronal) plane, the results are not so satisfactory as the split tendon is only half as thick. To attempt the operation subcutaneously entails worse results from inaccuracy.

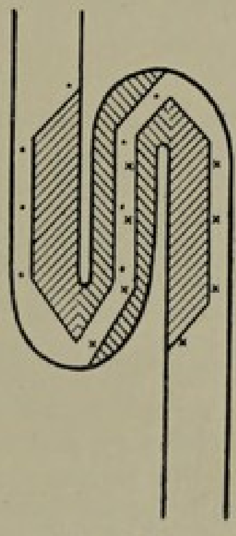


Fig. 138.

Besides the tendo-Achillis, contractures in other situations, *e.g.* the forearm, may be successfully dealt with by lengthening one group of tendons and shortening the other, either by excision of portions of the tendons (oblique section) or by simple plication, the latter method, however, proving less satisfactory.

To shorten a tendon, the redundant portion may either be simply excised by means of two parallel oblique incisions, and the edges united end to end with fine sutures, or the tendon may be shortened by plication. In the latter case, care must be taken to avoid leaving any thickening which would interfere with the mobility of the tendon. According to Hoffa and Borst, thickening of a tendon interferes considerably with the function, as, for example, in "trigger" finger. It can be avoided by excising portions of the tendon in the manner shown in Fig. 138, where the three layers of tendon are reduced to one-third their diameter. By the inclusion of the three adjacent surfaces in the sutures, firm union is obtained and the thickness of the tendon is not interfered with.

Tendon shortening and elongation give excellent results in spastic cases (cerebral palsy of infants), in Little's disease, and in spastic and paralytic conditions from other causes.

Equally good results are also obtained by transplanting and grafting operations, especially in the case of poliomyelitis anterior acuta, where only individual muscles or groups of muscles are paralysed.

The essential feature of such operations consists in dividing the tendon of an active muscle as close to its insertion as possible, and grafting its upper portion either laterally into a slit in the tendon of the paralysed (or weak) muscle, or dividing the latter tendon and joining them end to end.

Here also the grafted tendon must exert the right degree of tension so that the desired effect may be produced when the muscle contracts. This is best illustrated by an example.

Let us suppose a case in which the invertors of the foot are paralysed while the evertors are normal, the foot occupying the valgus position. The object here is to bring the foot into active inversion and to support and raise the sunken inner side of the foot. The tibialis posticus tendon (as well as the flexor tendons) is first exposed by an incision below the internal malleolus and the sheath is opened. Similarly the peronei tendons are both exposed and their sheath is opened behind the external malleolus. By following them down to the outer border of the foot, the peroneus longus is identified and cut across as low down as possible.

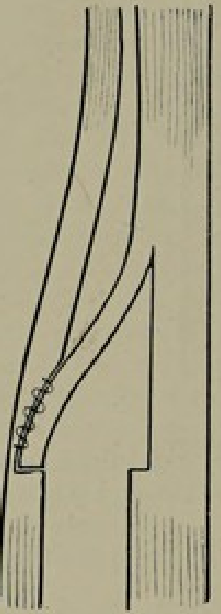


Fig. 139.

The upper end of the latter tendon is separated up to the point where it fuses with the muscular tissue, and is pushed with a long slender pair of catch forceps through to the inner side between the tibia and fibula and the deep muscles, where it is pulled out through the incision for exposing the tibialis posticus. Instead of unduly prolonging the latter incision to attain this, it is better to make a separate small wound through which the tendon is pulled. The foot is then placed in correct position, *i.e.* in the position of normal inversion and at right angles. The tendon of the peroneus longus is pulled upon until a slight amount of tension is produced, and is applied to the tendon of the tibialis posticus, the latter being now only cut across or slit in order to make the anastomosis. If asepsis can be guaranteed it is better to cut the tendons across and unite the two ends with fine sutures, the wound being then stitched up without drainage. The dressings and bandages must retain the foot in proper position for one or two weeks so as to avoid any passive strain on the sutures.

It is very rarely that one has to transplant tendons or muscles which have the same action, for they generally replace each other in time without any operative interference being required. One has more frequently to transplant tendons which are antagonistic in action, and whenever possible we prefer to select those that are doubly represented, *e.g.* one of the two peronei. The results obtained by splitting a normal tendon and uniting only one half into the paralysed muscle are not so satisfactory, and in consequence the operation is rarely performed.

We maintain, in opposition to Vulpius, who insists on a plaster bandage being worn for at least six weeks and then relieves the resulting stiffness by massage, baths, and electricity, that if fine silk has been used as the suture material, active movements should be begun in the course of a week or fortnight. Good stitches of fine silk keep the ends of the tendons together so securely that there is absolutely no need to fear over-stretching of the young tendinous cicatrix.

Equally excellent results are obtained in the case of the hand by tendon anastomoses of this type, and after a few months or years marked improvement or complete restoration of function may be expected.

In the case of a large joint such as the knee an efficient substitute for the powerful quadriceps extensor can be obtained by transplantation of the sartorius, semitendinosus and biceps tendons. Here there is no separate tendon into which the active muscles can be grafted, and one has to fall back upon the fixed point afforded by the insertion of the quadriceps into the patella, *i.e.* the proximal end of the active tendon is inserted into the periosteum and fascia covering the lateral edges of the patella (modified Lange's method). Even contractions at the knee may be permanently relieved according to Codivilla and Heussner by transplanting the flexor tendons into the extensor apparatus.

(e) Surgery of Articular Ligaments

We would merely observe in connection with the ligaments, that the treatment especially of traumatic lesions of joints, should be much more active than it is at the present time. A large number of cases of so-called chronic arthritis might be prevented were the torn ligaments promptly sutured and the loose cartilages removed. Ligaments heal comparatively well, and if persistent interference with movement after injury to a joint is to be prevented, conditions must be established which promote the earliest restoration of movement. Suture is a means to this end, if one knows how to open into the joint without causing damage to its function. The methods of performing arthrotomy are considered in the following chapters.

If operation is carried out promptly one often discovers far more serious lesions than the clinical evidence would suggest, lesions which would readily explain any subsequent and persistent limitation of function. In the elbow-joint in cases of supposed simple sprain (distortion) we have observed complete transverse rupture of the anterior ligament occasionally with separation of the internal condyle (the early stage of a posterior dislocation of the elbow) when the case would otherwise have been regarded as a simple sprain.

In dividing an articular ligament it is preferable to detach it along with a layer of bone, so that solid union will more easily occur. Thus, in old-standing fractures of the patella, v. Bergmann has advised separation of the tubercle of the tibia as a preliminary to wiring the patella.

Similarly, in many cases of arthrotomy, it is advisable to separate the superficial bony attachments of the capsule and ligaments rather than to divide them transversely.

(f) Surgery of Bones

The operative treatment of bones differs according as to whether the formation of new bone is, or is not, desired. The bone marrow, which is so essential a factor in hæmogenesis, may be regarded merely in the light of a foreign body enclosed in a strong bony shell. When it is inflamed or is the seat of a suppurative process it may be entirely removed without causing the least damage to the bone (this applies to the diaphysis).

The formation of new bone proceeds from the periosteum and the superficial osteoplastic layers. These layers must be carefully preserved if new bone is to develop, *e.g.* in many cases of osteotomy, resections of joints, and in certain disarticulations.

Ollier has shown that the regenerative process is to a considerable extent influenced by the manner in which the periosteum is detached. If a blunt elevator is employed for the purpose, practically nothing except the elastic tissue of the periosteum is detached. With the knife, on the other hand, numerous uninjured bone-forming elements are preserved along with the periosteum. With the sharp periosteum elevator (rugine, raspatory) the two bone-forming elements of the inner layer of the periosteum are raised intact, viz. the osteogenetic layer and the superficial bony lamella on its inner surface.

In amputations, on the other hand, new bone formation is as a rule to be avoided, for it has been shown that the stump then retains in a greater degree its original form. (Our assistant, Dr. v. Steiger, has published for us a large number of examples proving this point.) Hence as we shall see in the chapter on amputations, the best stumps are obtained by non-osteoplastic methods.

The question of a substitute for the marrow is of no little importance when the marrow has been removed or when cavities in the bone have been left which will take a considerable time to fill up. After earlier attempts, Mosetig and Moorhof have produced their iodoform bone-filling which has proved the best material for the purpose. It consists of 60 parts of finely powdered iodoform and 40 parts each of spermaceti and sesame oil, the melting-point of the mixture being 50° C. It is shaken up before use and is poured in a fluid state into the cavity, after all the bleeding has been completely stopped, and the cavity has been dried out with an electric hot-air apparatus or a sterile dry cold-air bellows. The cavity must be absolutely clean. Silbermark has shown that the filling slowly becomes replaced by bone tissues which grow from the periosteum and marrow. Mosetig has similarly filled up cavities left in the soft parts, particularly after resections of a joint. In the bone cases, in which he used the filling with success, the cavities were chiefly the results of chronic and tubercular osteomyelitis.

A. ARTHROTOMY, OSTEOTOMY, AND RESECTION

(a) Technique in General

The term "resection," which is used chiefly in connection with surgery of the joints, implies the removal of an intermediate portion of a limb, as distinct from amputation, where a terminal portion is removed. As a resection necessitates the employment of special incisions to expose the joint or bone, arthrotomy and osteotomy must first be the subject of consideration, although they actually comprise only part of a resection.

To Langenbeck belongs the credit of having called attention to a very important point in the excision of a joint or bone, viz. that the incision through the soft parts should be as simple as possible, and that in cleaning the bones we should retain them in their normal continuity with the periosteum. And Ollier must be recognised as having shown, by his experiments and by the excellent results of his operations, the significance of carefully preserving the periosteum in its continuity with the attachments of the capsule, ligaments, and tendons. But, nevertheless, it does not seem to us to be consistent with the spirit in which these masters worked to adhere strictly to their methods. All that is necessary is to adhere to the principles which we owe to their labours and to their genius.

We agree with König in his opinion that the day for typical resections is past, and that arthrotomy and osteotomy, with removal of nothing but the diseased soft parts and bone, should replace the stereotyped excisions that were formerly the rule. Kappeler has applied the term "Atypical" to such resections, but the name conveys an undue impression that there is some irregularity in the methods of performing these operations, whereas most exact rules are prescribed. We consider we have made a still further improvement by selecting for all joint incisions those methods which are specially devised to cause as little injury to the soft parts as possible, and which preserve also the nerve-supply of the muscles by preserving the smaller branches. We must keep in mind the importance of individual muscles and their insertions for the function of the joint. From this point of view some of our methods may well deserve preference.

Lastly, there has been a distinct advance in the mode of preserving the attach-

ments of the ligaments and tendons. König and Tiling introduced the admirable plan of chiselling off these structures along with the bony process or shell of cortical bone to which they are attached. We have to endeavour to spare the cortex of the bone not only for the sake of the epiphysis, but also to save as much of the periosteum as possible, so that now we separate the periosteum along with a superficial layer of bone with a sharp raspatory like the "Rugine" used by Ollier in order to ensure a better preservation of the germinal layer of the periosteum. The preservation of a thin layer of bone leads to more new formation of bone than when the periosteum alone is separated, as is proved by Ollier's researches (see Introduction). We therefore consider that, when it can be conveniently done, the subcortical method of resection is better than Langenbeck's subperiosteal method, or than Ollier's sub-periosteo-subcapsular method; and it may also be pointed out that union occurs more rapidly, and attempts at movement may be made sooner, as tendinous and ligamentous attachments are specially sensitive, and therefore delay the early resumption of active movement which is so important to the production of a good functional result.

The modern method for arthrotomy, osteotomy, and typical excisions which is most to be recommended seems to us to be the following:—

(1) To employ as simple an incision as possible (Langenbeck), care being taken to place it in the intervals not merely between the muscles, ligaments, and tendons, but also the smallest vessels and nerves, and in addition to make use of the neutral zones between the muscles supplied by different nerves.

(2) To detach subcortically the capsule, the periosteum, and the ligamentous and tendinous attachments, and to remove all the diseased bone and diseased soft tissues of the joint but only as much of the articular surfaces and healthy adjacent bone as is necessary in order to obtain a better functional result.

The method employed to open a joint and expose a bone should in no way bind the surgeon as to what his next action is to be. The incision should be equally suited for cases where, after the opening of the joint, nothing further needs to be done, or where part or all of the synovial membrane, or the articular ends of the bones, need to be removed. The first incision remains the same. For all the large joints we have come to employ one type of incision which may be termed the "hooked incision," and which will be described under the individual operations in a subsequent chapter.

The following varieties of operations on joints can be differentiated:—

(1) In arthrotomy, for example, in evacuating an effusion, or in removing a loose body, the incision is carried into the joint cavity through skin, aponeurosis, capsule, and synovial membrane.

(2) In performing arthrectomy the incision is only carried down to the diseased and thickened synovial membrane, which is generally tubercular, and the fibrous capsule is stripped off it, so that the synovial membrane, like a tumour, can be removed in one mass after detaching the visceral layer from the bone as far as the cartilage and removing the underlying tubercular granulations.

(3) In osteoarthrotomy the incision is made right down through the periosteum, the soft parts being then separated subcortically in one flap, and the bone removed in the same way as one shells out a simple tumour.

(4) In osteoarthrectomy, which is a combination of arthrectomy and osteoarthrotomy, the capsule is exposed and entirely cut away, but in addition to this the articular ends of the bones are removed.

Another point to which special attention must be directed is the best method of obtaining a good functional result. Two fundamental conditions are necessary. The first is the preservation of muscles which have the power of contracting, an important point, and one which surgeons often lose sight of in the course of operations. No form of treatment is so injurious as the fatal expectant treatment by which, through want of use, the muscles become atrophied, and the soft tissues dense and inelastic from inflammatory changes. The second point is the formation of a joint in which the ends of the bones are well shaped. How can one expect to

obtain proper movement between the ends of two bones if they are simply sawn straight across, as was formerly the practice? One must, on the contrary, carefully imitate the form of the articular ends in order to provide for the mechanical requirements of certain forms of movement.

(b) Indications and Contraindications

If attention be paid to these points, with strict aseptic precautions, arthrotomy can be undertaken with manifest benefit in the early stages of joint disease, which would otherwise become more serious. Whatever statistics may be brought forward at the present time, even in connection with tubercular inflammations of joints, early and complete exposure of the joint, with thorough removal of the tubercular tissues, combined with the rubbing in of iodoform, is the only means of obtaining a rapid and permanent cure.

It is by no means uncommon to find a caseous focus or sequestrum in the articular end of a bone during the earliest stage of tuberculous disease of the joint, when the main extent of the cartilaginous surfaces are still quite smooth, a focus which would have rendered recovery by conservative measures impossible. The existence of such a focus can only be determined by freely incising the joint, although fortunately in radiography we have now an aid most valuable in the diagnosis.

When we consider the distressing and tedious course that follows non-operative treatment in the various types of simple plastic arthritis and in the proliferative, deformative, and adhesive forms, modern surgery is still far too timid, only a few surgeons being distinctly in favour of arthrotomy. The reason of this timidity lies in the fact that the majority of operators persist in adhering to the older methods of excision. The incisions we suggest here are not intended merely for resections, but also for simply opening into a joint (arthrotomy), for excision of the joint-capsule, articular cartilage (arthrectomy), and also for partial osteotomy or osteo-arthrotomy.

It would be a mistake to recommend early arthrotomy, especially in tubercular cases, without alluding to the contraindications. These refer to the later stages, in which, according to some surgeons, operative interference is first indicated.

We again repeat: A well-executed resection is the only safe method by which a permanent and complete radical cure of a tuberculous joint can be obtained in a short space of time. We have never yet resected a joint "cured" by injection, even by the celebrated iodoform injection with or without prolonged fixation, without detecting tuberculous and caseous foci as well as cicatricial processes, often extensive, in the synovial membrane, in the dense tissues with which it is covered, or in the bone. It is all the more necessary to be familiar with the conditions which must be regarded as contraindications to these important operations.

Of the local conditions which may interfere with the success of a resection in a tuberculous case, mixed infection with suppuration and fistulæ is of the first consideration. In every case where there is a sinus, mixed infection (especially staphylococcal) is certain to be present. Resection is only to be recommended in cases in which one is sure of being able to remove all the diseased tissues together. The unfavourable statistics of resection in pre-antiseptic and semi-aseptic days attest the seriousness of the operation under these conditions.

If resection is to be undertaken, the sinus must, first of all, be opened up with the thermo-cautery and irrigated with very hot saline solution (42° C.). The exposed tissues must then be disinfected, a result which is most satisfactorily attained by means of the thermo-cautery. Where this method is not practicable the surfaces of the synovial membrane and of the bone should be swabbed over with 50-85 per cent alcohol, after which the resection can be performed under irrigation with very hot saline lotion. The after-treatment must then, without exception, be carried out by antiseptic packing and secondary suture.

The second great contraindication to resection is afforded by anything which may lead to the production of acute miliary tuberculosis. The latter condition occurs most

commonly in cases of general caseous suppurative inflammation of the joint, where the pus cannot be prevented from coming in contact with the fresh wound surfaces, especially if para- and peri-articular abscesses have to be dealt with simultaneously. Those individuals who show evidence of active tuberculosis in other organs are most susceptible, in which cases there is generally a rise of temperature shortly after the operation quite unconnected with the state of the wound, the pulse being accelerated, with some dyspnœa, a sense of heaviness, irritability, and a slight amount of albuminuria, while death may ensue from serous or tuberculous meningitis.

We might with advantage further mention among the contraindications two dangers associated with arthrotomy and resection, namely, the chance of paralysis from the use of Esmarch's tourniquet, and also the risk connected with spinal analgesia. Paralysis following the use of Esmarch's tourniquet is a by no means uncommon result of over-anxiety regarding the prevention of hæmorrhage. No doubt it is very agreeable to be unembarrassed by bleeding, to be able to determine the exact condition of the soft parts as well as the bone, and to remove deliberately all the disease, and also in the case of tuberculous individuals to avoid hæmorrhage. But great care must be taken to guard against causing paralysis, which is particularly apt to occur if the operation is of a prolonged nature, apart from application of the tourniquet too tightly or at an unsuitable position, *e.g.* the musculo-spiral nerve in the upper arm. Not long ago a case of complete paralysis of the arm after an operation lasting an hour and a half came under our notice, and the surgeon was completely nonplussed by the explanation of the resulting condition.

Esmarch's bandage has the further disadvantage that its use is frequently attended by subsequent hæmorrhage, which retards the healing of the wound even though it be only parenchymatous in its nature. If a tourniquet therefore is used, it must not be applied too soon and should be removed as early as possible, while in many cases its application can be dispensed with altogether.

Spinal analgesia which is frequently recommended for tuberculous disease in the lower extremity is not always free from adverse criticism. We regard Bier's spinal injections as unsuitable for tuberculous cases, and have on two occasions observed tuberculous meningitis follow a recourse to this method of producing anæsthesia. The slightest irritation of the meninges must always be avoided in these cases.

(c) After-Treatment

To obtain the most satisfactory results from arthrotomy the strictest asepsis must be maintained during, as well as after, the operation. The aversion that many surgeons have to opening tubercular joints is to a considerable extent due to inability to secure primary union.

We prefer to wear rubber gloves in operations on joints, although in other cases, *e.g.* in our thyroid operations, we dispense with their use. Notwithstanding the greatest care post-operative oozing cannot be avoided in these cases, and the growth of any organisms which may be introduced into the wound during the operation is thus facilitated.

Every precaution must therefore be taken to prevent decomposition of blood-clot in all cavities left in a bone or joint. This is attained (1) by rubbing in iodoform powder previously disinfected in sublimate lotion, or by filling the cavity with Mosetig's iodoform paste (*vide* Introduction to this section). (2) By preventing the occurrence of further hæmorrhage by fixing the parts in splints or plaster for the first eight days.

We employ plaster bandages very extensively, and always in joints such as the knee and ankle where ankylosis is the object in view after resection. If their application is difficult as in the hip and shoulder, weight extension will prove sufficient. In the case of the elbow and wrist, splints (especially the wire variety) may be used with advantage. The ends of the bones must be securely fixed in position, more especially in the case of the knee and ankle. This can be attained by making the cut end of the

femur convex or angled (Tavel) and the corresponding surface of the tibia concave. In the case of the ankle the tibia and malleoli are fitted in a similar manner into the astragalus or os calcis.

(3) By the thorough removal of wound secretions by employing drainage for a longer time than is necessary in other wounds, drainage tubes being often left in joints for eight days instead of twenty-four hours. This, however, introduces a risk of delayed infection. The drainage openings must therefore be well covered with antiseptic dressings so that decomposition of the blood in the dressings themselves may be prevented.

A thick layer of iodoform gauze, previously disinfected in 5 per cent carbolic lotion, forms the best dressing, and over it several layers of freshly-prepared corrosive sublimate gauze should be placed and changed at first every few hours and later two or three times a day.

In spite of this, drainage of blood from the raw ends of the bone is not always sufficiently complete, and the reparatory processes by which the ends of the bone are smoothed and on which the disappearance of tenderness depends, may be interfered with, while the resumption of movement is also delayed.

To obtain this result with rapidity we have frequently adopted a procedure which may be termed "the dislocation or secondary reposition method." In the elbow and hip, for example, after resecting the ends of the bones we bring them into a dislocated position, so that the sensitive sawn ends of the bones are merely in contact with the soft parts, and after ten to fourteen days, when the skin incision is quite healed, they can be easily replaced in proper position. The patient then begins at once to move the limb, which by the usual method he is quite unable to manage, in spite of every effort and desire. If a movable joint is required, as in the elbow and hip, it is essential, too, that the movements of the muscles should be commenced early, if the function of the joint is to be restored in a short space of time. By means of an apparatus provided with the means of elastic flexion and extension, while the axis of movement is maintained, the treatment is greatly assisted.

If one is sure that the joint cavity is thoroughly dry, and all the recesses have been filled with iodoform paste, the wound may be completely closed by stitching up the capsule, muscles, fascia and skin, primary union being readily obtained.

If arthrotomy or osteoarthrotomy is undertaken for arthrodesis (Albert) *i.e.* to ankylose a loose or flail joint, the joint must be efficiently immobilized from the beginning of the operation with rigid dressings even in the case of the shoulder, elbow, and hip.

With regard to the knee, wrist, or ankle, we do not generally aim in the first place at obtaining a movable joint, but prefer an attempt to secure good solid union, so that the mobility of the peripheral parts may be better maintained. This is of special importance in the case of the foot and still more in that of the hand. With the hand securely fixed on our dorsiflexed splint, the patient recovers the movements of the fingers in the shortest possible time.

After resection of the knee the patient may be allowed to leave his bed in a fortnight, the limb being immobilized in plaster of Paris in the fully extended position.

In regard to obtaining subsequent mobility of a joint mention must be made of the method of preventing adhesions by the interposition of a foreign body between the ends of the joint. A portion of the joint capsule, tendon, or muscle has been utilised for this purpose (the interposition operation).

Arthroplasty has recently been carefully investigated by Murphy,[1] who has come to the conclusion that in order to establish movement in a stiff joint, the best method is to detach and interpose a flap consisting of fascia, muscle, and a superficial layer of fat. For example, in the case of the knee, after the adhesions have been separated, a flap, the free border of which is directed upwards and the base below, is withdrawn from the fascia lata with a subjacent layer of the vastus externus muscle and a superficial layer of fat. The flap is rotated so that the condyles of the femur are covered, after which it is sutured in position. The same process may be repeated at the hip,

[1] *Journal of the Amer. Med. Assoc.*, May, June, 1905.

the results often proving very satisfactory. Hofmann (Graz) has interposed a layer of periosteum over the raw ends of the bone with equally good results. In ankylosis of the elbow-joint a portion of periosteum can be removed from the tibia and applied over the raw end of the bone.

(d) Operations on the Foot

1. Resection of the Phalanges and Metatarsal Bones. *Vide* Fig. 140.

2. Resection for Hallux Valgus. We have invariably obtained satisfactory results by chiselling off the inner half of the head of the first metatarsal bone, the projection which makes adduction of the toe an impossibility. An incision is made down to the head of the bone on the dorsal aspect, the joint capsule is opened, and the projecting portion of the head is chiselled off at the point where the curved articular surface joins the internal condyle of the metatarsal.

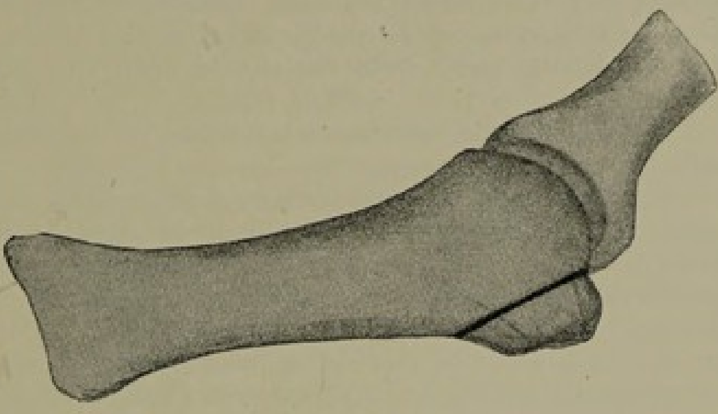


FIG. 140.

We can confirm Riedel's statement that the first metatarsal becomes curved, *i.e.* the anterior portion becomes adducted, owing to the pressure exerted by the outward displaced great toe. If, therefore, a wedge of bone is removed behind the head with its base on the inner aspect as is recommended by Reverdin, this adduction will become more marked.

3. Osteoarthrectomy at the Tarso-Metatarsal Joint and Anterior Tarsectomy. This is a very important operation in infective diseases (especially tuberculous) of the anterior tarsal joints, because the cavities of the majority of the joints are in communication with one another. Separate synovial cavities are most frequently found at the joint between the first metatarsal and internal cuneiform, at the anterior and posterior surfaces of the cuboid, between the head of the astragalus and the scaphoid, and lastly between the astragalus and os calcis (Fig. 141). In tubercular ostitis, which frequently begins in the bases of the metatarsal bones, excision of the bases and of the articular surfaces of the adjacent cuneiforms and cuboid is occasionally sufficient (tarso-metatarsal resection). When, however, the tarso-metatarsal joints are involved, it is safer to excise the scaphoid as well as the bones above mentioned. If the disease is still more diffuse the articular surfaces of the astragalus and os calcis must also be removed.

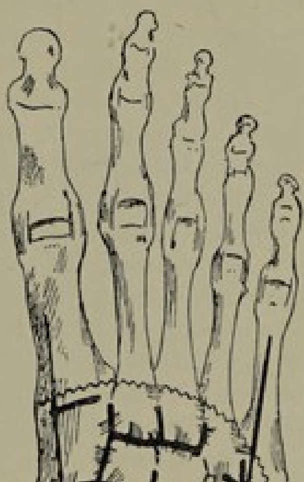


FIG. 141.—Excision of the anterior tarsus (usual arrangement of the synovial cavities).

The excision is performed by means of two dorso-lateral incisions (Fig. 141). The internal incision extends from the posterior third of the first metatarsal backwards as far as the inner aspect of the head of the astragalus, which is brought into view by abducting the foot. The posterior part of the incision divides the skin only, so as to avoid opening the part of the ankle-joint which projects forwards on to the neck of the astragalus. Beginning

internal to the extensor tendons of the great toe, the incision divides the attachment of the tibialis anticus to the first metatarsal and internal cuneiform, and exposes the dorsal surfaces of the cuneiform and scaphoid bones. The under surfaces of those bones are now laid bare, the tendon of the tibialis posticus lying posteriorly and inferiorly.

The external incision, which is placed external to the extensor tendons, extends from the posterior third of the fifth metatarsal to the upper surface of the os calcis in front of the external malleolus. The tendon of the peroneus tertius is separated from its insertion into the base of the fifth metatarsal, and the dorsal aspects of the cuboid and outer metatarsals are exposed. To lay bare the under surfaces of these bones, the tendons of the peroneus brevis and longus must be separated and drawn backwards, the latter from the groove upon the outer and under surfaces of the cuboid.

The bases of the metatarsal bones and the articular surfaces of the astragalus and os calcis are now removed.

In severe cases, especially where abscesses and advanced disease in the soft parts exist on the dorsum of the foot, it is advisable to join the two lateral incisions in front by means of a transverse one, *i.e.* to make a dorsal flap, but only through the skin and fascia so as to preserve the tendons, nerves, and vessels, which can be easily retracted to allow of the bones being dealt with. If the dorsal flap is made down to the bone so as to include the tendons, vessels, and nerves, the operation becomes unnecessarily severe, and the subsequent suturing of the tendons is tedious. It is only done when there is disease of the soft parts. The division of the tendons is not of so much importance as they become too long and must be shortened. In the last case on which we operated by means of a dorsal flap an extremely useful and movable foot was the result.

Obalinski and Catterina, in a modified form, have suggested a new method of performing anterior tarsectomy, by splitting the foot antero-posteriorly through the interspace between the second and third metatarsals, according to Catterina, and drawing asunder its two anterior portions, care being taken not to injure the plantar arch and the external plantar nerve.

The shortened foot is extremely useful both for support and movement.

4. Osteo-Arthrectomy at the Mid-Tarsal Joint. This operation is most frequently performed in the form of a cuneiform excision in talipes varus. This wedge-shaped excision gives excellent results, especially in old-standing club-foot. Indeed, if the resection is sufficiently extensive, the results are better than by any other method of operation.

The incision is begun over the dorsal aspect of the astragalo-scaphoid joint, passing obliquely downwards and backwards towards the outer border of the heel (*vide* Fig. 142). The musculo-cutaneous nerve is seen lying upon the fascia at the upper angle of the wound, while the short saphenous nerve appears at its lower angle: these nerves are drawn aside, and one or two veins are seized and twisted. After division of the fascia, the tendon of the peroneus tertius appears at the upper end of the wound, while at its lower part are the peronei tendons in contact with the outer surface of the os calcis. After their sheaths have been slit up the tendons are drawn aside with blunt hooks. The capsule is divided over the head of the astragalus, and the joint opened. The attachment of the capsule is then separated from the neck of the astragalus as far as the groove on its under surface (*vide* Fig. 143). After exposing and drawing downwards the upper border of the extensor brevis digitorum the calcaneo-cuboid joint is opened (*vide* Fig. 144). The neck of the astragalus and the greater process of the os calcis are now divided with a chisel, and drawn well out of the wound with a sharp double hook, so that they may be completely freed from their ligamentous connections and removed. In order that the foot may be dorsiflexed to less than a right angle by firmly pressing together the osseous surfaces, it is necessary, in aggravated cases of club-foot, to shell out the whole of the scaphoid and to chisel off a portion of the cuboid. The introduction of a drainage tube is not necessary, as there is no cavity remaining, and no secondary hæmorrhage is to be anticipated. The

wound is closed by a continuous suture. The foot is kept dorsiflexed and the knee bent by means of a plaster of Paris bandage, which extends upwards beyond the knee. To ensure a satisfactory result it is generally necessary to elongate the tendo Achillis.

The important points to be attended to in order to attain this end are, to obtain primary healing, to see that the foot is capable of being flexed to less than a right angle, and to prevent any tendency to talipes equinus by tenotomy of the tendo Achillis.

5. **Excision of the Scaphoid.** Apart from a localised tuberculous affection of the scaphoid which is of rare occurrence, removal of the scaphoid is undertaken in certain forms of flat-foot and talipes valgus. The shape of the foot is greatly improved, and at the same time the arch is reconstructed. The operation, which is not difficult to perform, is carried out by means of a longitudinal incision on the dorsum, followed by subcortical and subcapsular freeing of the bone, which is then removed with a strong elevator.

6. **Arthrotomy at Chopart's Joint.**

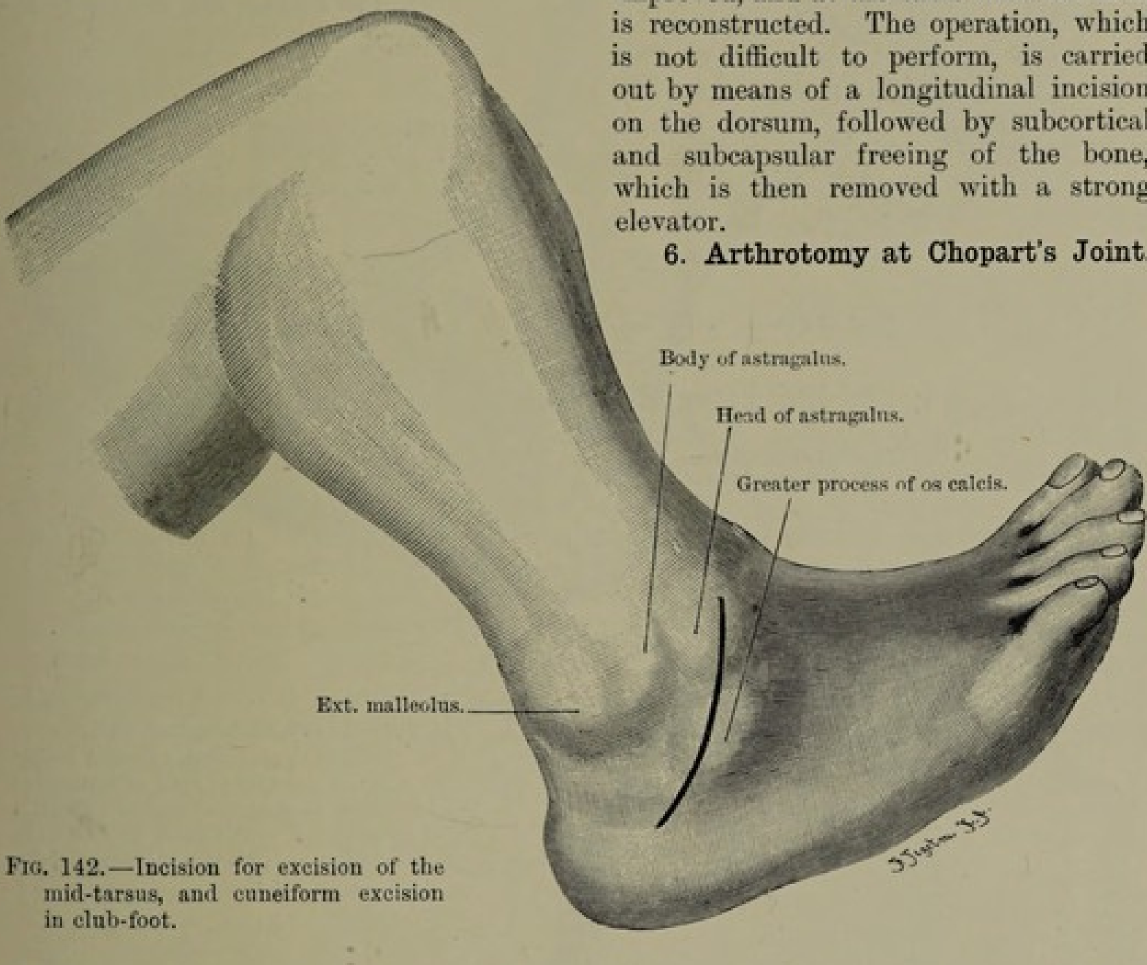


Fig. 142.—Incision for excision of the mid-tarsus, and cuneiform excision in club-foot.

For the correction of club-foot Phelps has recommended transverse division of all the contracted soft parts in the sole down to the bone, the main feature of the operation consisting in the division of the capsule between the head of the astragalus and the navicular, a method, however, more simply undertaken through a longitudinal incision along the inner border of the foot above the abductor hallucis muscle.

7. **Excision of the Astragalus.** It is unnecessary to give a special description of excision of each of the smaller tarsal bones, as these are operations which are seldom called for. Excision of the astragalus and os calcis, however, is often necessary in tuberculosis, in injury, and in club-foot, the two latter conditions calling especially for excision of the astragalus.

It suffices as a rule to make a free longitudinal incision upon the antero-external aspect of the ankle, as described by Vogt for excision of the ankle-joint. This incision begins a hand-breadth above the ankle at the anterior surface of the fibula, and extends downwards to the outer side of the extensor tendons (peroneus tertius) and the branches of the musculo-cutaneous nerve, over the outer surface of the astragalus to the tuberosity at the base of the fifth metatarsal bone. The incision

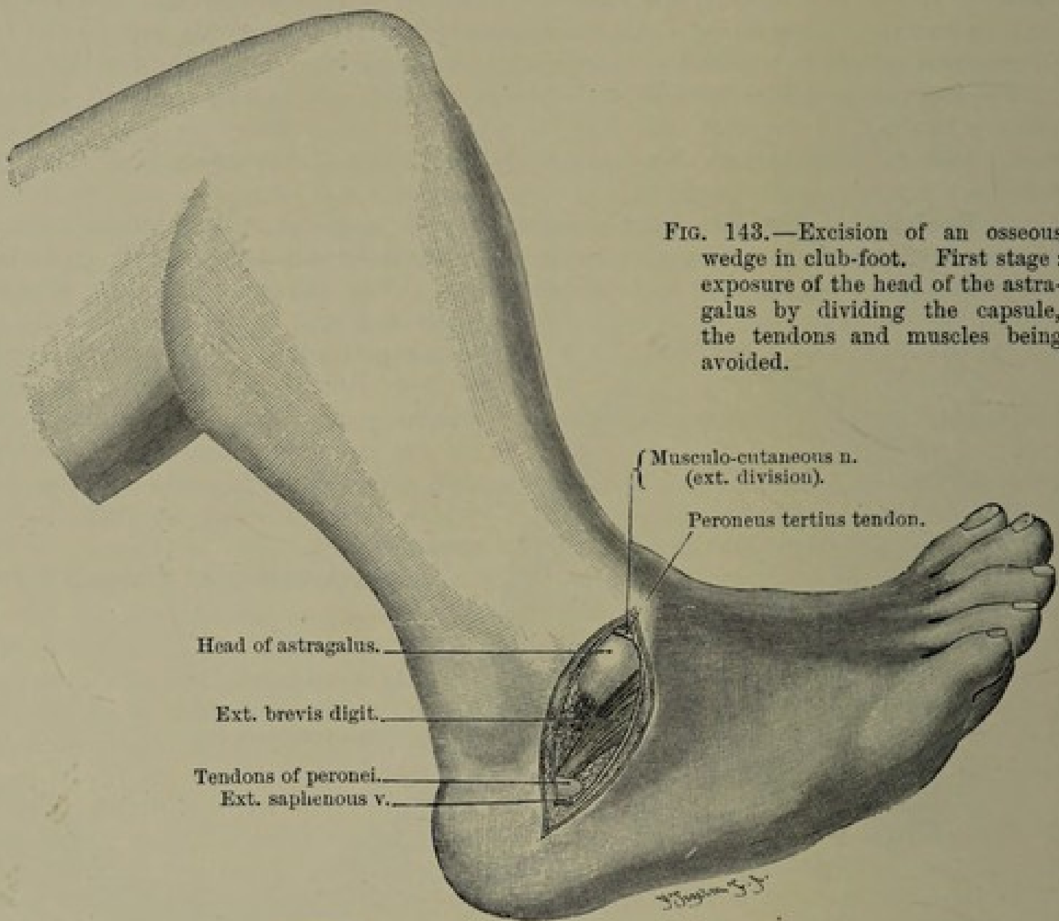


Fig. 143.—Excision of an osseous wedge in club-foot. First stage: exposure of the head of the astragalus by dividing the capsule, the tendons and muscles being avoided.

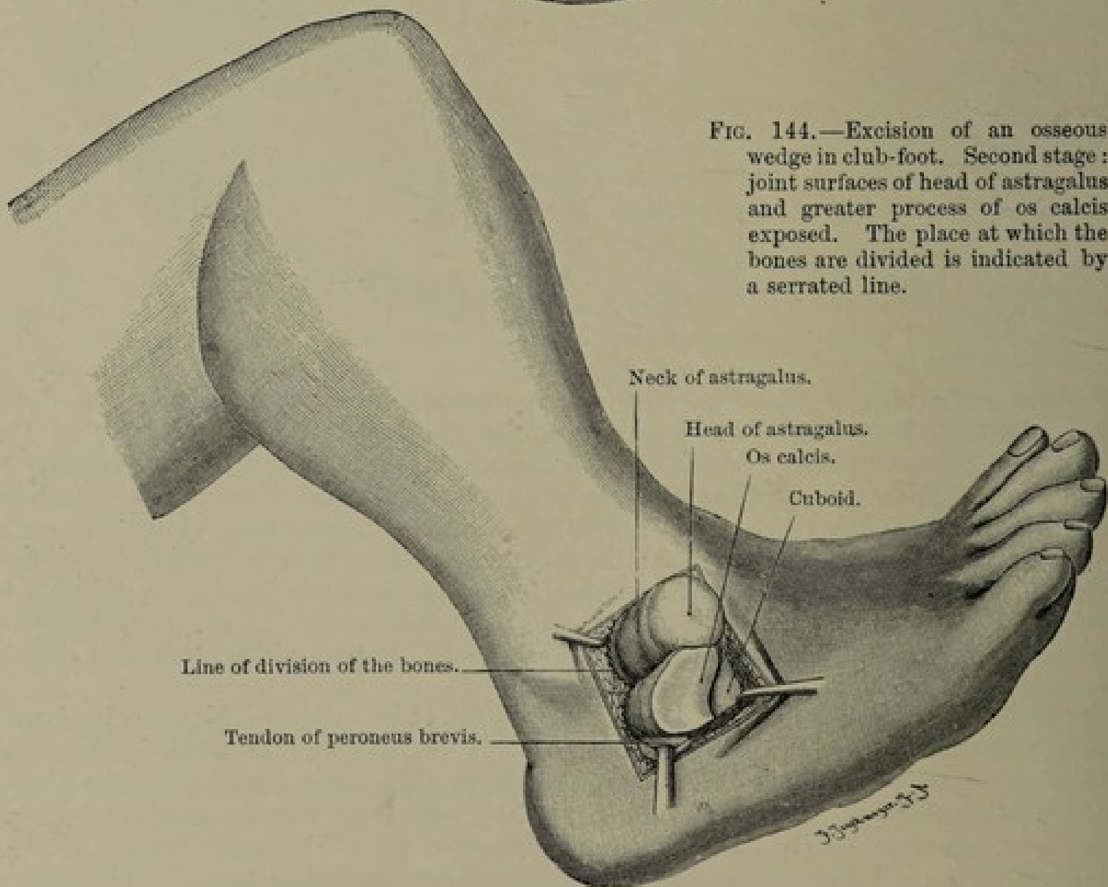


Fig. 144.—Excision of an osseous wedge in club-foot. Second stage: joint surfaces of head of astragalus and greater process of os calcis exposed. The place at which the bones are divided is indicated by a serrated line.

enters the ankle and mid-tarsal (Chopart's) joints, exposing the body and head of the astragalus. The capsule of the joint is thoroughly separated from the neck of the astragalus, and the strong interosseous calcaneo-astragaloid ligament is divided. The capsule is also separated along the anterior borders of the lower ends of the tibia and

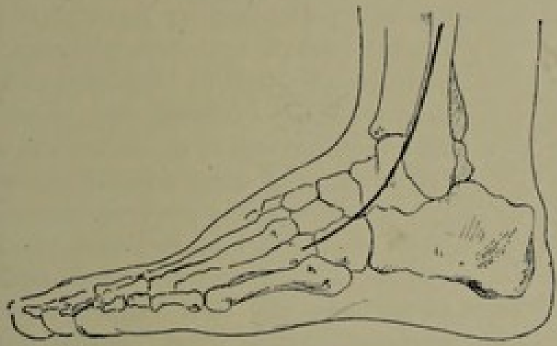


Fig. 145.—Excision of the astragalus (external incision).

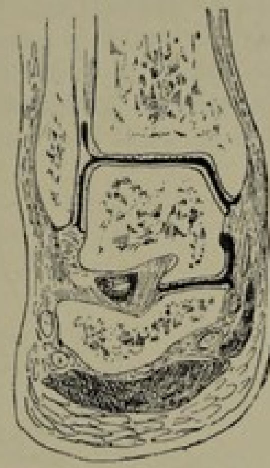


Fig. 146.—Coronal section through the ankle-joint (Henle).

fibula, and the anterior and posterior bands of the external lateral ligament of the ankle-joint are divided at the anterior and posterior surfaces of the body of the astragalus. The ligamentous connection with the os calcis is detached externally and along the posterior border of the astragalus. By forcible inversion of the foot, the astragalus is now raised to such an extent that an elevator can be introduced under it so as to divide the ligamentous attachments upon the inner aspect.

Astragalectomy, which is recommended for club-foot by Bessel-Hagen, ensures an excellent position of the foot if the external malleolus is at the same time shortened. The functional result, however, is not quite satisfactory, owing to the incongruity of the surfaces of the tibia and os calcis.

8. Excision of the Os Calcis. A longitudinal incision is made descending along the inner aspect of the tendo Achillis to the lower and hindermost part of the greater tuberosity of the os calcis, and from thence transversely around the heel, and forwards along its outer aspect to the tuberosity at the base of the fifth metatarsal bone. This gives sufficient room when the soft parts are flexible.

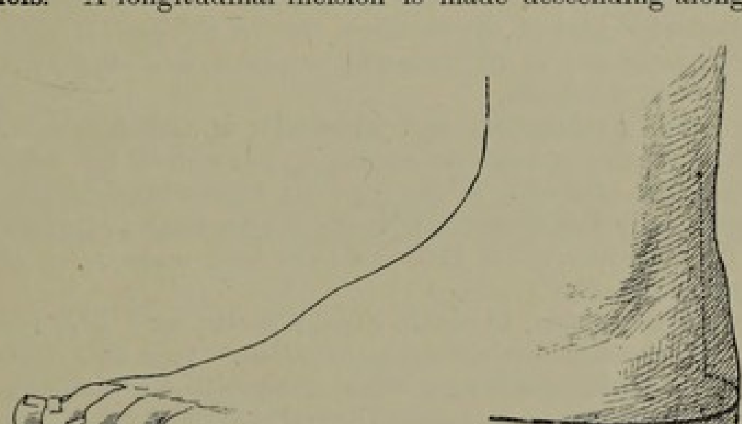


Fig. 147.—Excision of os calcis.

The tendo Achillis is detached from the posterior surface of the tuberosity; and the joint-capsule at the posterior and outer aspect of the os calcis, together with the calcaneo-fibular band of the external lateral ligament, is divided. After the peroneal tendons have been drawn upwards, the interosseous calcaneo-astragaloid ligament is cut across, and the dorsal and plantar calcaneo-cuboid ligaments are detached from the external and plantar aspects of the os calcis. The point of the heel is now well drawn over to the inner side so as to expose the tendon of the tibialis posticus, which is then displaced upwards over the

sustentaculum tali. Lastly, the os calcis is seized with a strong pair of forceps, and the internal lateral ligament of the ankle-joint, the subjacent calcaneo-astragaloid capsule, and (anteriorly) the ligaments connecting the tibia with the scaphoid and os calcis are detached.

Landerer recommends a mesial longitudinal incision extending from the tendo Achillis over the heel into the sole of the foot. By this incision he removes not only the os calcis, but, if necessary, all the other bones of the tarsus. He asserts that the scar does not in any way interfere with walking.

9. Astragalo-Calcanean Arthrectomy and Posterior Tarsectomy. Excision of the joint between the astragalus and os calcis was performed by Annandale by two lateral curved incisions, although it can also be effected by the method above described for excising the os calcis, or by a modification of the following method for excision of the posterior tarsus.

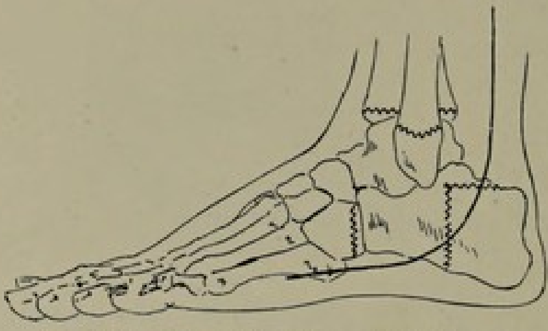


FIG. 148.—Resection of the posterior tarsus (Kocher).

Excision of the posterior tarsus—that is to say, the simultaneous removal of the astragalus and os calcis, and sometimes also of the adjacent articular surfaces—gives good results with the foot maintained in its normal position, because the leg passes down into the defect (Kocher, Kummer).

In the method which we recommend it is a necessary condition that there should be a possibility of preserving the tendons and muscles (peronei, tibialis anticus, and posticus) which move the foot.

The incision beginning upon the outer aspect of the tendo Achillis, a hand-breadth above the ankle-joint, is continued downwards behind the external malleolus and the peronei tendons, and thence forwards to the tuberosity at the base of the fifth metatarsal bone. After we have opened the sheaths of the peronei tendons and displaced the latter forwards, as has been described in excision of the astragalus and os calcis, these two bones are removed, and the articular surfaces of the bones of the leg and of the cuboid and scaphoid are sawn off. It is desirable to retain some of the external malleolus, so that the peroneal tendons may hook round behind it. If the posterior part of the os calcis can be retained, it may be utilised osteoplastically in the same way as in Pirogoff's amputation of the foot, as indicated by the serrated lines in the figure.

10. Arthrotomy and Resection of the Ankle. Excisions of this joint do not always give satisfactory results, on account of the complexity of the joint, and of the presence of disease in the adjacent astragalo-tarsal joints, together with their bones, especially the os calcis. Hence the constant endeavours to improve the technique of the operation. The incisions have been made upon all aspects of the joint, and in every direction.

The incision, to obtain a good result, must give free access to the ankle-joint and to the astragalo-calcanean articulation. It is still better if it affords an opportunity of examining the tendon sheaths, especially of the peronei.

Vogt makes an antero-lateral longitudinal incision; König and Riedel make bilateral incisions with chiselling off of the malleoli; Meinhardt Schmidt makes the same together with a posterior incision; Hüter, an anterior transverse incision, which had been previously employed by Sabatier, Heyfelder, and Hancock; Liebrecht makes a posterior transverse incision; Wackley and Textor make the same combined with a posterior longitudinal incision; Busch, Hahn, Ssabanejeff, an inferior stirrup-shaped incision with separation of the tuberosity of the os calcis; Moreau, Langenbeck, Ollier, Chauvel, Girard, lateral incisions sometimes along with transverse incisions.

We have modified the curved lateral incision, which we introduced along with Reverdin, in that we place it farther back, extend it higher up the limb, and carry the curve down to the level of the astragalo-calcanean joint, thus giving more room

and allowing of the astragalus being excised if, as often happens, the astragalo-calcanean joint is also diseased. Our incision is therefore analogous to the one first recommended by Albanese on Catterina's initiative, and later by Donenstein (Figs. 149, 150).

The skin and fascia are divided, while the external saphenous vein and nerve, which lie immediately behind the incision, are preserved.

The incision terminates at the tendon of the peroneus tertius and avoids the musculo-cutaneous nerve. The sheaths of the peroneus longus and brevis are then exposed and slit upwards behind the fibula as far as the upper end of the wound. The tendons have to be divided in some cases so as to afford more room, but each is

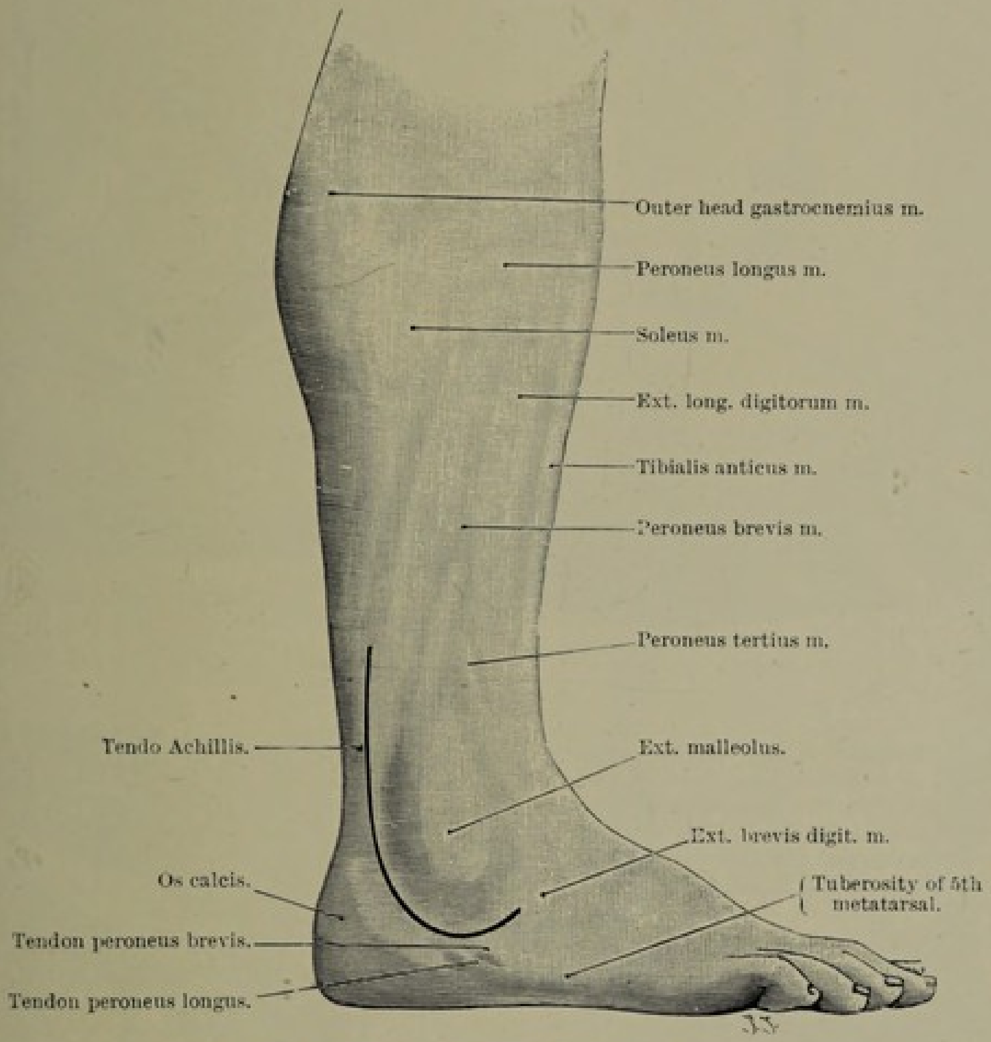


FIG. 149.—Incision for arthrotomy of ankle on right side.

secured with silk in order to be sutured at a later stage. The periosteum is separated from the outer and lower aspect of the external malleolus and the joint opened into in front of it.

The capsule is now detached along the outer surface of the astragalus, exposing it as far as the fibula. The three bands of the external lateral ligament are divided close to their attachment to the tip and inner aspect of the external malleolus.

The capsule, together with the periosteum, is separated from the anterior border of the tibia as far as the internal malleolus, the extensor tendons being hooked upwards, a similar method being adopted at the posterior surface of the fibula so as to leave the tendon sheath of the peronei in relation to the periosteum.

The foot is forcibly dislocated inwards over the internal malleolus, so that the upper surface of the astragalus looks downwards and the sole of the foot upwards, as

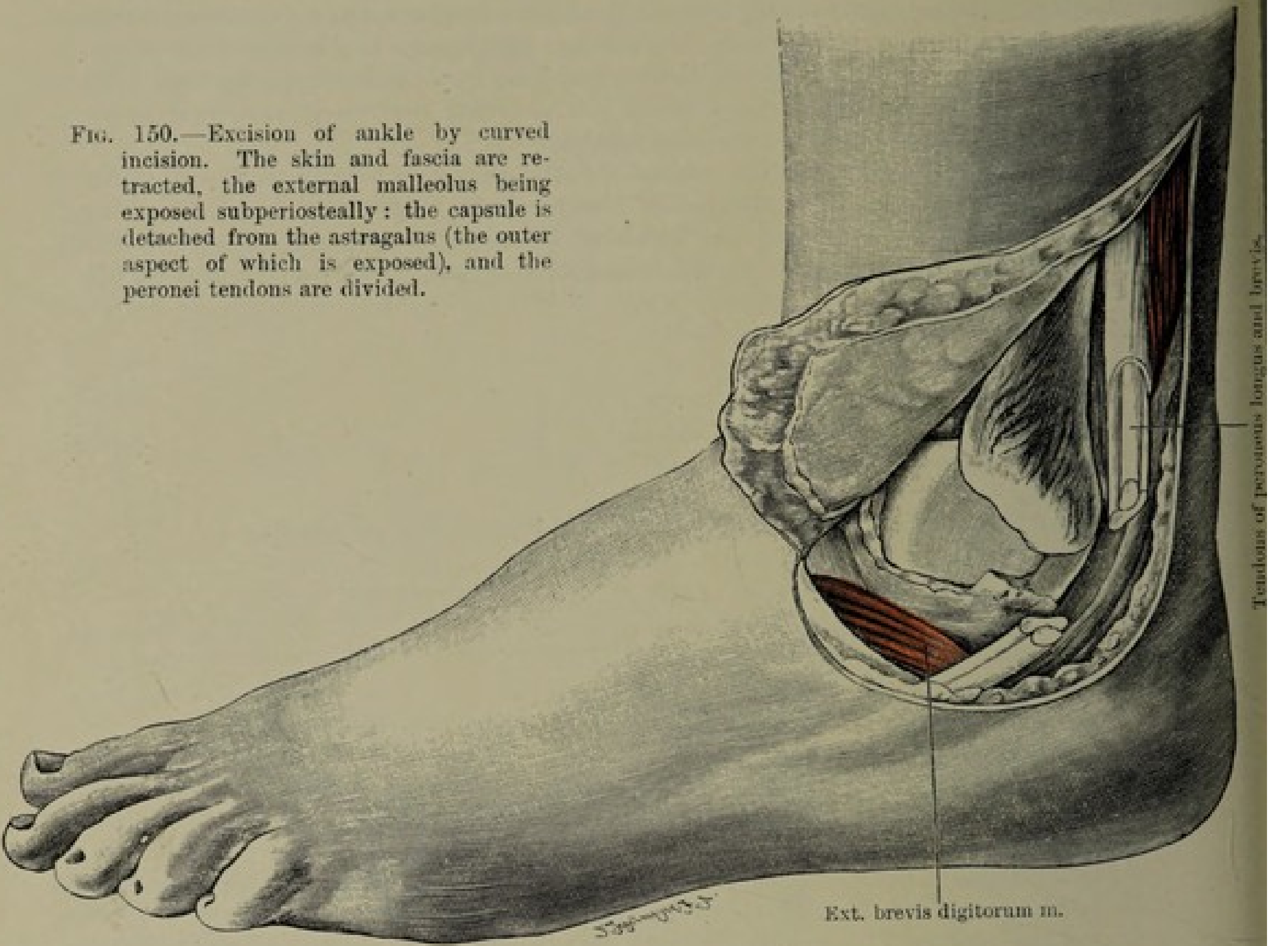


FIG. 150.—Excision of ankle by curved incision. The skin and fascia are retracted, the external malleolus being exposed subperiosteally: the capsule is detached from the astragalus (the outer aspect of which is exposed), and the peronei tendons are divided.

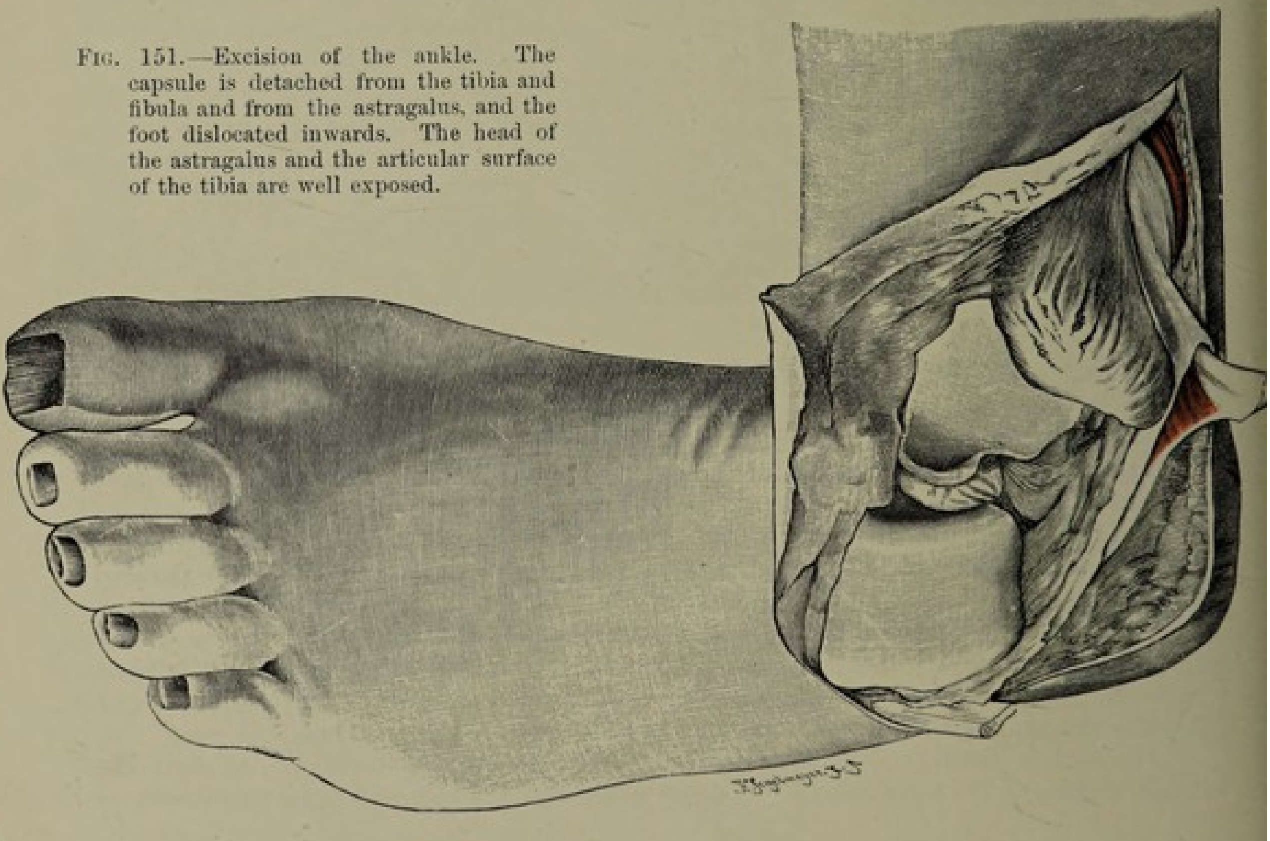


FIG. 151.—Excision of the ankle. The capsule is detached from the tibia and fibula and from the astragalus, and the foot dislocated inwards. The head of the astragalus and the articular surface of the tibia are well exposed.

shown in Fig. 151. If the bone is softened the internal malleolus is not infrequently broken in accomplishing this, but it is just in such cases that this accident entails no injury.

The ankle-joint is now well exposed, and can be thoroughly examined, as also can the tibio-fibular joint; and one can decide if the astragalus and the astragalo-calcanean joint are so involved that removal of the whole astragalus is necessary. In tubercular affections it is often desirable to try this method to ensure the riddance of all the disease, and there are no special difficulties in connection with the operation.

If there is no necessity for excising the astragalus, all that need be done is arthrectomy or excision of the ankle-joint.

The strong internal lateral ligament should be left attached to the tip of the internal malleolus, and should only be divided if the disease be extensive. It should be divided close to the bone, or better, a superficial layer of bone should be taken along with it, as the flexor tendons lie immediately behind the malleolus. The joint can now be easily scraped out and the astragalus removed. If the astragalus is to be retained, the astragalo-calcanean joint should not be opened unnecessarily, an accident which will be avoided by preserving the attachments of the capsule on the posterior and lateral aspects of the astragalus.

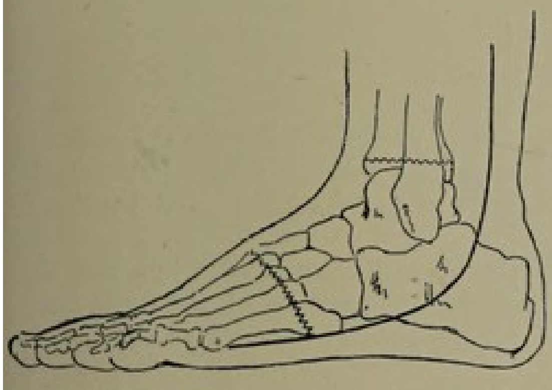


Fig. 152.—Resection of the entire tarsus (Wladimiroff, Mikulicz).

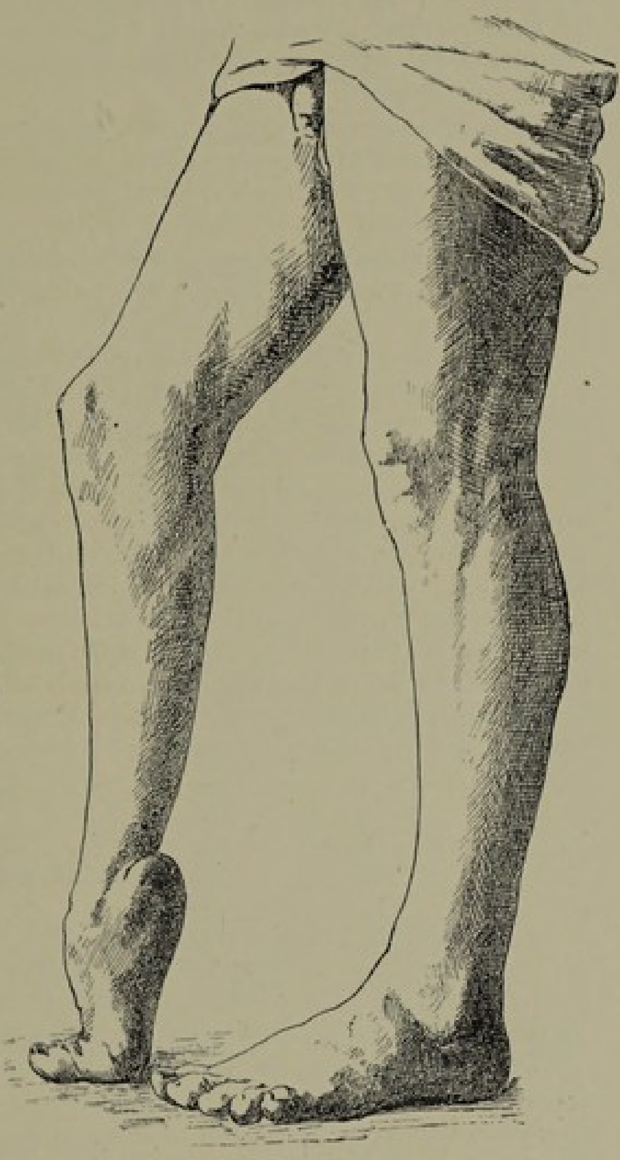


Fig. 153 shows the result after complete resection of the tarsus (from a photograph of a case operated on by the author).

The method above described keeps intact the ligamentous apparatus upon the inner aspect of the joint, as well as the support of the external malleolus upon the outer aspect, and thus provides as far as possible against lateral displacements of the foot.

The after-treatment is of great importance: the foot should be kept at right angles to the leg by means of a plaster of Paris bandage, applied at once, and retained until the wound is thoroughly healed. If the wound heals by first intention the patient can leave his bed in two or three weeks. At a later stage it is advisable to maintain the good position of the foot by means of a Scarpa's shoe.

11. Total Tarsectomy. Wladimiroff and Mikulicz have added to our measures for

preserving the foot by a method of operation which they have employed for disease of the posterior tarsus, a method which we regard as superfluous for disease of the posterior tarsus when the soft parts of the sole and heel can be retained, but one which we consider especially valuable in disease affecting all the bones and joints of the tarsus, as it affords the possibility of obtaining a useful foot. After the entire tarsus has been excised, the sawn bases of the metatarsal bones are applied to the sawn surfaces of the bones of the leg, the foot being brought into a vertical position continuous with the axis of the leg. The patient walks upon the anterior surfaces of the heads of the metatarsal bones, the toes being markedly dorsiflexed. If the scaphoid and cuboid, or the latter and the three cuneiforms, are sawn through, a broader and firmer surface is obtained.

The same principle is applied here as in Pirogoff's amputation, in which the posterior part of the foot is rotated 90° so as to elongate the leg.

As, however, Mikulicz's method presupposes a defect of the skin of the heel, which is an exceptional condition, and in the presence of which the management of the incisions is self-evident, we prefer to describe the method of operation in a typical case, namely, when the disease affects the entire tarsus and leaves an available skin covering.

The incision is just the same as that for excision of the posterior tarsus, namely, a postero-lateral curved incision (Fig. 152), beginning a hand's-breadth above the ankle-joint, and extending downwards behind the external malleolus and peronei tendons, and then forwards to the fifth metatarsal bone. As in the method already described, the bones and joints between the leg and the metatarsus are laid bare by separating the tendo Achillis and periosteum from the os calcis, and by freeing the peronei tendons from their sheaths and drawing them forwards. The insertions of all the long tendons of the foot (peroneus tertius, brevis, and longus) are detached from the upper, outer, and under surfaces of the tarsus respectively, as also are the insertions of the tibialis anticus and posticus from their upper, inner, and under surfaces. In doing this the blood-vessels and nerves are to be preserved.

Lauenstein, in cases where the ankle-joint is stiff, recommends that the boot be fitted with a suitable cylinder sole, the rounded surface being transverse to the axis of the foot.

(e) Operations on the Leg

12. **Supramalleolar Osteotomy**. This operation is performed for the correction of club-foot. The tibia and fibula are divided through an incision which runs from above obliquely downwards and inwards above the internal malleolus, and by this means the adduction of the foot is removed.

The foot, however, then assumes the abducted position that is met with in a Pott's fracture. As there is no real improvement in the ultimate position of the foot, the operation should be restricted to cases in which other methods have failed or in which the deformity has recurred.

13. **Resection of the Lower Third of the Leg**. In the case of extensive disease of the lower third of the bones of the leg, it may be admissible, by means of a very long postero-external incision, to expose and remove a slice of bone from the posterior surface of the os calcis, and to apply its raw surface to the sawn surface of the tibial diaphysis.

Brodnitz has adopted our suggestion with a slight alteration in the direction of the saw cuts. We reproduce in Fig. 154 illustrations of his modification of our methods.

14. **Osteotomy of the Tibia**. This operation, which is frequently undertaken, presents no difficulty, as the inner surface of the tibia is subcutaneous. It is performed after osteomyelitis to remove a sequestrum, a wide gutter-shaped opening being chiselled out on the inner aspect of the tibia through which the focus in the marrow is reached. To fill up the gap in the diaphysis of the tibia it is advisable to

turn the skin from both sides into the cavity so that it may become adherent to the edges of the bone, a process which may be facilitated either by pressure with iodoform gauze or by fixation nails.

Osteotomy of the tibia and fibula is also undertaken in rachitic curvatures. The bone is divided with the chisel without detachment of the periosteum through a small incision along the anterior edge of the tibia (the same operation being performed on the fibula on the outer side) generally below the middle of the bone.

In malunited fractures the operation varies in regard to the individual case. In genu valgum a wedge of bone may be removed on the inner side of the tibia below the epiphyseal cartilage.

The skin and periosteum are divided two fingers'-breadth below the level of the joint in the line of cleavage of the skin, *i.e.* transversely inwards from the tubercle

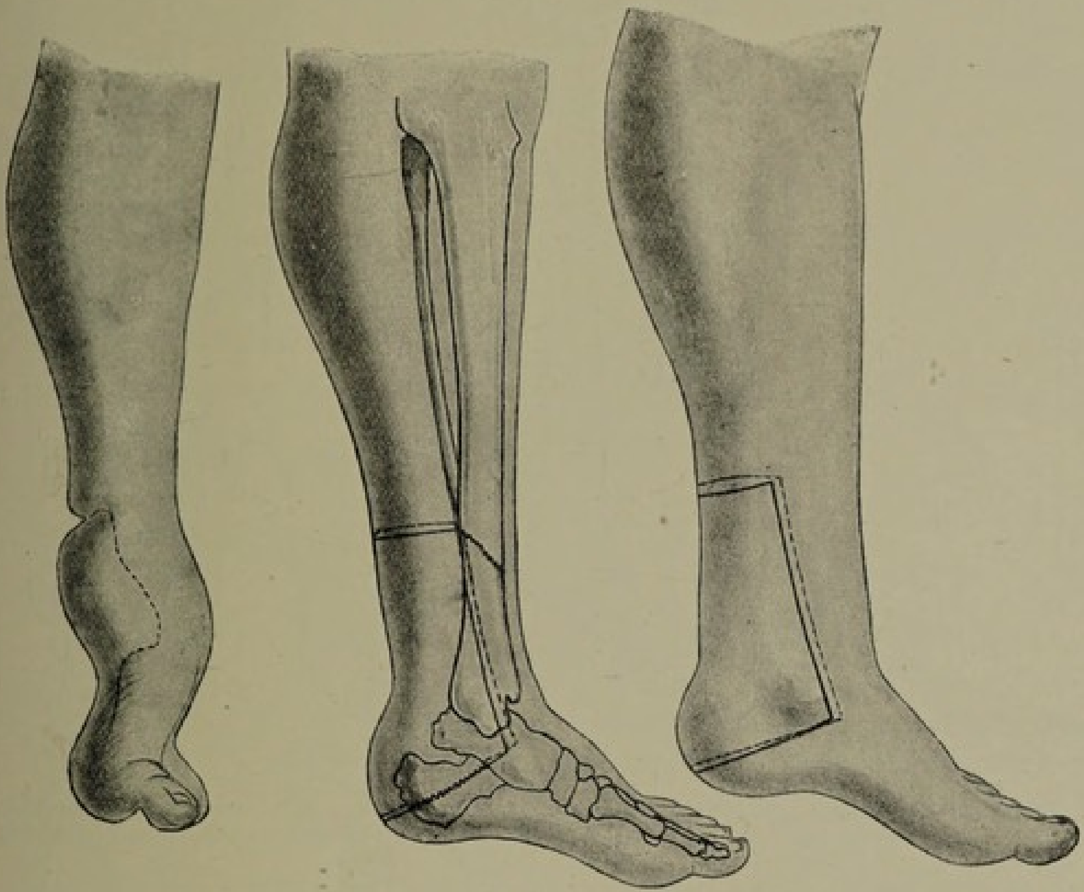


FIG. 154.

of the tibia to the edge of the calf muscles. After separation of the periosteum the chisel is applied in the direction of the skin incision. The attachment of the ligamentum patellæ must not be injured, because the bursa between it and the tibia may communicate with the joint. In an aggravated case of genu valgum it is better to remove a wedge from the tibia having its base directed inwards, otherwise, with the leg in the straight position, there is too great a strain on the head of the fibula, and paralysis of the external popliteal nerve which winds round it may be the result. Luksch (Nicoladoni) prefers to remove a prism of bone from the tibia.

15. Resection of the Tibia. Resection of the tibia may be necessary in acute osteomyelitis with extensive necrosis; or the entire diaphysis may have even to be removed. We have always found that, provided the periosteum is retained and the fibula is preserved as a support, complete regeneration of the tibia is to be expected. Although the upper end of the fibula projects upwards and the leg has a tendency to take the varus position owing to the traction of the new-formed and somewhat

consolidated bony tissue, a perfectly functional joint (capable of bearing weight) is obtained. In cases of total resection of the tibia where it has not been possible to preserve the periosteum, the fibula of the other limb may be transplanted. In an earlier edition we mentioned a case in which this had been successfully accomplished.

16. Resection of the Fibula. The diaphysis, and indeed the entire fibula, may be removed by an incision behind the whole length of the peronei muscles (*e.g.* in the case of a tumour or when it is to be used as a substitute for another bone), without interfering with the supporting power and activity of the limb, or with the movements of the foot in all directions. The external popliteal nerve is to be avoided as it winds round the neck of the fibula, and the peroneal artery is to be borne in mind as it runs down behind the lower half of the fibula.

Fig. 155.—Resection of the lower third of the leg.

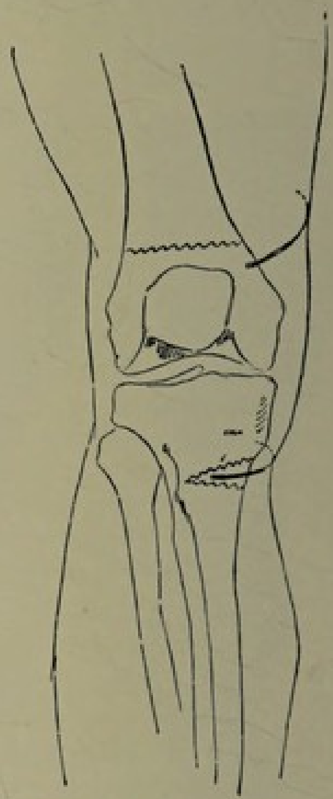


Fig. 156.—Osteotomy of the femur. Cuneiform osteotomy of the tibia.

(f) Operations on the Knee

17. Arthrotomy, Arthrectomy, and Resection at the Knee-Joint. (*a*) *Arthrotomy, and Resection of the Knee* (Figs. 157, 158). We have tested the many methods which have been proposed for freely opening the knee-joint. None of them, however, gives sufficiently free access in so simple a manner as the transverse curved incision with its convexity below. It must, however, be carried as far backwards as to include at least two-thirds of the circumference of the knee. It is not quite clear which surgeon has the merit of having introduced it, as Park appears to have first made the suggestion, and Textor is mentioned as the father of the method. Erichsen, however, has done much to popularise the operation.

Volkmann recommends a horizontal incision through the centre of the patella, while Diakonow (Starkow) divides the patella and the patellar ligament in a vertical direction, and detaches the tibial attachment of the latter together with a shell of bone. Like most mesial incisions it has the advantage of simplicity, and is attended with less injury to neighbouring structures.

We have completely replaced our former method of excision by means of a transverse curved incision by an external slightly J-shaped incision, as after having opened the joint (arthrotomy) it allows one to proceed to whatever extent of resection may be necessary. Apart from the skin incision, our method resembles the subcapsulo-periosteal method in always aiming at entire removal of the diseased tissue; in fact, after excision for diffuse tuberculosis of the knee, the skin is placed in direct contact with the bone. But we always endeavour to keep the quadriceps extensor apparatus intact, so that we may be free to continue the operation in

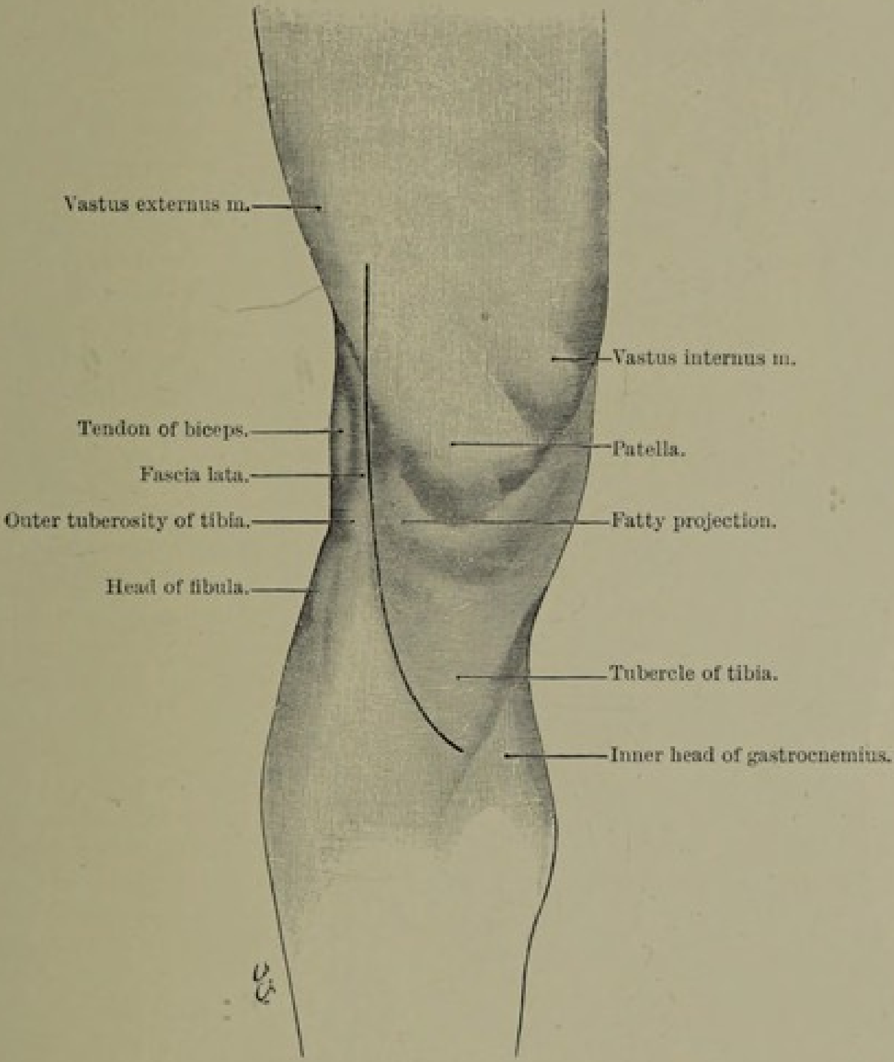
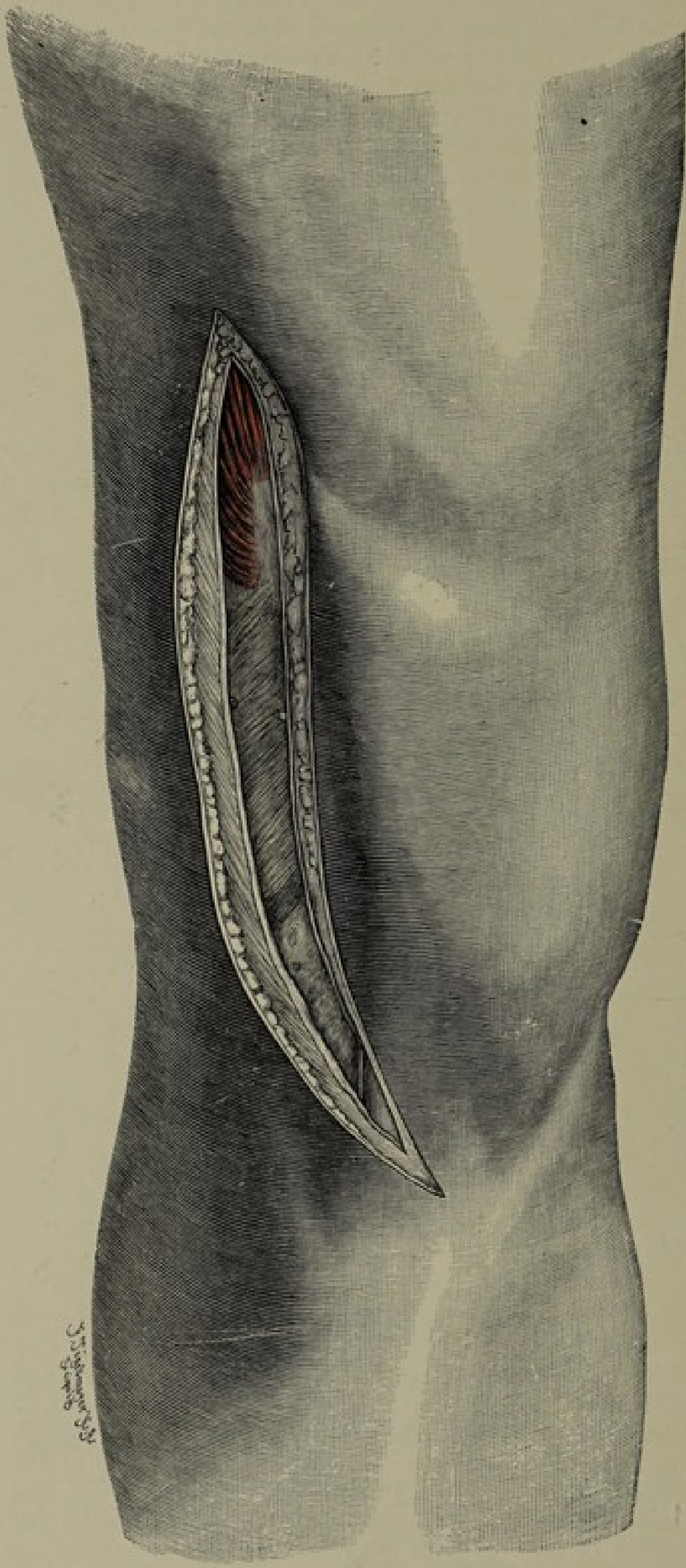


Fig. 157.—Incision for arthrotomy of knee.

whatever direction seems necessary, and our method of excision falls into line with the method of arthrotomy.

Langenbeck has employed a similar incision, but he makes it more curved and places it on the inner side of the joint. It is better, however, to place the incision on the outside, because should the knee give way subsequently it is almost always in the direction of genu valgum. It is important, therefore, that the resistance of the tissues on the inner side should not be diminished by dividing them, and for this reason we maintain that the external incision is preferable. We shall describe our procedure as we are in the habit of performing it on the living subject.

The incision (Figs. 157, 158), which begins over the vastus externus, a hand's-breadth above the upper border of the patella, extends at first vertically downwards a finger's-breadth external to it, and then curves slightly inwards to end at the



anterior border of the tibia just below its tuberosity. After dividing the skin, the dense fascia lata is exposed and divided, its fibres, which run obliquely downwards and forwards, being very thick below. At the upper end of the wound the outer edge of the vastus externus is exposed and divided: below this, are exposed, from above downwards, the outer surface of the capsule, some fatty tissue, and the outer edge of the ligamentum patellæ, which is freed down to the tubercle of the tibia, the latter, along with the ligament and the periosteum of the tibia, being then detached subcortically and retracted inwards.

In the upper part of the wound the capsule of the joint is divided over the outer aspect of the external condyle, and the upper end of the synovial pouch behind the quadriceps is exposed. Lower down, however, one keeps more to the middle line, so that without detaching the capsule from the external semilunar cartilage, the anterior extremity of the latter may be cut away from the tibia, and, along with the capsule, separated from the upper surface of the tibia. The ligamentum patellæ is then pulled to the inner side with a sharp hook, and after dividing the anterior extremity of the internal semilunar cartilage in front of the anterior crucial ligament, the meniscus, along with the capsule and periosteum of the tibia, is detached from the cartilaginous margin of the internal condyle.

FIG. 158.—Arthrotomy of the knee by means of the curved external incision; skin and fascia lata divided, with the vastus externus appearing above, and in the lower end of the wound the capsule, fat, and the outer edge of the ligamentum patellæ.

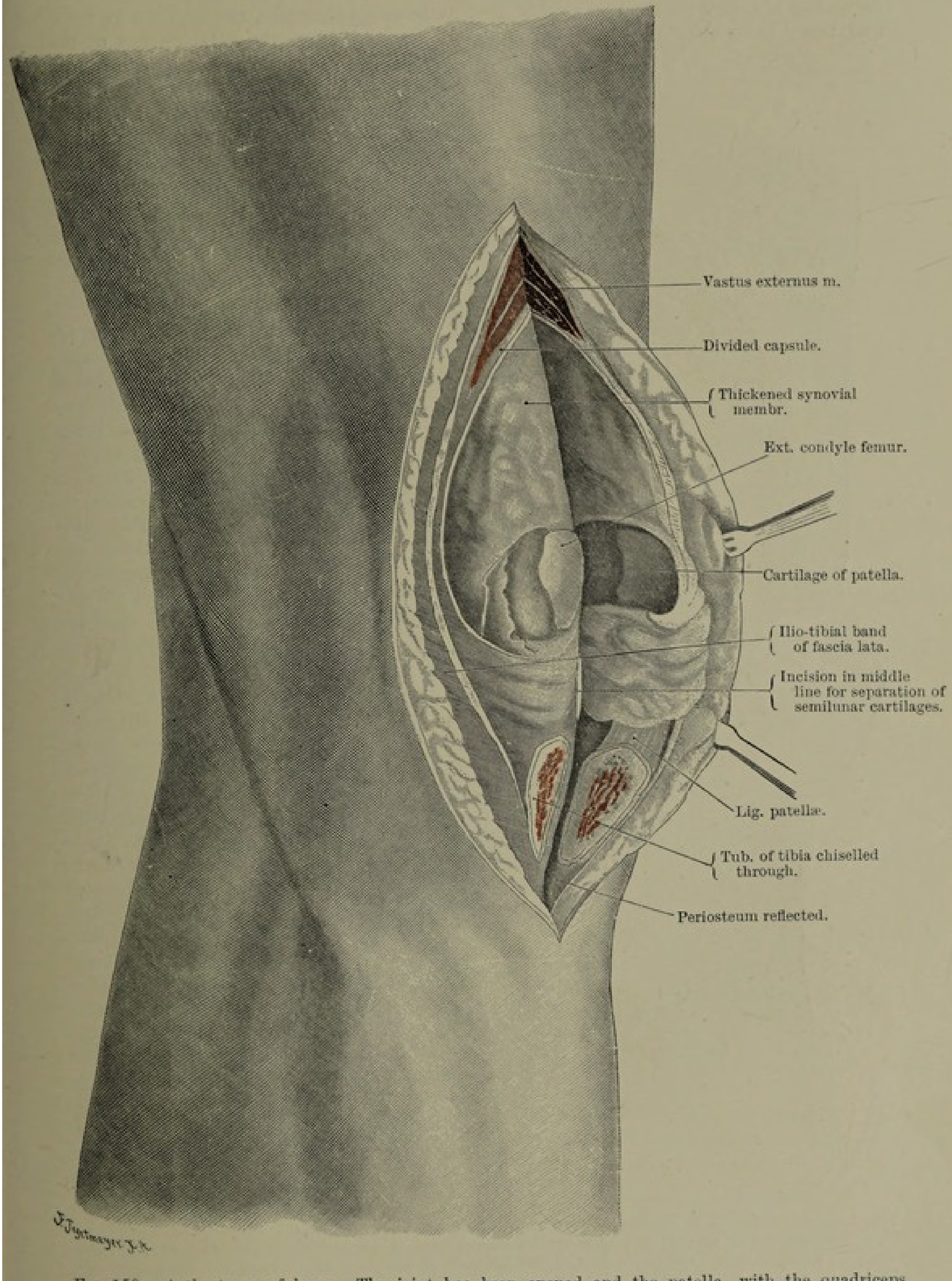
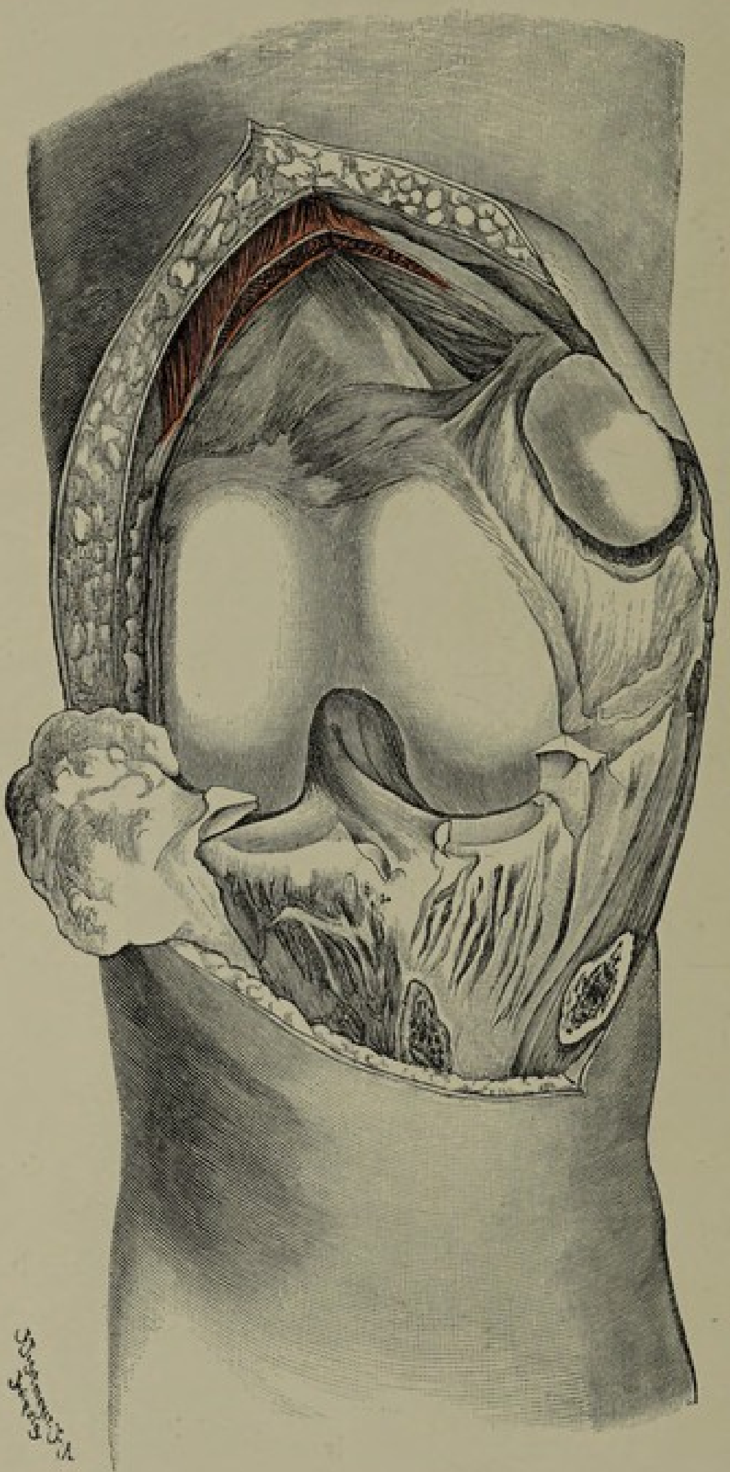


FIG. 159.—Arthrotomy of knee. The joint has been opened and the patella, with the quadriceps tendon and ligamentum patellæ pulled inwards; also the tuberosity of the tibia, which has been chiselled through, and is seen retaining its normal connection with the patellar ligament above and the periosteum below.

The patella should now be dislocated over to the inner side (Fig. 159), and by detaching the capsule from the tibia internally and externally, the leg can be more and more bent, until finally it is completely flexed. Next the attachments of the crucial ligaments are severed from the spine of the tibia (or a piece of bone is detached along with them) as far as the posterior attachments of the semilunar cartilages, which, along with the crucial ligaments, are separated as far as the posterior surface of the tibia (Fig. 160).



If it be necessary to remove the ends of the bones, the upper attachments of the crucial ligaments are separated from the intra-condyloid fossa in such a way that they, along with the semilunar cartilages, retain their connection with the posterior wall of the capsule and the periosteum. Next the capsule is divided at the edge of the cartilage of the femur, and if it is not to be removed it is detached backwards subperiosteally as far as the upper attachments of the lateral ligaments. The femur is now sawn convexly below the level of the separated lateral ligaments, while the tibia, after the capsule and periosteum are separated from its posterior aspect, is sawn in a concave manner.

If the disease extends more deeply into the bones, the lateral ligaments, after chiselling through the epicondyles, are more extensively separated from the bones. In the case of the femur it is especially important, after separation of the periosteum and capsule

Fig. 160.—Arthrotomy of the knee by an external curved incision, giving a complete exposure of the joint. The capsule has been split upwards into the lower muscular fibres of the vastus externus, and downwards as far as the tubercle of the tibia, which has been chiselled off, still retaining its connection with the periosteum below, which is separated for a short distance. The whole of the lower part of the quadriceps apparatus can now be everted and thrown over to the inner side. The anterior attachments of the semilunar cartilages are detached and reflected, the one inwards and the other outwards, each retaining its connection with the capsule.

as far as the epicondyles, to detach these bony processes, together with the lateral

FIG. 161.—Excision of knee. Tubercle of tibia and semilunar cartilages detached as in Fig. 160; the attachments of the lateral ligaments are chiselled off through the epicondyles of the femur, and the crucial ligaments are separated from the intercondyloid notch of the femur and the upper surface of the tibia in continuity with the capsule.

ligaments and tendon-insertions, with hammer and chisel (according to the plan introduced by König for preserving the attachments of the ligaments), and to displace

them backwards, in continuity with the periosteum, as far as the level of the saw line (Fig. 161).

In order to further firm ankylosis by accurate apposition of the bones, the way in which the ends of the bones are sawn off is a most important matter. To avoid forward displacement of the femur upon the tibia, the saw has been directed at all kinds of angles, and a great variety of means of fixing the sawn surfaces has been employed. Nails and sutures have been used. As, however, these often tear out, and do not fulfil their object, Albert, in Vienna, and others, have bevelled the surfaces during the sawing. We have got by far the best results by sawing the femur so as to leave a convex surface, and the tibia so as to produce a corresponding concave surface. This method was recommended by Metzger, and by Fenwick, first in 1871, and later in another publication, where he reports twenty-eight cases in which the functional results were very good. If the operator thoroughly understands how to estimate the direction of the saw, the bony surfaces may be brought into such accurate contact and may be so firmly pressed together that all further artificial means of fixation are quite superfluous, provided, of course, that the limb is firmly fixed to a splint in the fully-extended position.[1] Sawing the femur in a curved direction has the further advantage of more certainly avoiding the epiphyseal line, a matter of great importance as regards the future growth of the femur. After adapting the two sawn surfaces to one another, all that we require is to introduce a suture which penetrates deeply through the skin and fascia, drainage tubes being inserted through special openings. By this plan, just as in simple wounds of the soft parts, we have of late years obtained complete union by first intention in numerous cases, so that after eight to fourteen days the patient can get up either in the plaster case applied after the operation, or the limb may be immobilised in a special water-glass bandage. The patient is able to stand on the leg six weeks after the operation. In those cases in which, on account of suppuration or other local infection, open-wound treatment must be employed, the ends of the bones cannot be fixed together by making curved sawn surfaces. In such cases it is well to retain the extensor apparatus.

(*b*) *Arthrectomy of the Knee-Joint.* Arthrectomy of the knee-joint by means of the external incision differs from the other methods in that the diseased capsule is laid bare as far as possible from the outer aspect: the incision, the subcortical separation of the crucial and lateral ligaments, the detachment of the epicondyles, the separation of the semilunar cartilages, together with the spine of the tibia, are the same.[2]

If the capsule is so diseased throughout that one is certain beforehand (*e.g.* in tuberculous synovitis and arthritis) that it must be removed *in toto*, whether a resection of the ends of the bones may require to be done in addition or not, one proceeds as follows:—

After the skin incision, a portion of the vastus externus and the fascia lata are divided (Fig. 158), the attachment of the patellar ligament is separated, the capsule of the joint is not cut into, but its outer surface is exposed over its entire upper and lower extent, and the visceral layer separated from the bones, which in the case of the femur may be easily done right up to the edge of the articular cartilage, as the pouch behind the quadriceps is separated from the bone by a distinct layer of fat.

[1] Küster (in the *Festschrift für Leuthold*, Bd. 2) thinks that too little attention has been paid to the exact coaptation of the joint surfaces. We have always emphasised the importance not only of primary exact coaptation, but also that the bones should be held in position, which is much more difficult with his method.

[2] It is reassuring to see from Blauel's article (*Beiträge zur klin. Chir.* Bd. 42) that Bruns has adopted the "extracapsular" method described by us six years ago in a former edition, and that he sets great value on it. He has, however, overlooked the fact that it had already been accurately described by us. Bruns uses the curved incision downwards (Textor) or upwards (Hahn) as was our former custom, but which we abandoned in favour of the lateral-shaped incision, as it is a disadvantage to injure the extensor apparatus in these cases (*e.g.* Volkmann's transverse patellar incision), if there is any doubt about a total resection being required. For the same reason also only a limited use is found for the extracapsular method of Wolkowitsch and Sabanejew, which begins on principle with sawing through the femur and tibia, and has been abandoned by Bruns. The same is true of Flint's operation (*Annals of Surgery*, 1906, 3).

The entire capsule is then divided along the edges of the articular cartilage of the femur, tibia, and patella,[1] the patella being detached along with the quadriceps and ligamentum patellæ. In children the separation of the attachments of the ligaments and the detachment of the epicondyles can be done with the knife.

In arthrectomy, in contrast to arthrotomy, the semilunar cartilages are removed, as they are also diseased, and it is not possible to preserve them in removing the capsule from above or below. The nature of the operation, especially in tuberculosis, is governed by the principle that all the diseased tissues, whether synovial membrane, cartilage, or bone, must be as thoroughly removed as if dealing with a malignant tumour.

After-treatment. When the capsule is preserved, it is to be carefully sutured, after which the flap is brought into position with a few deep sutures, and then, after providing for drainage, the continuous cutaneous suture is applied. To secure permanent healing in tubercular cases iodoform should be rubbed into all the recesses and folds. When sinuses and open wounds exist, the cavities are stuffed with iodoform gauze, the skin being retained in position by introducing temporary sutures, which are removed after one to ten days, and the definite suture is introduced (secondary suture) according to the plan recommended by us, and more recently somewhat modified by Bergmann, Sprengel, Helferich, and others. When there is any uncertainty the wound must be treated by the open method to the end. Küster's transverse elliptical incision with removal of the patella is a very suitable method when the wound has to be kept open, and packed with iodoform gauze or with Mosetig's iodoform filling, because it gives excellent access and the dressing is simplified.

The limb should always be fixed from the beginning in the extended position in plaster of Paris extending from the tuber ischii to the malleoli, the bandages being applied so that the wound can be dressed without the least movement of the limb, while the foot may be left free and moved from the first.

Atypical resections in connection with the knee-joint—for example, resection of one or other condyle or tuberosity—are only justifiable when one is certain of bringing about ankylosis of the other tuberosity or condyle with the opposing bone.

In resection of the knee, bone ankylosis is the object in view, while in arthrectomy fibrous ankylosis is, as a rule, undesirable. When ankylosis is fibrous or cartilaginous, as is often the case in children even after resection, it is very difficult to prevent subsequent flexion deformity when advanced atrophy of the quadriceps has occurred. The question may be raised whether tendon transplantation should not be undertaken to prevent this, by freeing the insertions of the biceps and either the semitendinosus or semimembranosus and uniting them with the fascia and periosteum to the edge of the patella.

18. Meniscotomy. Excision of a semilunar cartilage has frequently to be undertaken, as a result of injury, and is indicated much more often than is generally supposed. The so-called dislocation of the cartilage (generally the inner) is not a true dislocation, and it would be better if the term were no longer employed. It consists rather in a crushing of the cartilage with rupture and displacement of the torn ends which become locked and give rise to the well-known symptoms of a loose body in the joint.[2] The condition is cured by partial or total excision of the cartilage.

A curved incision from above downwards and outwards, similar to that employed in arthrotomy, is used on the inner side of the knee. After division of the skin and fascia, the capsule is opened over the cartilage by an incision from the internal lateral ligament to the ligamentum patellæ. The condition present can then be seen. By flexion and slight abduction of the knee, any tags projecting into the joint are observed and either the whole or merely the anterior part of the cartilage may be excised. The entire cartilage need only be removed when it is no longer connected with the

[1] In cases where extracapsular excision of the capsule is indicated, Küster is perfectly justified in emphasising the necessity of removing the patella on principle, which has for long been our practice.

[2] We intend shortly to publish our cases in conjunction with Dr. A. Kocher, who has studied the subject experimentally.

capsule or when it is thickened or sensitive. The wound is closely stitched without drainage.

The subsequent movements are thoroughly restored, but the knee has a tendency to a slight degree of genu varum.

19. Arthrotomy for Habitual dislocation of the Patella (congenital). The patella may be displaced outwards either from congenital reasons or as the result of a trauma. The displacement recurs very readily on account of the angle formed on the outer side of the knee by the tibia and femur, which gives the quadriceps a preponderating pull outwards.

Plication of the capsule on the inner side of the patella with a rampart suture ("mauernaht") has produced satisfactory results, while at the same time the aponeurosis of the vastus internus is split longitudinally and sutured as far as possible in a transverse direction.

Krogius has described a method, *i.e.* transplantation of muscle and tendons, which promises still better results. He raises a long bridge-like strip of the vastus internus along with its fascial extension and stitches it to the outer side of the patella through a separate incision. The synovial membrane need not be opened. Our external J-shaped incision may be used with advantage.

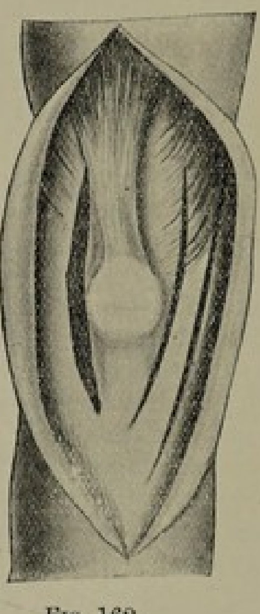


Fig. 162.

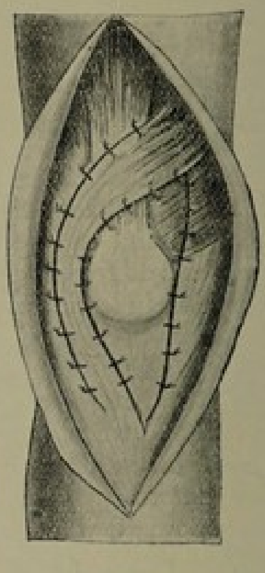


Fig. 163.

20. Excision of the Patella. This is an important operation for primary disease of the patella (which is not uncommon) in order to prevent diffuse disease of the joint. The individual steps of this very simple operation are—longitudinal incision, division of the fascia and of the smooth-walled bursa which is generally found underneath it, stripping off of the quadriceps fascia and of the periosteum, and, lastly, separation from the anterior wall of the capsule. After removing the patella the cut edges of the capsule can be united in the longitudinal direction without difficulty, the joint being closed and the extensor apparatus re-established. The results are very satisfactory, as a completely movable joint can be obtained (Dr. Kummer).

(g) Operations on the Thigh

21. Supracondylar Osteotomy of the Femur. The incision, whether on the outer or inner side, is along the line of cleavage of the skin, and passes obliquely from above downwards and forwards through the skin and the fascia lata, which is especially strong on the outer side. The vastus (internus or externus) is exposed at its posterior border and drawn upwards, while the periosteum is split vertically above

the epicondyle and separated forwards and backwards, and the bone divided with a chisel for two-thirds of its breadth, the remainder being broken across.

The superior internal (or external) articular artery is to be looked out for, and internally especially the deep branch of the anastomotic artery. Along with Macewen (to whom belongs the credit of devoloping this operation) we were the first to perform osteotomy of the femur for genu valgum.

An incision above the internal condyle, a finger's-breadth in front of the insertion of the tendon of the adductor magnus, must be regarded as the normal one, as it avoids the superior internal articular artery. Moreover, the bone is more easily reached from the inner side, and, after dividing the skin and the relatively thin deep fascia, it is necessary, in order to reach the periosteum, to free and hook aside the lower border of the vastus internus. By this plan the soft parts can be ensured against injury better than by the widely adopted procedure of Macewen, who introduces a chisel down to the bone through quite a small opening.

We employ a chisel with a blunt projection at one side.

After dividing the greater part of the bone the remainder is fractured. The after-treatment is generally carried out by means of a carefully-applied plaster of Paris bandage. We have, however, given up this plan and now apply weight-extension in order to prevent stiffness of the knee-joint. The small wound is sutured and covered with a collodion dressing.

Supra-condyloid osteotomy has completely taken the place of Ogston's ingenious method of intra-articular division of the internal condyle of the femur for the femoral form of knock-knee. It is far preferable to every form of osteoclasia or forcible reduction without operation. It is not so frequently employed for contracture and ankylosis of the knee in bad position, because an excellent result is got by removing a wedge from the femur and tibia and dividing the capsule of the joint, by which means the cure is more permanent, as there is less chance of leaving behind some disease in the joint. In our own experience, in certain cases of contracture where there is a slight degree of movement at the joint, supra-condyloid osteotomy gives a better result than excision, the limb being brought into the extended position without injuring in any way the movements of the joint.

An incision is made external to the quadriceps (vastus externus), and the latter muscle is detached off the bone and retracted forwards along with the joint capsule. A wedge with the base forwards is cut with the chisel sufficiently high above the articular cartilage to avoid opening into the joint.

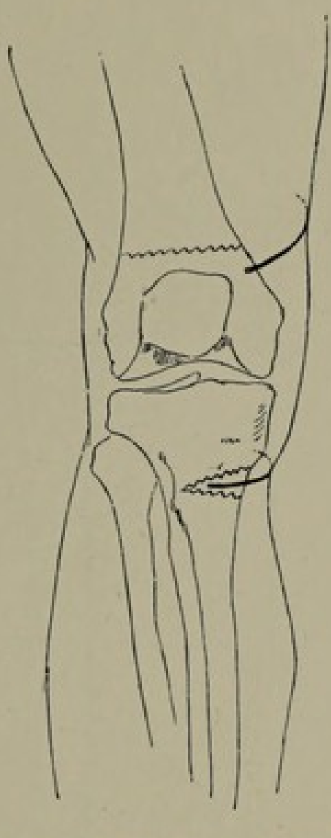


FIG. 164.—Osteotomy of the femur. Cuneiform osteotomy of the tibia.

22. Osteotomy and Resection of the Femur. Partial resections of the femoral diaphysis are undertaken in the treatment of acute and chronic osteomyelitis, especially in the latter, where local pain and fever may otherwise remain for a considerable length of time.

An incision may be made along the whole length of the outer side of the thigh without entailing any real damage on neighbouring structures. It should follow the posterior border of the vastus externus after dividing the skin and the strong fascia lata (ilio-tibial band) *i.e.* it may extend from the base of the great trochanter across which the terminal branch of the external circumflex artery runs, to the external condyle over which the superior external articular artery passes. The whole diaphysis of the femur is, however, only removed in the performance of extensive sequestrotomy after acute osteomyelitis.

23. Osteotomy and Sub-trochanteric Cuneiform Resection of the Femur.

Osteotomy below the trochanter is of historical interest as the operation which first brought osteotomy into notice. It was introduced by Rhea Barton. It was extensively employed by Volkmann, and Adams and Sayre have shown its advantages. It is an excellent operation for all malpositions of the hip which cannot be remedied otherwise: it is especially indicated, therefore, in old hip-joint disease with ankylosis, or stiffness in the position of extreme flexion and adduction. In bad cases one is glad when cure occurs with ankylosis, as in these circumstances excision of the hip with restoration of the movements at the joint would be unfavourable on account of the atrophied condition of the muscles. This difficulty is overcome by means of subtrochanteric osteotomy, which is equally efficient in correcting the deformity. The operation is easily performed, and if asepsis is secured it is not more serious than a simple fracture.

By subtrochanteric osteotomy a marked improvement can also be made in the mode of progression in old-standing, as well as in congenital dislocations of the hip. The operation in these cases is often far less serious than the severe open operation necessary for replacing the head of the femur into the acetabulum when reduction cannot be effected in any other way. If the dislocated head is well retained and movable in its false position, it is better to leave it there and to be content with straightening the limb by an osteotomy.

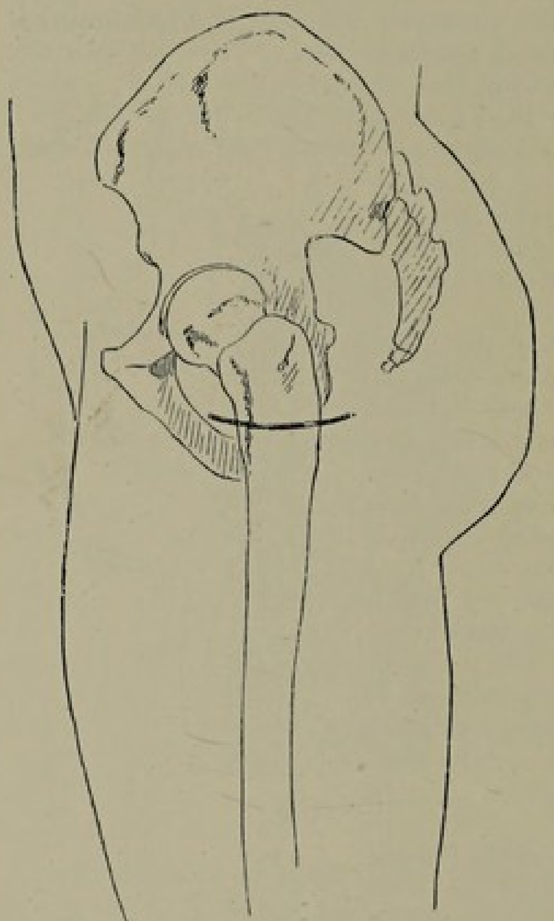


FIG. 165.—Subtrochanteric osteotomy.

FIG. 166.

A transverse incision (or, still better, an oblique incision in the direction of the line of division of the bone) is made down to the bone on the outer side, through the skin and tendon of the gluteus maximus, behind the tendinous insertion of the vastus internus at the level of the base of the great trochanter and below the trochanter minor. The transverse terminal branch of the external circumflex artery runs parallel to the incision. The bone is chiselled through obliquely downwards, forwards, and inwards, so as to prevent the lower fragment from being displaced inwards or forwards when the limb is forcibly abducted.

For the after-treatment, in cases where the bad position is easily rectified, a plaster of Paris bandage is all that is required; but when there is any difficulty in at once bringing the limb into good position, weight-extension should be employed.

(h) Operations at the Hip and Pelvis

24. Arthrotomy and Resection of the Hip.—(*a*) *Excision of the Hip by the Anterior Method.* We have tried Hüter's anterior resection, which has been warmly recommended especially by Barker, Lücke, and Schede, but we regard it as indicated only in partial excision, *i.e.* for the removal of the anterior part of the capsule and head of the bone. Hüter's anterior longitudinal incision is especially adapted for exposing the acetabulum in congenital dislocation of the hip. For a description of the operation for congenital dislocation of the hip the reader should consult the works of Hoffa and Lorenz.

An incision, 10 to 15 cm. (4 to 6 inches) long, is carried downwards from the anterior superior spine of the ilium dividing the skin and fascia. The external cutaneous nerve lies to the inner side. The incision strikes the interval between the sartorius with the underlying rectus femoris (arising from the anterior inferior iliac spine) and the tensor fasciæ femoris. In the lower part of the wound the transverse branch of the external circumflex artery may be divided between two ligatures. The neck of the femur is then reached, and the capsule opened. If plenty of room is wanted, it is incised longitudinally from its upper limit downwards along the attachment of Bertini's ligament to the intertrochanteric line.

This method allows of a simple or cuneiform osteotomy of the neck of the femur being performed, and we have employed it in the case of coxa vara. It can further be adopted in malunited fractures of the neck, for the removal of a focus of disease in the head and anterior aspect of the neck, and for making an acetabulum in a case of congenital dislocation of the hip. When, however, a thorough inspection of the joint has to be made, or when the capsule or part of the acetabulum has to be removed, it allows a very insufficient amount of space.

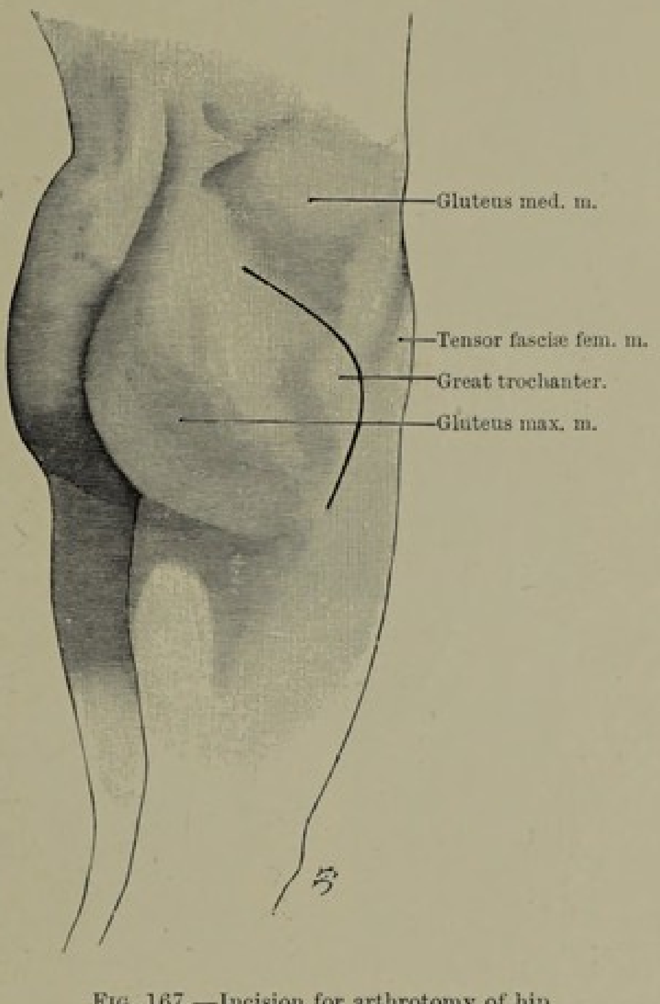


FIG. 167.—Incision for arthrotomy of hip.

(*b*) *Posterior Method.* The posterior incision gives much more room, if the joint is to be freely exposed, especially if the following method is employed :—The incision is an angular (or curved) one, extending from the base of the outer surface of the great trochanter upwards to its anterior superior angle, and from thence obliquely upwards and backwards in the direction of the fibres of the gluteus maximus. The skin and fatty tissue are divided (Fig. 167). At the base of the trochanter branches of the external circumflex artery are divided and ligatured. The dense aponeurotic insertion of the gluteus maximus is now divided upon the outer aspect of the trochanter, exposing the periosteum and the insertion of the gluteus medius, which covers the

whole of its upper border, the detachment of the gluteus maximus being thus facilitated (Fig. 168).

The upper and back part of the incision divides the gluteus maximus in the direction of its fibres, and generally some vessels of considerable size, which must be ligatured. When possible, a still better plan is to expose the upper border of the gluteus maximus and to retract it downwards if it is weakly developed.

A fatty layer now appears, and after dividing it, the interval is reached between the lower border of the gluteus medius and minimus above, and the pyriformis below. The broad tendon of insertion of the gluteus medius (attached to the outer side of

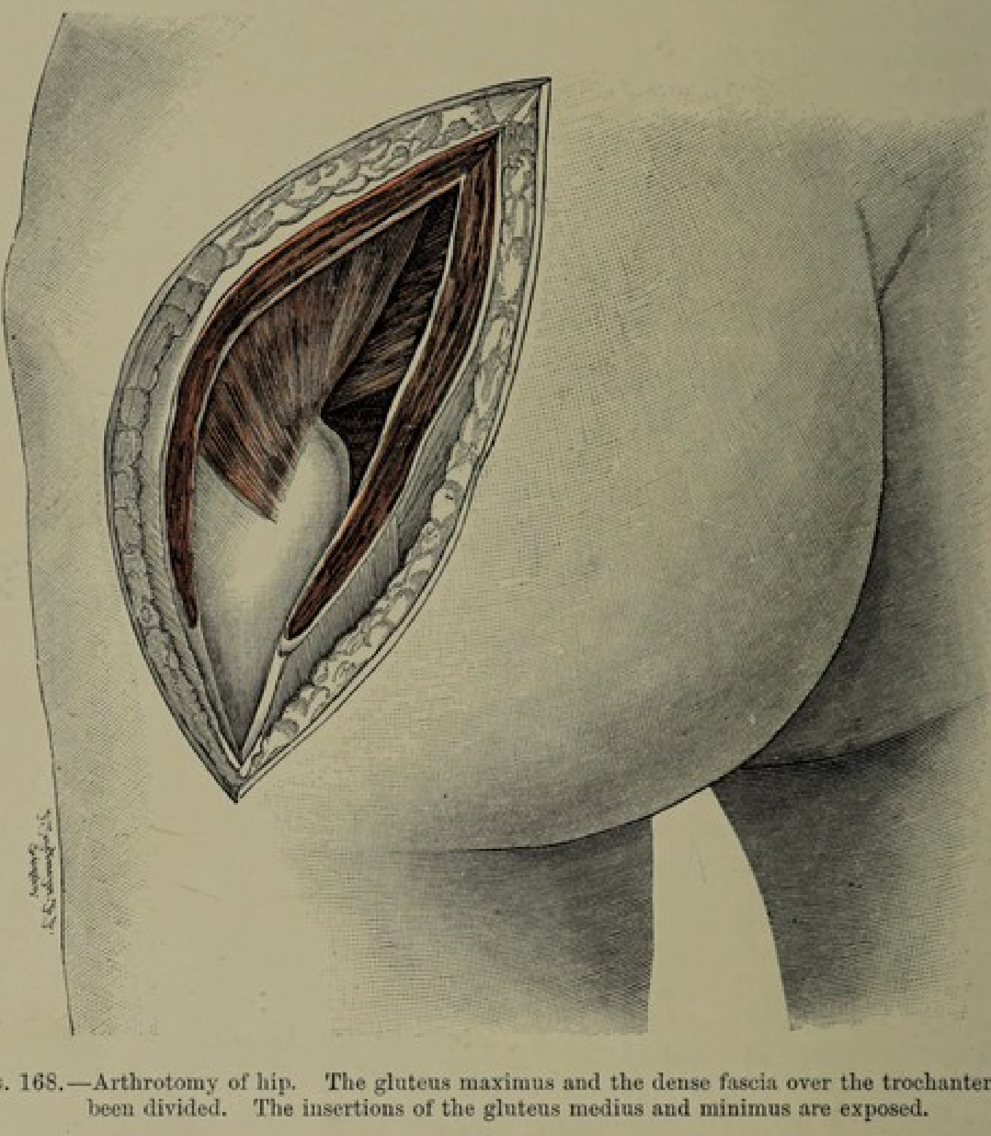


FIG. 168.—Arthrotomy of hip. The gluteus maximus and the dense fascia over the trochanter have been divided. The insertions of the gluteus medius and minimus are exposed.

the great trochanter), and under it the tendon of the gluteus minimus (attached to the anterior border of the great trochanter), together with the periosteum, are incised down to the anterior intertrochanteric line and detached forwards. The limb being flexed and rotated outwards, the ilio-femoral ligament is then separated from the anterior intertrochanteric line. The capsule is now divided along the upper border of the tendon of the pyriformis, and on flexing and rotating the thigh inwards the insertion of the pyriformis into the inner surface of the trochanter is detached along with the periosteum covering the bone. All the external rotators, along with the periosteum (or a superficial layer of bone), are then retracted backwards, beginning in front with the tendon of the obturator internus, the two gemelli, and the obturator

externus. In this way the periosteum covering the inner surface of the trochanter, together with the structures attached to its posterior surface, are reflected in their continuity (Fig. 169).

By this method the muscles supplied by the superior gluteal nerve, namely, the gluteus medius and minimus, are drawn forwards and upwards towards the tensor fasciæ femoris muscle, which has the same nerve-supply, and which, along with the glutei, is of special importance for the future abduction of the thigh; while the remaining muscles, the gluteus maximus, the pyriformis, and the obturators, which

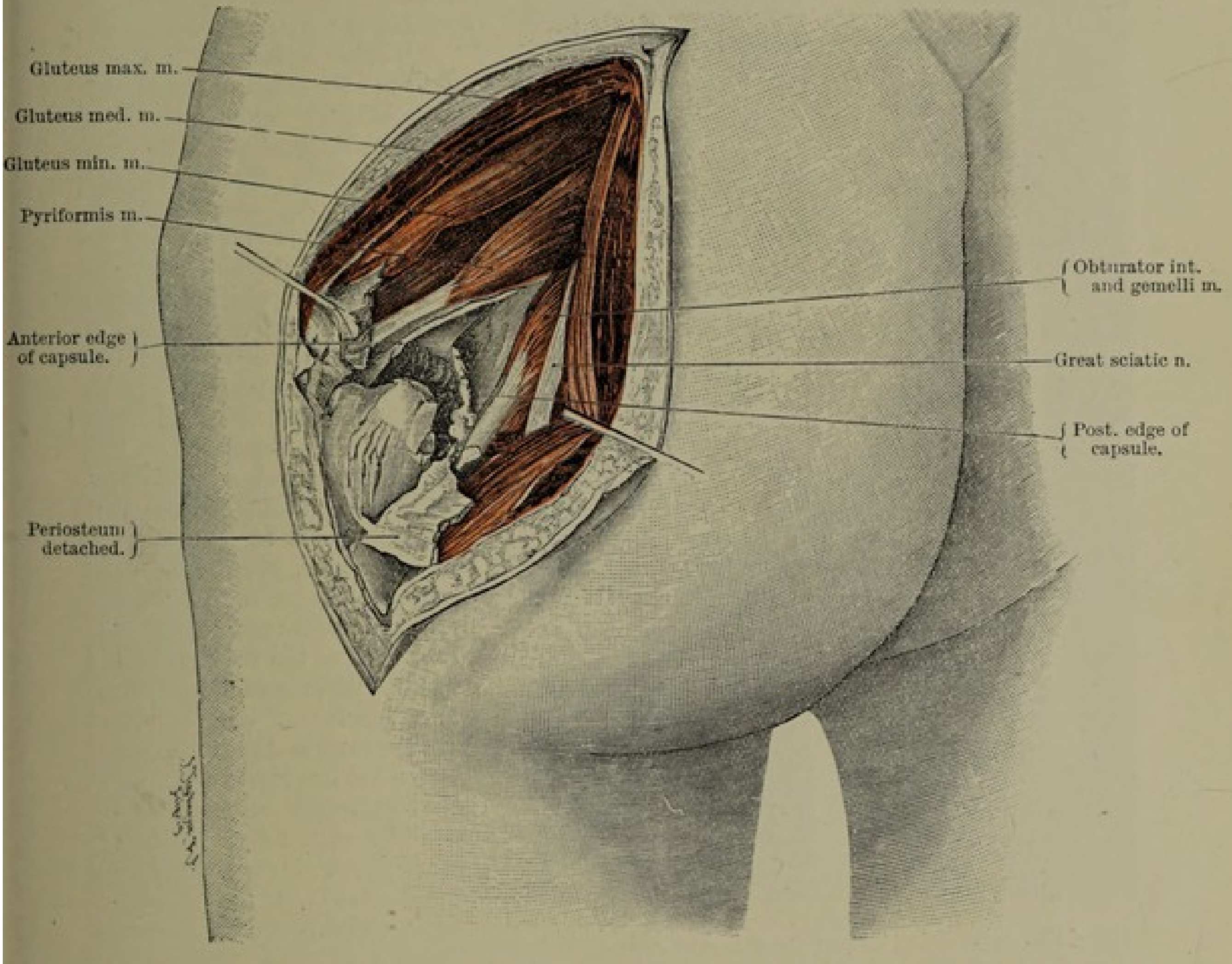


FIG. 169.—Arthrotomy of the hip. The capsule has been opened; the insertions of the gluteus medius and minimus, together with the pyriformis and periosteum, are detached in an upward and forward direction; the capsule, along with the periosteum and tendinous insertions of the obturator internus, gemelli, and obturator externus, is separated downwards and backwards.

are mainly supplied by the inferior gluteal nerve, are drawn downwards The pyriformis now and then receives a branch also from the superior gluteal nerve, which, however, is given off so high up that there is no fear of injuring it.

In this way also the entire posterior, external, and anterior surfaces of the head and neck of the femur, and as much as is necessary of the trochanter are exposed. One or two branches of the internal circumflex artery which run transversely over the capsule at the neck of the femur require to be ligatured; while the transverse branch of the external circumflex artery may also need similar treatment where it winds round the base of the trochanter under the vastus externus. As a rule it is sufficient to catch the small vessels with forceps and to twist them before closing the wound.

When the synovial membrane is tuberculous and has to be excised, it is easy, before opening the capsule, to dissect down accurately upon a large area of it from behind, and to separate it from its attachment to the acetabulum and neck of the femur, and thus to remove the posterior wall of the capsule *in toto*. The ligamentum teres is divided by cutting on to the head of the bone from behind and below, the limb being powerfully adducted, flexed, and rotated inwards. The head is then dislocated backwards, and the acetabulum rendered visible. The tuberculous tissue is now removed with scissors and forceps and scraped with a sharp spoon, while the wound surfaces are swabbed with a solution of carbolic and alcohol.

Of the numerous methods employed for excising the hip we know of none which allows of such free inspection of the joint with so little injury to the muscles, nerves, and bone. It is a further development of Langenbeck's method by the oblique incision, which, however, does not admit of extirpation of the capsule alone with at the same time preservation of the bone. We shall therefore dispense with a comparison of this with other methods of operation.

If an arthrotomy is sufficient, or only bone is to be removed, the capsule is opened at once along the upper border of the pyriformis, from the acetabulum to the neck of the femur, and the capsule, periosteum, and muscular insertions are detached from the neck and the trochanter. The tendon insertions which have been detached subperiosteally (or along with a layer of bone), anteriorly, and posteriorly, are then replaced over the trochanter and sutured. Even when the disease implicates the anterior aspect of the neck of the femur, we have found this method better than an anterior incision.

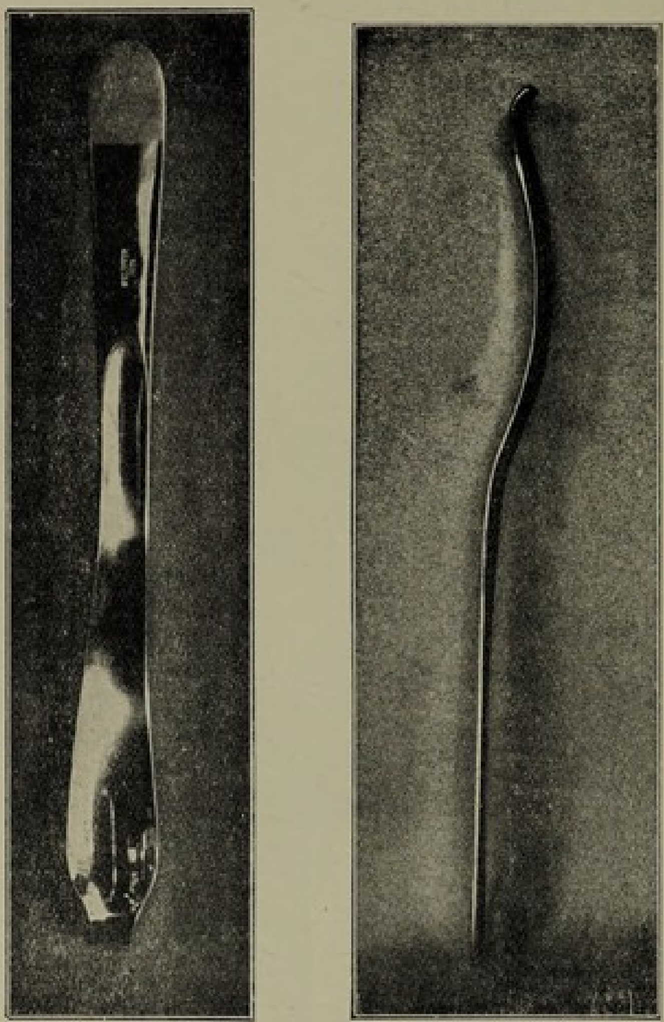


FIG. 170. FIG. 171.

Scoop for the reposition of the head of the femur in the open operation for congenital dislocation of the hip.

Bardenheuer employs a still more drastic method by excising the joint completely together with the synovial membrane and capsule without opening the latter, *i.e.* by removing the head and neck of the femur and the acetabulum, and employing the Larghi-Sprengel transverse incision.

His method certainly ensures the most thorough removal of all the disease, but it necessarily entails sacrifice of the epiphysis and of bone which might have been preserved, since the synovial membrane envelops most of the neck of the bone.

As regards after-treatment, the ends of the bone must not be kept absolutely rigid, as is done in the knee with plaster of Paris, because here a movable joint is desired. The after-treatment is best carried out by weight extension, at the same time elevating the pelvis and maintaining both limbs in an abducted position. The initial dressing must consist of several layers of strongly-antiseptic gauze, which should not be changed

for eight to ten days. The drainage tubes should be wrapped in iodoform gauze wrung out of carbolic, and the wound covered with several layers of perchloride gauze, the skin being protected. The part is swathed in perchloride wool, which can be readily changed without interfering with the abducted position of the limbs.

25. Arthrotomy in Congenital Dislocation of the Hip. In the previous chapter we alluded to the anterior operation which is the one most popular with authorities on congenital dislocation, *e.g.* Hoffa and Lorenz. In our experience it has not afforded satisfactory results.

When an open operation is indicated, the posterior incision we have described provides the best access and consequently is most likely to prove successful. It has the further advantage that one may begin with a short incision. With the limb adducted and the head of the bone in consequence projecting posteriorly, an incision, 5 to 6 cm. (2 to 2½ inches) long, is made in the direction of the fibres of the gluteus maximus, the edges of which are held apart with two retractors and the joint is opened by cutting down on the thick capsule on the back of the dislocated head of the bone.

A lever, which we have found to be indispensable, is now forcibly pushed forwards towards the acetabulum between the head and the smooth surface of the dorsum ilii on which synovial membrane also extends, until it slips over the posterior margin of the acetabulum. At the same time by forcibly abducting the limb and rotating it outwards or very often inwards, the head of the bone which now rests in the hollow of the instrument is levered into the acetabulum by carrying the handle of the instrument forwards. The wound is simply closed with a continuous suture covered with collodion, and the limb is then put up in plaster.

For long-standing non-congenital dislocations, Ollier and Mikulicz employ a transverse incision with its convexity downwards over the trochanter, the tip of which is chiselled off. Rydygier uses a similar flap and speaks with praise of the excellent access to the acetabulum obtained by cutting with the chisel right through the great trochanter above the trochanter minor.

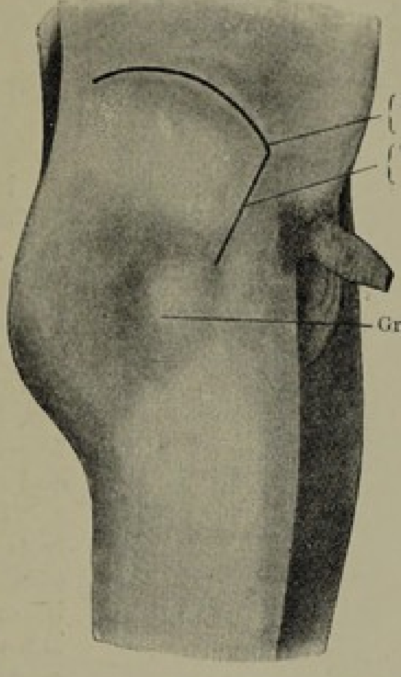


FIG. 172.—Sprengel's incision.

26. Osteotomy of the Pelvis. To obtain free access to the outer surface of the ilium and to the upper and posterior aspects of the acetabulum, Sprengel has devised an incision which is deserving of notice, and which perhaps might be considered in connection with certain cases of congenital and old-standing dislocations. Sprengel has by this means cured obstinate cases of pelvic suppuration. It is, however, a more severe operation than our posterior method.

He carries an incision downwards from the anterior superior spine of the ilium between the anterior border of the tensor fasciæ femoris and the sartorius, dividing the dense fascia lata. A few small vessels are ligatured, and the wound is then extended backwards along the crest of the ilium, dividing the fascia and the origins of the gluteus medius and minimus, which are stripped off the pelvis with a sharp raspatory. By turning down a flap in this manner one obtains a very good view of the hip-joint and of the margin of the acetabulum. We once removed a traumatic exostosis from the acetabular margin by this method. The advantage of Sprengel's incision is that the entire soft parts together with the periosteum can be raised in a single piece.

27. Resection of Half the Pelvis. We first performed this operation in 1884 on a man, aged fifty-one, suffering from osteochondrosarcoma of the pelvis.

The tumour, which was first noticed six weeks after an injury, rapidly increased in size, and was attended with pain and interference with the joint movements. The right iliac fossa was almost entirely occupied by a large irregular, dense, hillocky tumour, covered here and there by a thin shell of bone and pushing the glutei before it, causing pain on pressure, and creaking on the hip-joint.

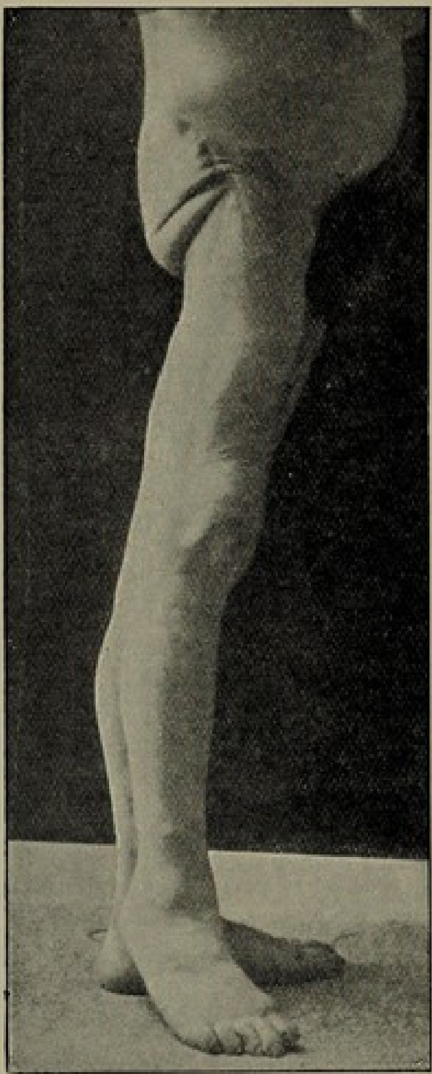


FIG. 173.—Excision of hip and innominate bone for a tumour of the pelvis.

At the operation (9th December 1884) the pubis and ischium were sawn through 2 cm. internal to the acetabulum, and the ilium was separated posteriorly at the sacro-iliac joint. The upper end of the femur had also to be resected.

On 19th January the patient was allowed to attempt walking, and on 16th March he was discharged, able to get about with the aid of crutches. His condition on 13th July 1888 (Fig. 173) was reported as follows:—Patient has been very well since the operation, and began to do light work one month after leaving hospital. He can now do light agricultural work, and can walk for an hour without fatigue.

He limps in the same way as a patient after excision of the hip, *i.e.* walks on the points of his toes and swings his leg forwards. The leg is in normal position and the knee can be fully extended. There is 4 ins. of shortening. Of passive movements there is a range of 270 degrees, and of active movements abnormal external rotation is possible. Normal active extension; passive hyperextension of 45 degrees. Passive abduction and adduction up to 70 degrees on both sides.

The upper end of the femur is only $1\frac{1}{4}$ in. from the middle line of the body, and is on the same level as the anterior superior spine of the ilium of the opposite side. The femoral artery is tortuous and pulsates strongly. The horizontal ramus of the pubis is $1\frac{1}{4}$ in. in length. The femur can be pushed upwards and downwards to the extent of an inch or so. There is a hernial protrusion of the abdomen the size of one's fist.

Soon after this case Roux performed a similar operation, and recently we have operated on another case in a boy, aged thirteen years, for sarcoma of the pelvis. The steps of the operation depend on the extent of the disease. In this case they were as follows:—An incision was made from the sacro-iliac joint along the crest of the ilium, and thence along Poupart's ligament.

After this incision the abdominal muscles are divided along their attachments to Poupart's ligament and the iliac crest, and the fascia transversalis and peritoneum are separated from the tumour as far as the large vessels (iliac artery and vein), which, with the anterior crural nerve, are retracted inwards. The smaller nerves (external cutaneous, etc.) have to be divided, the anterior and posterior circumflex iliac arteries being grasped with forceps.

The muscles which lie behind Poupart's ligament and external to the large vessels are then separated and divided. The rectus femoris, sartorius, tensor fasciæ femoris, and the iliac attachments of the gluteus medius and minimus are detached with a blunt instrument and divided as far back as the sacro-iliac joint.

The ilio-psoas and the capsule of the joint are then divided, while internally the pubis and ischium are exposed subperiosteally and cut through with forceps. A strong knife is then inserted into the upper part of the sacro-iliac joint, which is divided, and the innominate bone is dislocated downwards. The rest of the posterior surface of the pelvis is then exposed, and the attachments of the flexor muscles and the great sacro-sciatic ligament to the tuber ischii, and of the lesser sacro-sciatic ligament to the spine of the ischium, are divided. The bleeding, on account of the duration of the operation, is considerable, but none of the larger vessels are injured, and in our last case not a single vessel had to be ligatured. The wound, in the case of the boy, healed by first intention.

From our experience, in elderly and weakly subjects who do not survive operation, it appears to us to be an advantage, after detaching the abdominal muscles from the crest of the ilium and Poupart's ligament, and pushing back the fascia transversalis and peritoneum, to prevent excessive hæmorrhage by ligaturing, temporarily or permanently, the internal iliac vessels.

Partial excisions of the pelvis have been frequently performed (*vide* Gussenbaur, *on the Removal of Osseous Growths of the Pelvis*, 1891). Wilms has reported a case of Trendelenburg's where the entire anterior part of the pelvis was removed, after which the patient was able to walk about surprisingly well.

28. Resection of the Sacrum. We performed total resection of the sacrum for suppurative cario-necrosis in a woman aged thirty-seven, in December 1899, but she, unfortunately, died from cerebro-spinal meningitis. However, it is certain that the sacral canal and the sacral foramina can be opened and the cauda equina and nerves lifted out without any real harm. The woman had no muscular paralysis. The operation was performed with a knife and chisel.

(i) Operations on the Fingers and Hand

(*a*) *Preliminary Remarks on Operations on the Fingers.* The operations which the surgeon is called upon to perform on the fingers consist in the opening of abscesses, the removal of tumours, the resection of the small joints for acute necrosis of the articular extremities and for tuberculous arthritis, excision of an entire phalanx for tuberculous osteomyelitis (spina ventosa), and, lastly, amputations for injuries and gangrene of the fingers

While we are scarcely ever called upon to expose the small arteries and nerves, it is often necessary to make incisions so as to avoid them. As a rule, therefore, incisions, whether made merely through the soft parts, or in resecting the bones or joints, should be placed on the lateral aspects of the fingers: dorsal and palmar incisions are only made with the object of opening suppurating tendon sheaths, or for the purpose of suturing divided tendons. The chief mass of the subcutaneous soft parts of the fingers is made up of the tendons, which are absent upon the smaller lateral surfaces. The *flexor tendons* lie upon the periosteum. Opposite the middle phalanx the deep flexor tendons pass through those of the superficial flexors. The latter are crescentic on transverse section, with the convexity towards the bone, the former being cylindrical.

The two divisions of the flexor sublimis tendon, after embracing the tendon of the flexor profundus, are inserted into the lateral surfaces of the middle phalanx. The flexor profundus tendon, after passing through the slit in the flexor sublimis tendon, is inserted into the base of the terminal phalanx. As far as the bases of the terminal phalanges the tendons are enclosed in a fibrous tube continuous with the palmar fascia, and from the heads of the metacarpal bones downwards they are surrounded in addition by closed synovial sheaths, which, in the case of the thumb and little finger, approach and often communicate with the common flexor sheath in the palm. Vincula tendinum pass from the bones and the capsule of the joints to the under surface of the tendons.

The *extensor tendons* of the fingers are attached by some of their fibres to the

bases of the first phalanges, upon which they divide into three divisions. The tendons of the lumbrical muscles and interossei (flexors of the first and extensors of the second and third phalanges) pass under the lateral divisions to join the middle portion and to be inserted along with it into the base of the middle phalanx. The lateral portions, after extending laterally over the first interphalangeal joints, unite again upon the dorsum of the second phalanx and are inserted into the base of the terminal phalanx. All the extensor tendons are flat and fascia-like.

The extensor primi internodii pollicis is inserted into the base of the first phalanx of the thumb; the extensor secundi, placed somewhat dorso-ulnawards, is attached by all three divisions to the base of the terminal phalanx.

As the *terminal phalanges* have tendinous insertions only at their bases, incisions may be made anywhere according to the indications; that is to say, they may be placed either mesially or laterally.

The *digital arteries and nerves* give off branches which pass towards the dorsal aspect of the second and third phalanges. Lateral incisions over the middle phalanges are to be made nearer the dorsum, as the digital vessels and nerves come more into relation with the flexor tendons.

The palmar and dorsal digital vessels and nerves are of considerable size opposite the first phalanges, and here again the palmar vessels lie more towards the flexor tendons (the nerves being anterior to the vessels), so that incisions may be made laterally. Towards the base of the first phalanges, however, after the skin has been divided, the deeper incisions are to be curved towards the palmar aspect of the finger in order to avoid the broad tendinous insertions of the lumbrical and interosseous muscles. When a choice is possible, it is better to make an incision upon the ulnar rather than the radial aspect, because the lumbrical muscles (flexors of the first phalanges) wind towards the radial aspect of the finger.

(*b*) *Preliminary Remarks on Operations on the Hand.* Incisions are often required to be made in the hand in consequence of the frequency with which infective inflammations and abscesses are met with in this part of the body. The arteries, especially of the palm, are large enough to allow of the direct application of a ligature. Besides the incisions necessary to evacuate deep collections of matter, and for the ligature of the vessels, there are those required in operating on the tendons of the hand, be it for inflammatory affection of their sheaths or for suturing wounded tendons.

On the dorsum we have to deal only with tendons and nerves which for the most part can be felt through the skin, and hence serve as guides in making incisions. Large vessels are only met with behind and along the metacarpal bone of the thumb, and these, like the nerves, can be felt through the skin.

On the back of the hand a line drawn along the middle of the third digit up to the wrist separates the areas supplied respectively by the radial and ulnar nerves. The dorsal carpal arch and the metacarpal arteries are comparatively small vessels.

The extensor tendons at the wrist have for the most part separate synovial sheaths which extend downwards as far as the middle of the metacarpus. On the dorsum of the hand the radial nerve can be felt over the base of the second metacarpal bone, and the dorsal branch of the ulnar nerve over the base of the fifth metacarpal. In the interval between the first and second metacarpals, on the dorsum, the radial artery can also be traced upwards upon the base of the first metacarpal and then upon the trapezium.

The radial vein is visible as it ascends across the hollow between the tendons of the extensor secundi and extensor primi internodii pollicis.

Examination of the Structures which can be felt beneath the Skin. In the palm the vessels and nerves run in the intervals between the metacarpal bones, while the tendons are placed over them: all lie under the strong palmar fascia which gives off processes to join the tendon sheaths upon the fingers. Between the processes the fascia ends in concave arches which, by means of the septa passing from them to be attached to the deep transverse ligament, serve to separate the flexor tendons and lumbrical muscles from the digital vessels and nerves.

Under the palmar fascia is the bundle of flexor tendons with the lumbrical muscles,

surrounded by a synovial sheath which reaches from the ends of the bones of the forearm downwards to the middle of the metacarpus. The flexor longus pollicis possesses a sheath of its own. Under the tendons is a thin deep fascia which covers the interosseous muscles and the bones.

As landmarks for incisions in the region of the wrist, the following are to be mentioned: the *pisiform bone*, with the insertion of the flexor carpi ulnaris, and the ulnar vessels and nerve, which may be felt in contact with its radial aspect: upon the ulnar side of the wrist-joint below the pisiform bone the projecting body of the *unciform bone*, upon which the dorsal branch of the ulnar nerve can be felt: a thumb's-breadth below, and somewhat to the radial side of the pisiform bone, at the radial edge of the hypo-thenar eminence, is the *hook of the unciform*, below which the

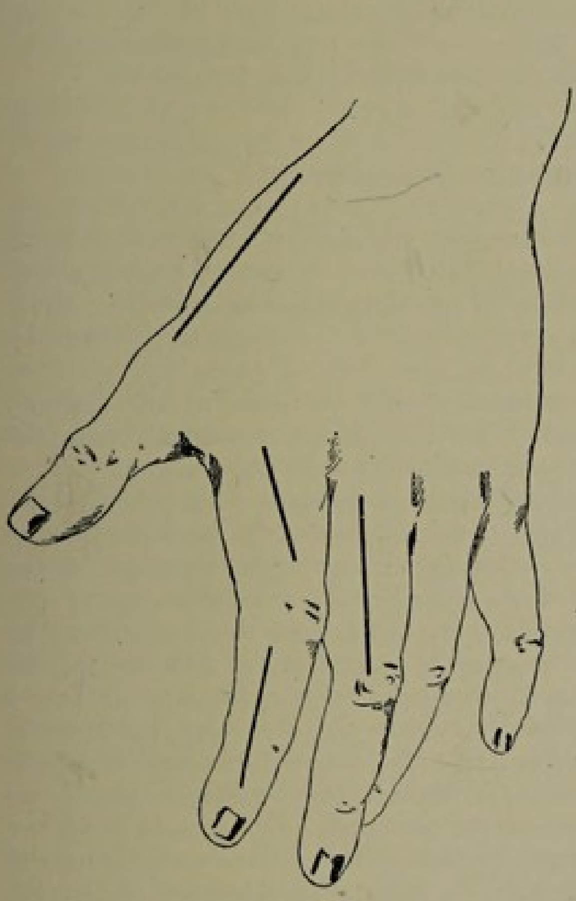


FIG. 174.—Excision of the phalanges and 1st metacarpal bone.

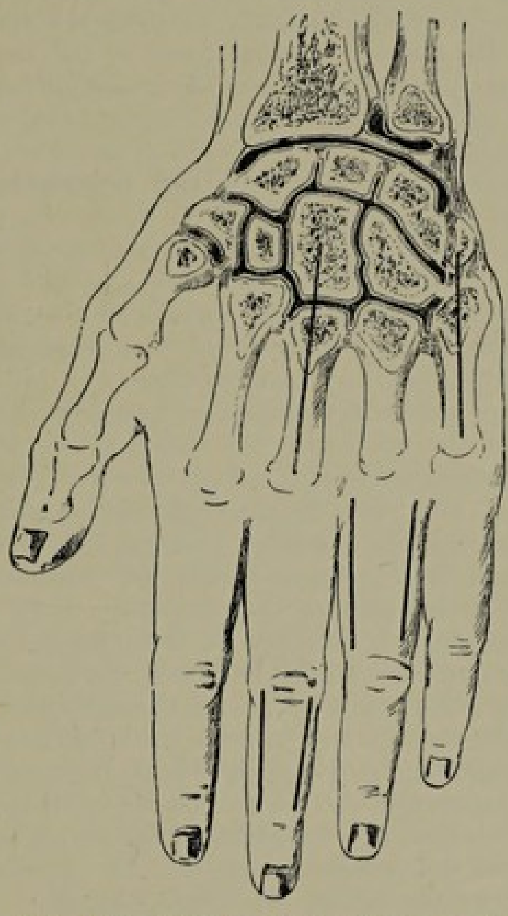


FIG. 175.—Excision of the phalanges and metacarpal bones. (Coronal section of the wrist, after Henle.)

deep branch of the ulnar artery and nerve curves round: the superficial sensory division of the ulnar nerve can be felt through the skin and rolled from side to side over the hook of the unciform: lastly, immediately above the ball of the thumb is the projection of the *os trapezium*, over which the superficial volar branch of the radial artery, which may be felt through the skin, descends to complete the superficial palmar arch. Two fascial envelopes surround the wrist, one a part of the general fascial envelope thickened by transverse fibres, the other situated deeply around the ligaments of the wrist-joint. Besides these, upon the palmar aspect is the strong anterior annular ligament which bridges over the tendons occupying the hollow of the carpal bones, and gives origin to some of the muscles of the thumb.

29. Excision of Phalanges and Metacarpal Bones, of Interphalangeal and Metacarpo-phalangeal Joints (Figs. 174 and 175). For the phalanges and their joints, lateral incisions are made, and for the metacarpal bones, dorsal incisions. The

incisions upon the fingers are placed near the dorsum, and this is to be the more particularly attended to the farther they extend towards the tips. In the case of the fingers it is desirable in removing a bone to make bilateral incisions, in order to prevent unilateral contraction of the scar and consequent lateral bending of the finger. The extensor tendons and nerves on the dorsum are to be avoided, the incisions being made over the bones where they can be felt beneath the skin.

When not contraindicated, the subperiosteo-capsular resection is to be performed. The head of the bone is first exposed because it can be more easily rendered movable.

In the case of the metacarpal bone of the thumb, the extensor brevis pollicis along with the periosteum is detached to one side, and the muscles of the ball of the thumb are detached to the other, the tendon of the extensor ossis metacarpi pollicis being separated from the base of the bone. In the case of the remaining metacarpal bones, the interosseous muscles are separated along with the periosteum. The carpo-metacarpal joint of the thumb is the only one with a separate synovial membrane, the others being continuous with the intercarpal joints.

(k) Operations on the Forearm

Incisions have to be made on the forearm to ligature wounded vessels, to suture nerves and tendons, and, not infrequently, to resect or suture fractures, and in the treatment of pseudarthrosis, as well as to open deep-seated abscesses under the muscles (associated with suppuration in the tendon sheaths), and under the periosteum in osteomyelitis.

Incisions on the *flexor surface* of the forearm should be made so as to avoid, on the one hand, the radial artery and radial nerve, and, on the other hand, the median nerve and the anterior interosseous nerve and artery.

The whole length of the radius and the interosseous membrane may be cut down upon without fear of injuring the nerves by an incision between the supinator longus and the flexors, as this is the frontier line between the structures supplied by the different nerves. The best plan is to pass down between the supinator longus and the flexors, and then to free the radial nerve on its outer side so that it may be retracted inwards along with the radial artery. In the lower third of the forearm the radial nerve must be left to the outer side of the incision, because here it leaves the radial artery to pass on to the dorsum of the wrist. In this way we recently exposed the whole length of the medullary canal of the radius in a case of diffuse osteomyelitis. At the upper end of the wound the fibres of the supinator brevis are detached and retracted outwards, while those of the pronator quadratus at the lower end are detached inwards. If it be necessary to expose the interosseous membrane from the radius, the muscles attached to the radius must be divided and separated, viz. the pronator radii teres in the middle third, the radial attachment of the flexor sublimis digitorum below it, and behind it the flexor longus pollicis. In the lower half of the arm the interosseous membrane can be reached from the inner side of these muscles without interfering with their attachments, because at this level there are no branches of the median nerve to injure. In the upper half of the forearm, after division of the pronator radii teres and flexor sublimis digitorum, it is a good plan to free the median nerve and then to pass to its outer side, as if in search of the anterior interosseous nerve. By dissection down to the radius and the interosseous membrane to the outer side of the last-mentioned nerves, the only branch likely to be injured is the one going to the flexor longus pollicis. Abscesses situated deep down on the interosseous membranes are not infrequently met with as the result of extensive suppuration beginning in the tendon sheaths of the hand.

Incisions on the *extensor* surface of the forearm, the muscles of which are supplied by the posterior interosseous nerve, may be made along the whole length of the ulna, as the dorsal branch of the ulnar nerve pass under the flexor carpi ulnaris quite at the lower end of the ulna. Further, this incision lies along the radial border of the extensor carpi ulnaris, which receives its nerve-supply at a higher level. Incisions

may be made on the radial side in a line from the head of the radius to its styloid process, but commencing $2\frac{1}{4}$ ins. below the head of the radius so as to avoid injuring the posterior interosseous nerve as it pierces the supinator brevis, the incision passing down between the radial extensors of the wrist and the extensor communis digitorum. After retracting the radial extensors outwards and the common extensor inwards, the extensors of the thumb are exposed with the posterior interosseous artery lying in the interval between the abductor longus pollicis (the muscle placed farthest to the radial side) and the extensor longus pollicis. In the lower half of the forearm, where the radial extensors appear from under the obliquely-placed extensors of the thumb, the radius must be cut down upon between the latter and the tendon of the supinator longus, the dorsal branch of the radial nerve being avoided. In the lower third, to the ulna side of the muscles of the thumb, incisions may be made between all the tendons on the posterior surface, because there are here no vessels or nerves to be avoided.

30. Osteotomy and Resection of the Ulna. The ulna lies subcutaneously along the whole length of the forearm, in the interval between the flexor and extensor carpi ulnaris muscles. It can therefore be excised either partially or completely without any difficulty and without injury to the surrounding structures. Staphylomycotic and tuberculous ostitis are not infrequent indications, while in fractures of the upper third of the bone, it may be necessary to wire the fragments in order to secure satisfactory coaptation.

31. Osteotomy and Resection of the Radius. The radius is much less easily accessible than the ulna. The head of the radius can always be felt under the skin at the outer part of the posterior surface of the elbow, and can therefore be resected by a part of the incision, the direction and position of which is fully described in our method of excision of the elbow.

The middle third of the diaphysis may be felt upon the posterior surface of the limb between the radial extensors of the wrist and the extensors of the fingers. It may be cut down upon here without fear of vessels, nor do the branches of the nerves come into question, as the adjacent muscles receive their nerve-supply higher up. The upper third of the radius is covered by the supinator brevis muscle, through which the posterior interosseous nerve passes backwards. The lower third, besides being covered by the supinator longus and the two radial extensors, which run all the way along it, is also covered by the pronator quadratus, and by the extensors of the thumb which pass obliquely over its postero-external aspect.

An incision extending down to the radius in its whole length is only possible along the line for ligature of the radial artery, by drawing the radial nerve to the outer, and the radial artery to the inner side. In the upper third the nerve lies well to the radial side of the artery; in the lower fourth it winds to the dorsal aspect of the wrist. In recent as well as old fractures of the radius, it may be necessary to perform osteotomy and wire the fragments, as otherwise fractures in the upper and middle thirds often unite very unsatisfactorily.

(l) Operations at the Elbow

Operations in the region of the elbow mainly comprise incisions into the joint for resection or for suturing the bone. It is only on its postero-lateral aspect that the joint is readily reached without danger of injuring neighbouring structures: hence this site is chosen for opening the elbow-joint, and we prefer our curved lateral incision. It is only in the region of the supracondyloid ridges that the humerus is so superficial that it can be cut directly down on without hesitation. The best guide to the level of the joint is furnished by the head of the radius, felt from the postero-external aspect. Other important landmarks are the two epicondyles and the olecranon process.

The tendon of the biceps can be easily felt at the front of the elbow with the pulsation of the brachial artery on its inner side. Lying behind the internal epicondyle

is the ulnar nerve. In most people the median basilic vein, which is selected for venesection, is generally visible at the bend of the elbow.

32. Arthrotomy, Resection, and Arthrectomy of the Elbow. In arthrotomy and excision of the elbow-joint, just as in all other joints in which a free exposure of the cavity is desired in order to remove accurately all diseased tissues, we adhere to the principle of making a somewhat more complicated skin incision, in order not only to preserve all the muscles along with their attachments, but especially also to spare the nerves which supply them. This was the main reason why we employed the posterior curved incision for arthrotomy of the shoulder, and why we subsequently also modified the methods which had been employed for excision of the elbow.

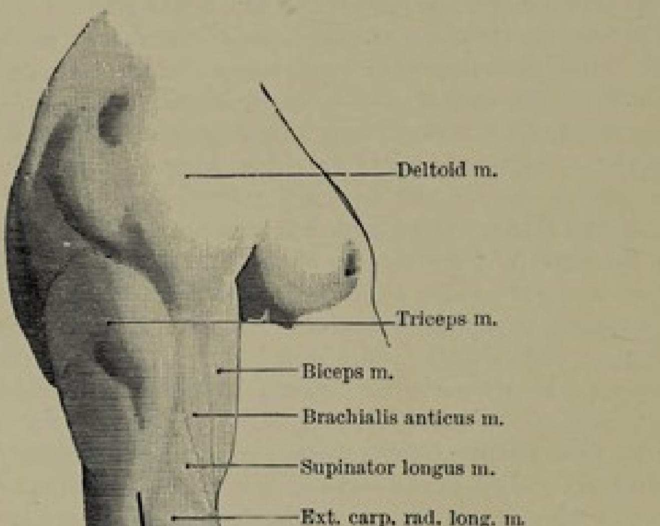


Fig. 176.—Arthrotomy of the elbow and wrist.

To begin with, we employed the simple method of Langenbeck with a posterior longitudinal incision, which was re-introduced by Treves, Park, and Maisonneuve; but we found, especially in tuberculous disease which was localised in or had extended to the region of the head of the radius, that the access was not so satisfactory. Ollier's bayonet-shaped incision is an excellent method for gaining this access, but it has the disadvantage of throwing the anconeus out of action. It is true that the oblique middle portion of Ollier's incision extends through the interval between the outer head of the triceps and the anconeus; but as the branch from the musculo-spiral nerve which supplies the latter muscle descends as an outrunner from the branch supplying the outer head of the triceps, it is necessarily divided, with the result that the anconeus atrophies. As it is our special duty in the case of the elbow to obtain an actively movable joint, the function of the anconeus ought to be preserved, as it serves to stretch and fix the capsule of the joint. We attain this by the following method of operation :—

With the elbow flexed to an angle of about 150°, an angular incision (Fig. 176) is, like Ollier's incision, begun at the external supracondyloid ridge 3 to 5 cm. ($1\frac{1}{2}$ to 2 in.) above the line of the joint, and is carried downwards practically parallel to the axis of the humerus, *i.e.* vertically downwards to the head of the radius, and from thence along the outer border of the anconeus to the posterior border of the ulna, 3 inches below the tip of the olecranon; finally, the incision terminates by curving inwards over the inner surface of the ulna. The first part of the incision extends down to the outer border and external condyle of the humerus, between the supinator

FIG. 177.—Arthrotomy of the elbow. The incision has been made through the skin and fascia down to the bone, in the interval between the triceps (posteriorly) and the supinator longus and extensor carpi radialis longior (anteriorly); lower down it has been carried through the capsule down to the head of the radius, while in the lowest part of the wound it has passed down to the ulna between the anconeus (posteriorly) and the extensor carpi ulnaris (anteriorly). The lowest fibres of the anconeus have been divided.

longus and radial extensors anteriorly, and the edge of the triceps posteriorly; below the external condyle it passes down to the bone between the extensor carpi ulnaris and the outer border of the anconeus, and divides the strong capsule over the head of the radius together with the annular ligament at its attachment to the ulna. The lower end of the incision divides the lower fibres of the anconeus transversely at their attachment to the posterior border of the ulna, because the muscle extends for a considerable distance down the forearm. The incision, therefore, falls accurately along the interval between the muscles supplied by branches of the musculo-spiral

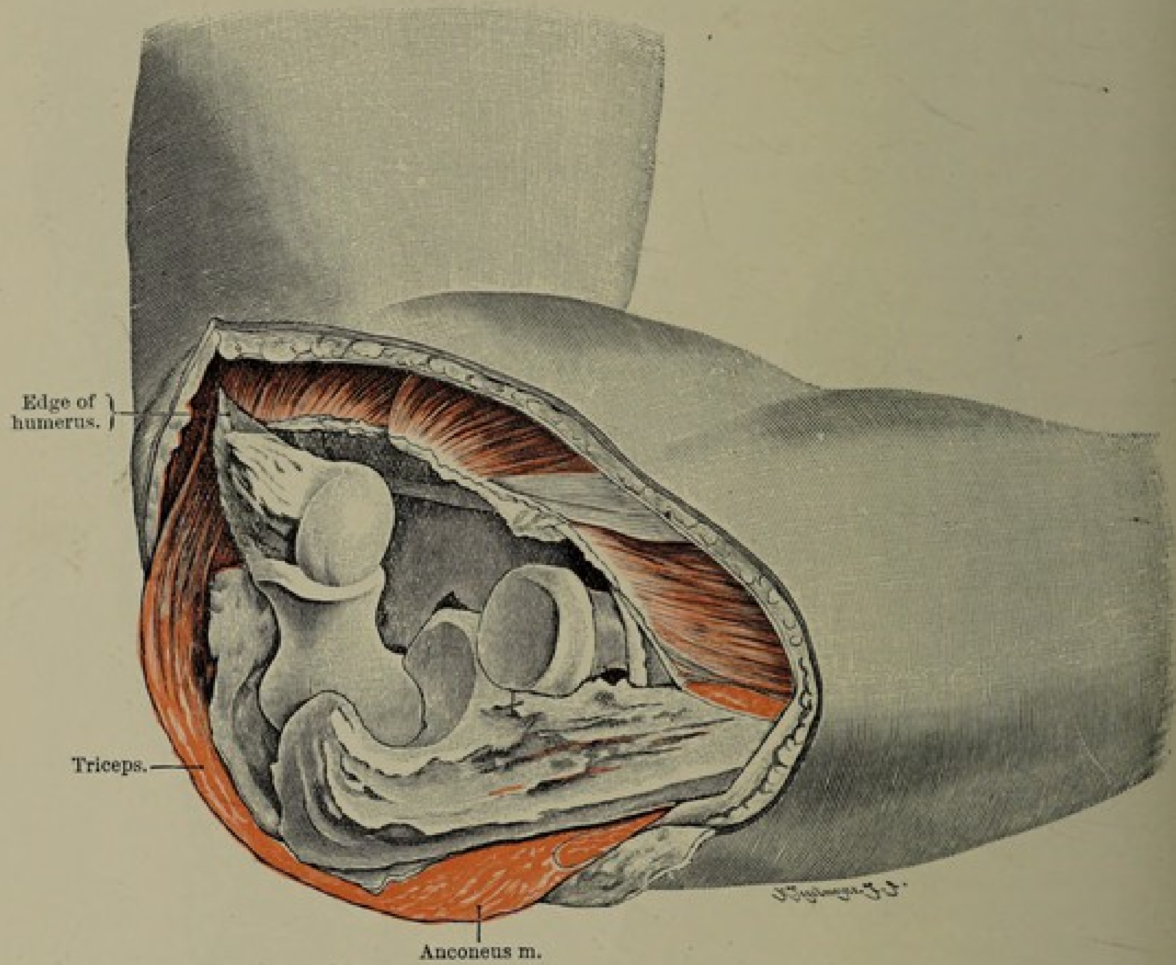


Fig. 178.—Arthrotomy of the elbow after the forearm has been dislocated inwards. The outer surface of the ulna is exposed with the anconeus detached from it. The cut surface of the anconeus is seen below. In the upper part of the wound the supinator longus is seen detached subperiosteally (or subcortically) from below upwards, as are also the extensor carpi radialis longior and brevior, extensor communis digitorum and extensor carpi ulnaris.

nerve and those supplied by the posterior interosseous, thus avoiding the possibility of subsequent muscular atrophy. The bone having been exposed and the capsule divided, the outer head of the triceps, together with the periosteum and the upper attachment of the capsule, is detached subperiosteally from the humerus, the anconeus from the posterior surface of the ulna, the insertion of the triceps from the tip of the olecranon, and the triceps-anconeus flap is (the joint being extended) displaced over the olecranon to its inner side. The external lateral ligament, with the attachments of the extensor tendons and the capsule attached to the external condyle, are separated subcortically with a sharp raspatory from below by means of a chisel and drawn forwards. The joint has now become so movable that the forearm can be

completely dislocated inwards (Fig. 178). The whole extensor apparatus, both as regards muscles and nerves, is preserved in its continuity, and the internal lateral ligament is still intact. If complete resection is to be performed, after dislocating the joint as above described, the internal lateral ligament is separated subperiosteally along with the muscles from the inner border of the ulna and the internal condyle of the humerus, and the ends of the bones are removed. In separating the lateral ligaments it is better to remove a shell of bone along with them, so as to preserve their attachment to the periosteum.

For many years we have been in the habit of making curved sawn surfaces in performing excisions ; here not, as in the knee, merely to join the bones firmly together, but also in order to ensure an angular movement (flexion and extension) at the new joint. It is especially important to saw the olecranon in a curved direction, in order to preserve a lever into which the triceps is inserted. This goes a long way towards preventing partial dislocation forwards of the forearm.

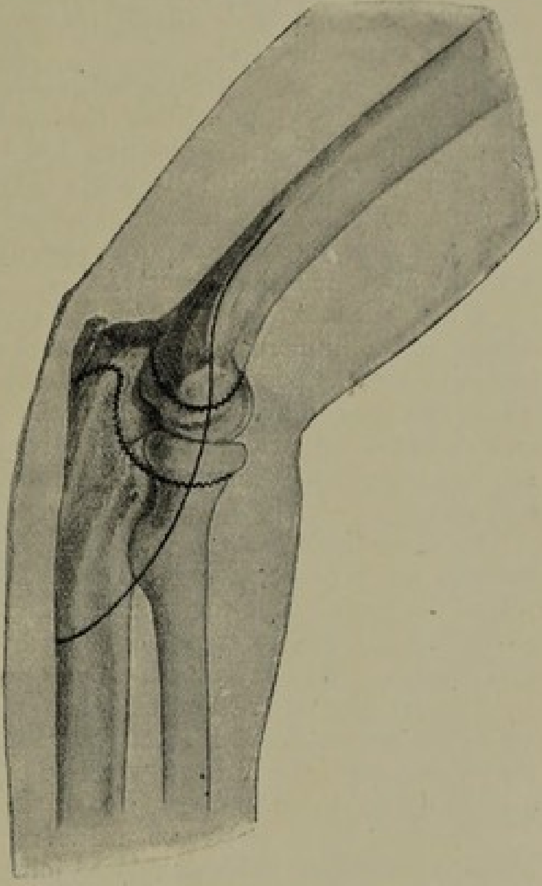


Fig. 179.

We have already stated that as compared with the simple posterior longitudinal incisions, of which Langenbeck's is the most generally employed, the curved incisions, especially advocated by Ollier, have the great advantage of giving more room and better exposure of the joint, especially in the region of the head of the radius. It is not very likely that any one will care to employ transverse incisions (straight or curved), either alone or combined with one or two longitudinal incisions. The main directions of the incision must always be longitudinal if the muscles and their nerves are to be preserved. The only method which we need refer to is that of Auguste Nélaton, which is mentioned by Farabœuf. It has nearly the same direction as our incision, being carried longitudinally over the external condyle of the humerus and then bending at a right angle from the head of the radius towards the ulna. Nélaton's object in employing this incision is to thoroughly expose the head of the radius, but, like Ollier, he pays little attention to the preservation of the anconeus. Hueter, and, according to Farabœuf, Marangos have also recommended skin incisions which are allied to ours, but planned with a different object. Compared with our own method, the lateral transverse incision of Cavazzini is the reverse of an improvement, because it divides the anconeus transversely. He, however, dislocates the joint in the manner we have advised.

No other incision gives equally good access to all parts of the joint with so little injury and with such complete preservation of the important extensor apparatus. Moreover, after making the incision it allows us, better than other methods, either to completely expose (from the outside) and excise the capsule, or to resect the bones subperiosteally, because the incision only lies over the capsule for a short part of its extent.

For cases in which the disease is confined to the olecranon, the simple posterior longitudinal incision of Langenbeck has the advantage that it is carried directly down upon the seat of disease. When the disease is limited merely to the external condyle

or the head of the radius, Cavazzini's transverse external incision is occasionally of value. In all cases, on the other hand, where a thorough view into the joint is desired, our method above described has great advantages, while it is always more advisable to make it a rule to open into the joint.

After-treatment and Results of Resection of the Elbow. In the elbow more than in any other joint one can count with greater certainty on obtaining a freely-movable joint, provided the disease has been thoroughly removed and a mechanically sound new joint has been constructed. No plaster bandages are requisite, as active movements will be resumed in a few days. The forearm must, however, be placed in correct position, as the upper arm has a tendency to become rotated outwards and abducted. It should not be bandaged to the body in the position of adduction and pronation as is the usual practice, but should be placed so that the ends of the radius and ulna are in contact with the end of the humerus (which is rotated outwards). The forearm is simply placed vertically upright and is held in position by means of a curved splint.

In tubercular cases the surface of the wound should be swabbed with an alcoholic solution of carbolic and either thoroughly smeared with freshly-sterilised iodoform powder or paste after the bleeding has been carefully stopped, or the cavity of the wound may be filled with Mosetig's iodoform filling. A drain is inserted through a special opening on the anterior aspect of the joint. If the operation has been strictly aseptic, drainage may, however, be dispensed with, after the joint has been filled with the above-mentioned paste.

When resection has been undertaken for an old-standing dislocation, the sawn surface of the humerus should be smeared with iodoform paste and active movements begun as soon as possible. The same remark applies to the radius and ulna, but as a rule one tries to avoid sawing off the articular ends of the bones of both the upper and forearm. Apart from faulty division of the joint surfaces, neglect of starting active movements at an early stage must be regarded as a frequent cause of subsequent stiffness.

In tubercular cases complicated by mixed infection (sinuses) and also in those cases in which conservative treatment has been persisted in for too long a period, and where the proper time for operation has expired, it is best not to attempt to obtain a movable joint, but to treat the wound by the open method with iodoform plugging and procure solid bony union.

During the after-treatment the upper arm should be laid flat on a table, and while the patient holds it steady with his other hand, he at the same time carries out movements with the forearm which is in the upright position. The movements may be guided by means of an elastic apparatus. Passive movements are decidedly harmful.

Mention must lastly be made of the method which Quénu recommends for obtaining mobility in an ankylosed joint, *i.e.* by the interposition of a portion of the joint capsule and aponeurosis. The technique, however, must be decided in each individual case.

The best results are obtained by interposing the brachio-radialis muscle (supinator longus). It should be detached from the external supracondylar ridge and stitched to the inner side of the triceps tendon, a flap of periosteum being also placed over the joint surface. In tubercular cases it may be necessary to ensure mobility by interposing a layer of deep fascia.

(m) Operations on the Upper Arm

Very extensive operations have often to be performed on the upper arm for necrosis, for tumours of the humerus, and for pseudo-arthrosis. In 1898 we completely excised the humerus for diffuse sarcoma. The operation is done with least injury to the adjacent structures by making an incision upon the outer aspect of the humerus from the anterior border of the deltoid downwards along the external bicipital sulcus. In the upper part of the wound the cephalic vein is drawn inwards, and the anterior circumflex artery is ligatured below the head of the humerus. The lower part of the

incision is carried down to the bone between the outer head of the triceps and the brachialis anticus, the musculo-spiral nerve and inferior profunda artery being retracted posteriorly.

It is satisfactory to note that Rolando (*Clin. chir.*, Milano, 1904) has arrived at an incision which corresponds in every detail with that we have described.

On the inner aspect of the limb the bone is reached alongside the main vessels and nerves (median and ulnar), which are drawn inwards, but the dissection cannot be carried as far upwards and downwards as on the outer aspect. An incision is therefore only made along the internal bicipital furrow with the object of exposing the vessels and nerves or excising limited growths, *e.g.* a diseased lymphatic gland above the internal epicondyle.

In the case of a large osteochondroma of the humerus for which two other authorities had advised disarticulation of the arm, we succeeded in removing the tumour by the two incisions mentioned, and retaining a useful arm.

The best landmarks in examining the upper arm are the internal and external bicipital sulci: the biceps and the long head of the triceps can be gripped between the fingers and raised up from the bone.

The brachial artery can be felt in the entire length of the upper arm along the internal bicipital sulcus, from the head of the humerus, which can be palpated through the axilla, down to the middle of the bend of the elbow: the median nerve, which crosses the middle third of the artery from without inwards, can also be felt, while the artery can be compressed in its whole length against the biceps.

33. Osteotomy and Resection of the Diaphysis of the Humerus. For purposes of excision the relations of the humerus are not so simple as those of the femur. The removal of the upper and lower ends of the bone is considered with excision of the respective joints. The most important relation to be borne in mind is the musculo-spiral nerve, which winds round the posterior and outer aspects of the shaft.

It is mainly in osteomyelitis and fractures of the humerus, pseudoarthrosis (particularly common in this region) and malunited fractures, that the operation is indicated, *e.g.* for adhesions and paralysis of the musculo-spiral nerve.

The external bicipital sulcus is the only line along which the entire length of the diaphysis may be exposed. The circumflex vessels and nerve are to be avoided at the surgical neck. The fascia of the deltoid is divided in order that (the arm being abducted) its anterior border may be drawn outwards; next, the fascia covering the biceps is divided and the bone reached along the outer borders of the coraco-brachialis and brachialis anticus muscles. The musculo-spiral nerve and the accompanying superior profunda artery lie to the outer side, whilst, in the lower third, the musculo-cutaneous nerve, which descends between the biceps and brachialis anticus, is drawn inwards.

(n) Operations at the Shoulder

Operations in the region of the shoulder are most frequently performed in order to open the shoulder-joint, and to remove tumours, especially glandular swellings, from the axilla. The incisions are usually made along the anterior and posterior edges of the deltoid, which can be easily felt. If this does not give enough room, an additional incision may be made along the origin of the deltoid from the acromion process and clavicle, or along the spine of the scapula (see the anterior and posterior incisions for excision of the shoulder described on pages 320 and 322). The axilla may be opened up by an incision parallel to the furrow between the upper arm and thorax, *i.e.* crossing the folds of the axilla (sagittal incision), this latter incision giving good access to the axillary space without injuring the deeper structures. On bringing the arm to the side, the edges of the wound come together naturally, so that sutures are unnecessary. The sagittal axillary incision is especially useful for tumours of the glands, as well as for exposing the lower border of the glenoid cavity and the head of the humerus, when the latter has been dislocated forwards. In making the incision the arm should be well abducted.

34. Arthrotomy, Arthrectomy, and Resection of the Shoulder-Joint. (*a*) *From the front*—in disease of the head of the bone, or in old-standing anterior dislocations (Figs. 180 and 181).

The head of the humerus overlaps the glenoid cavity to a considerable extent anteriorly. The diameter of the latter in the horizontal direction is only half that of the cartilaginous portion of the head; so that to expose the head from the front is easy, while exposure of the glenoid is difficult. The simplest method is by the anterior longitudinal incision employed by Baudens, Malgaigne, Roeret, Dubreuil, and developed especially by Langenbeck and his pupils. The improvement by Hueter, Ollier, Chauvel, and Spence, which consists in making an oblique incision to preserve the deltoid (instead of the vertical incision downwards through it from the acromion), appears to be the most rational procedure, because this muscle plays the chief part in the subsequent movements of the arm.

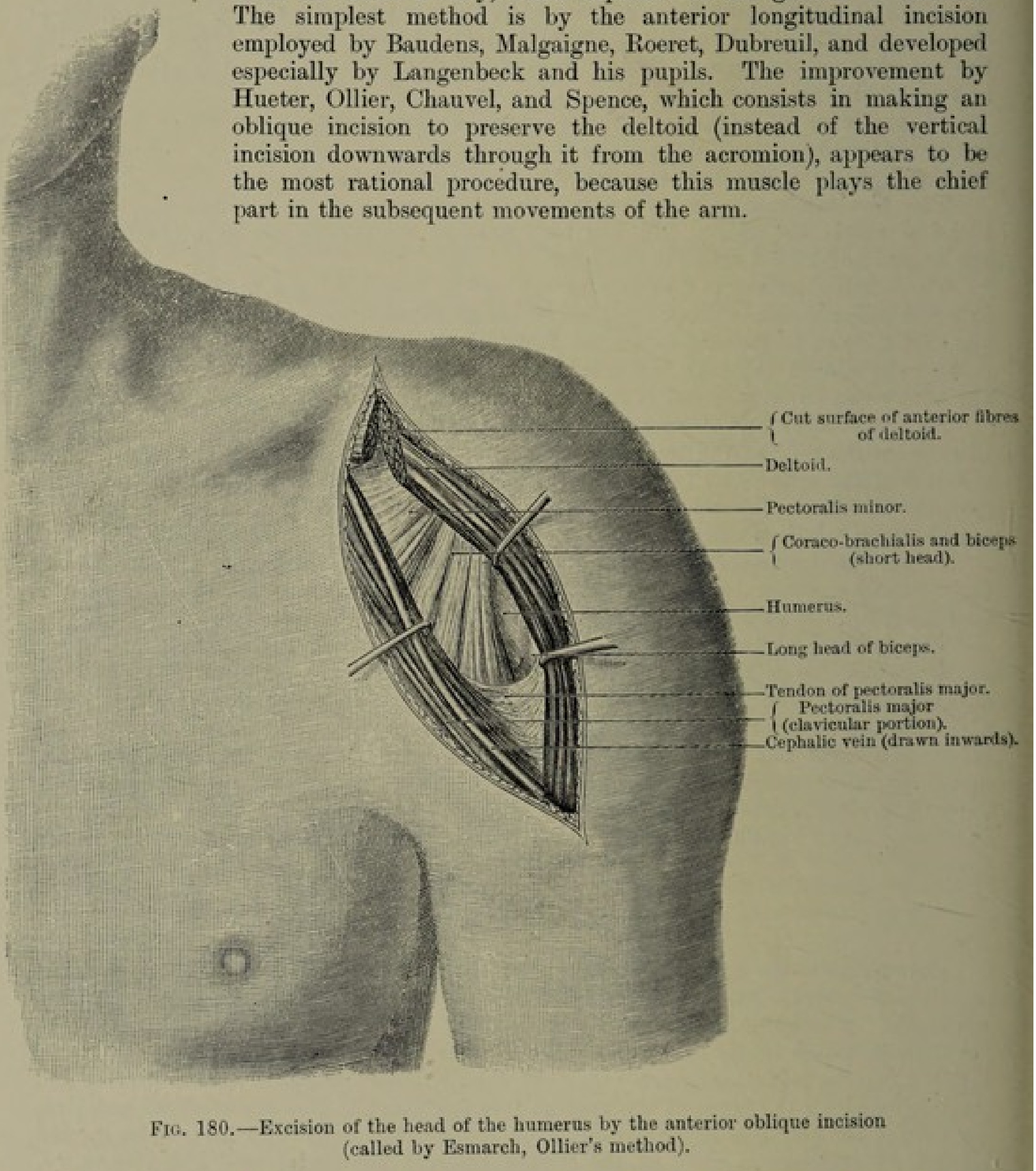


FIG. 180.—Excision of the head of the humerus by the anterior oblique incision (called by Esmarch, Ollier's method).

The incision begins upon the clavicle above the coracoid process, and passes downwards along the anterior border of the deltoid. The edge of this muscle, which lies close to the clavicular portion of the pectoralis major, is recognised by its relation to the cephalic vein, which is drawn inwards along with the pectoral muscle, the deltoid being drawn outwards. The upper and anterior fibres of the latter muscle are divided close to the clavicle, and a branch of the acromio-thoracic artery which lies under it is ligatured.

The muscles attached to the coracoid process, viz. the pectoralis minor, the short head of the biceps, and the coraco-brachialis, now appear, in front of which, at the lower part of the wound, the upper edge of the smooth tendon of the pectoralis major is seen passing to its insertion into the humerus. The arm being slightly rotated inwards, the sheath of the biceps tendon is opened by cutting down to the bone at the outer border of the above muscles, where the bicipital groove may be distinctly felt. The sheath is now slit up along with the capsule as far as the edge of the glenoid, and the tendon which is thus freed is drawn inwards. The biceps tendon is exposed, not only that it may be preserved, but in order that the upper end of the bone may be rendered accessible along the line of the

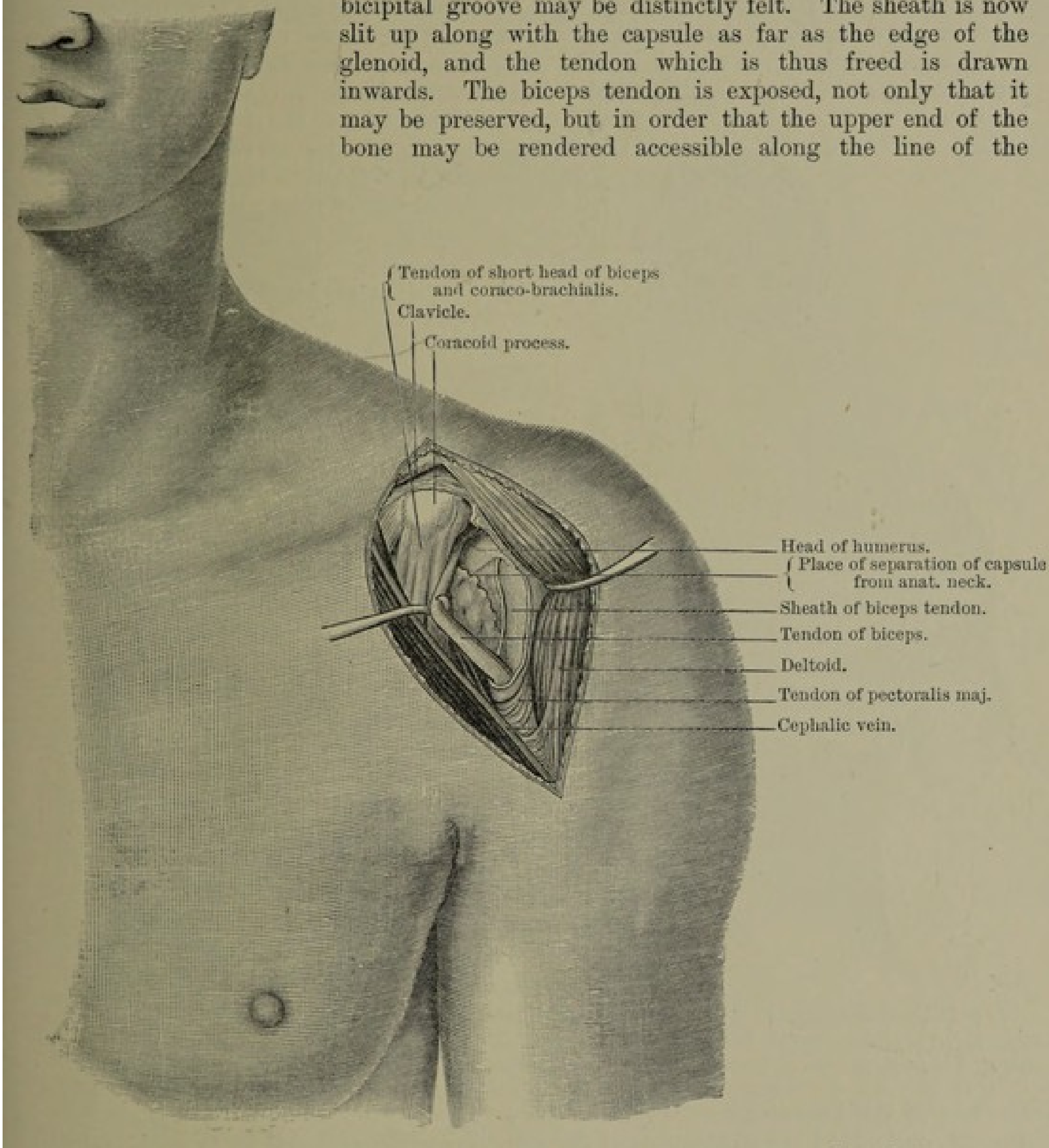


FIG. 181.—Excision of the head of the humerus by the anterior incision. Second stage: the biceps tendon is lifted out of its sheath, and the joint is opened.

bicipital groove which corresponds to the boundary between the attachments of the anterior and posterior muscles. The tendons which are inserted into the upper end of the humerus and the capsule, viz. the subscapularis into the lesser tuberosity, the supraspinatus, infraspinatus, and the teres minor into the greater tuberosity, are now separated close to the bone by means of vertical cuts made parallel to the bicipital groove. In doing this the humerus is rotated first outwards and then inwards. *No* transverse incision is to be made in the capsule. In cases in which the humerus must

be exposed farther downwards, the anterior and posterior circumflex arteries and the circumflex nerve which surround the surgical neck must be borne in mind, and the former if necessary ligatured. Catterina has obtained better access from the front by carrying the incision obliquely across the clavicle, dividing the latter in its outer third, and dislocating it backwards along with the deltoid, after first of all dividing the attachment of the trapezius above and the coraco-clavicular ligament below.

(*b*) *Resection from behind* (Figs. 182 to 186) is employed when the disease involves more especially the glenoid cavity, or in diffuse disease of the joint.

The skin incision, as shown in Fig. 182, is carried from the acromio-clavicular joint over the top of the shoulder and along the upper border of the acromion to the outer part of the spine of the scapula (root of the acromion), and from thence downwards in a curved direction towards the posterior fold of the axilla, ending two fingers'-breadth above it. The upper limb of the incision passes through the superior ligament right into the acromio-clavicular joint (the strong fibres of which are divided), and in the rest of its course divides the insertion of the trapezius along the upper border of the spine of the scapula. The descending limb of the incision divides the dense fascia at the posterior border of the deltoid, and exposes the fibres of the latter. The thumb is now introduced beneath the smooth under surface of the deltoid so as to separate it from the deeper muscles (with which it is connected merely by loose cellular tissue) up to its origin from the acromion, and its posterior fibres are divided. The finger is then carried along the upper border of the infraspinatus muscle so as to free it opposite the outer border of the spine and the root of the acromion.

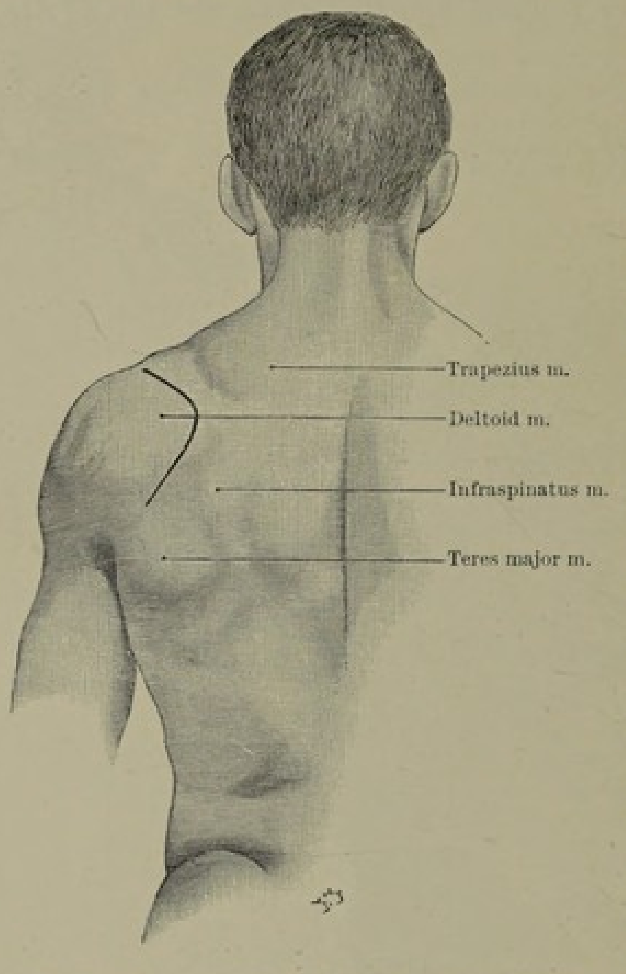


FIG. 182.—Arthrotomy of the shoulder by posterior curved incision.

In a similar manner the lower border of the supraspinatus is detached with a blunt dissector from the upper border of the spine of the scapula, in order that the finger may be passed from above underneath the root of the acromion. The root of the acromion, which is now freed, is chiselled through obliquely towards the neck of the scapula, and the acromial portion, along with the deltoid, is forcibly pushed forwards with the thumbs over the head of the humerus.

In chiselling through the bone, care must be taken not to injure the suprascapular nerve which passes under the muscles from the supraspinous into the infraspinous fossa by avoiding too deep division of the scapular spine; the nerve is also protected by the transverse ligament of the scapula. It is desirable before chiselling the bone to bore the holes required for the subsequent suture.

Instead of dividing the root of the acromion, the formation of the posterior flap may be simplified by merely detaching the scapular origin of the deltoid subcortically: this allows of a subsequent very firm union.

After reflecting the acromio-deltoid flap, the head of the bone is readily accessible

in its upper, outer, and posterior aspects, covered by the tendons of the external rotators, viz. the supraspinatus, infraspinatus, and teres minor muscles. The posterior surfaces of these muscles are also exposed. An incision is now made over the head of the bone, and in order to avoid unnecessary injury this must be done accurately. The assistant pushes the head of the humerus backwards and upwards, rotating it at the same time outwards, till the bicipital groove is felt. Posteriorly, where the muscles and their tendons are inserted into the greater tuberosity and the spine of the greater

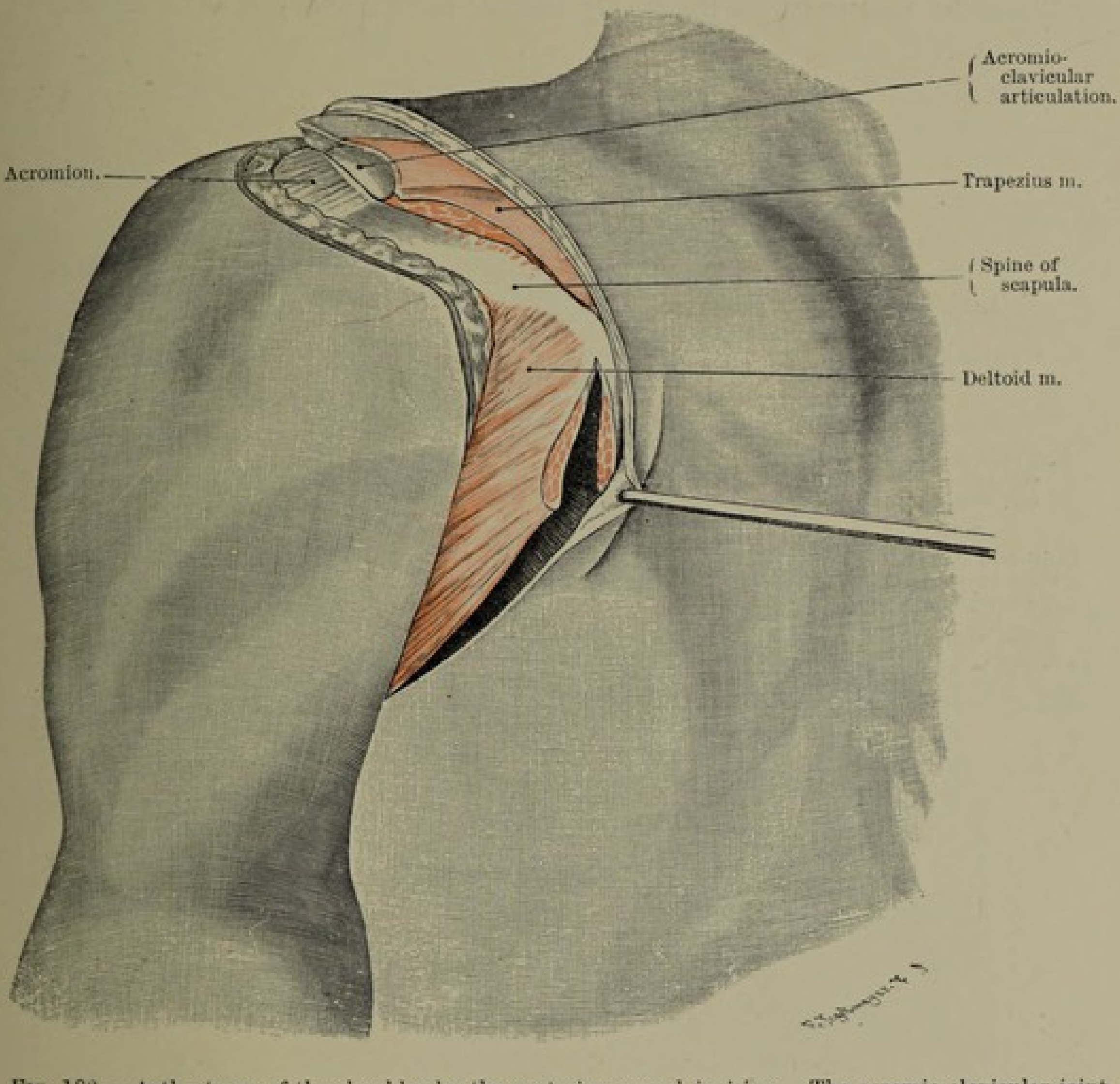


FIG. 183.—Arthrotomy of the shoulder by the posterior curved incision. The acromio-clavicular joint is opened and the trapezius is detached from the upper border of the spine of the scapula. The deltoid is exposed along its lower border, and its attachment to the spine is divided posteriorly, and at this point, after detaching the supra and infraspinatus muscles, the chisel is inserted to divide the spine of the scapula.

tuberosity, a longitudinal incision is carried down to the bone in the coronal plane. It extends upwards through the capsule along the anterior edge of the insertions of the external rotator muscles and over the highest part of the head of the humerus, so as to expose the tendon of the biceps as far as its attachment to the upper edge of the glenoid cavity. The insertions of the external rotators are now separated from the greater tuberosity and drawn backwards. The biceps tendon is freed from its groove and drawn forwards, so that its sheath may be inspected. The whole procedure is made easier by carrying the elbow forwards and at the same time rotating the arm outwards, and pushing it backwards.

In this way the entire head of the humerus and the glenoid fossa can be freely exposed, and if it is not necessary to perform a complete excision, the anterior wall of the capsule and the insertions of the anterior muscles can be preserved. In other cases the insertion of the subscapularis into the lesser tuberosity is detached upwards and inwards.

The circumflex vessels and nerve which emerge from under the teres minor can be preserved: indeed, if the operation be properly performed there need be no fear of injuring them.

When the head has been thoroughly cleared, and especially if it be excised, an

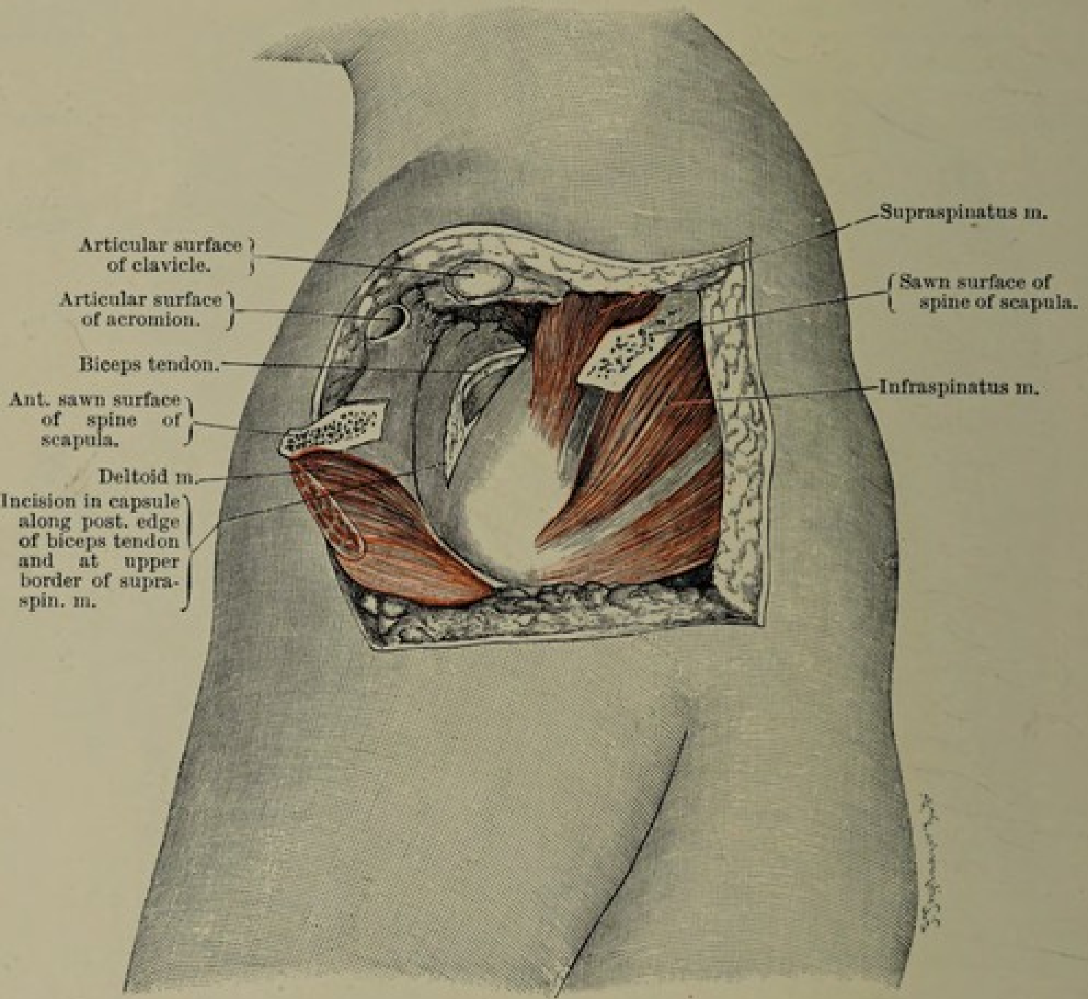


FIG. 184.—Arthrotomy of the shoulder. The flap, consisting of skin, deltoid, and acromion, has been thrown forwards. The capsule has been incised immediately behind the long tendon of the biceps, at the upper border of the supraspinatus.

excellent view of the glenoid is obtained, much better than is possible by the anterior incision; and as it is most important to remove all the infected tissues in tuberculous disease, this complete exposure of all parts of the joint is the great advantage of the method. Moreover, this free exposure is obtained without interfering with the function of the deltoid or other muscles of the shoulder. Yet another advantage over the anterior method is, that when the disease in the head is limited or absent, only the posterior muscles require to be separated, while the anterior part of the capsule, the coraco-humeral band, and the subscapularis muscle are preserved intact, and in this way there is no tendency or the head of the bone to be displaced upwards towards the coracoid, which so frequently occurs as the result of the anterior operation. The method is therefore especially valuable in partial arthrectomies.

Neudörfer has recommended an incision below the acromion, while MacCormac recommends a posterior longitudinal incision, but they have not found favour, as they do not give sufficient space.

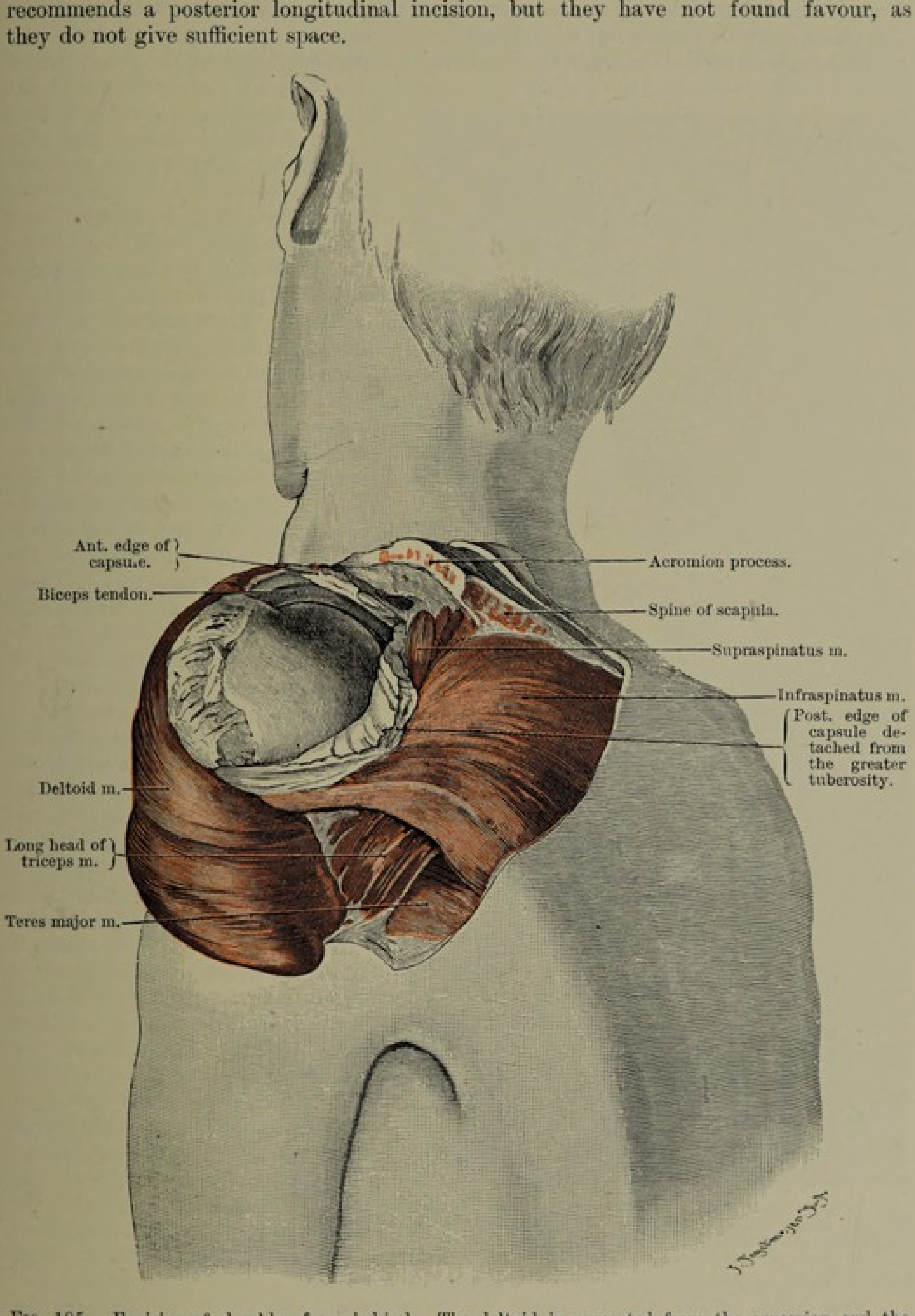


FIG. 185.—Excision of shoulder from behind. The deltoid is separated from the acromion and the spine of the scapula; the bone is not yet divided. The capsule has been incised at the upper border of the supraspinatus, and has been stripped backwards off the head of the humerus along the greater tuberosity.

The excellent results to be obtained by our method are shown in Fig. 186. It

represents a resection of the shoulder-joint performed by Dr. Lardy for fracture through the tuberosities of the humerus with rotation of the head of the humerus. The photograph was taken five months after operation.

In ankylosis of the shoulder Coville obtains a movable joint by the interposition of a flap of the deltoid. If the anterior operation is used, a strip of the deltoid is taken from the front of the clavicle; but with our posterior method it is even better to detach a flap from the fibres attached to the spine of the scapula, and stitch it to the intact anterior wall of the capsule.

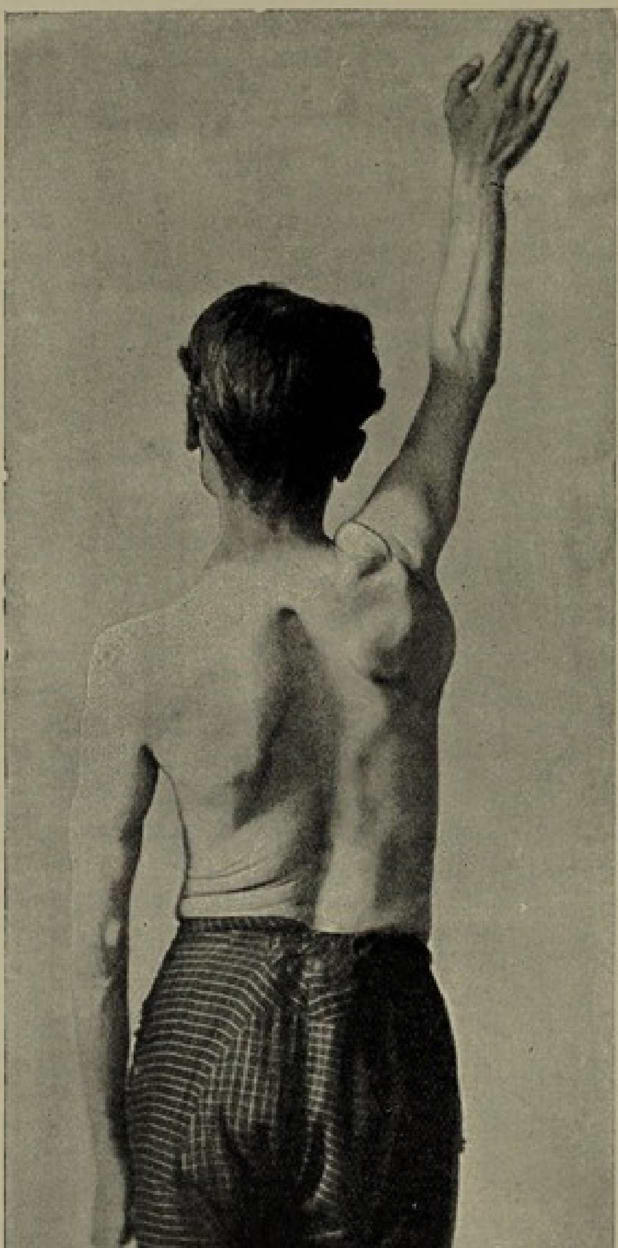


FIG. 186.—Excision of the shoulder for tubercular disease, with fracture and rotation of the head of the humerus.

Total Arthrectomy of the Shoulder-Joint. Bardenheuer performs a total extracapsular excision of the shoulder in a similar manner to that already described for the hip. The advantages of this operation have been dealt with in connection with the knee, of which the procedure was given in full detail. He detaches the insertions of the muscles along with a scale of bone behind, in front, and below, and then removes the head of the humerus below the attachment of the capsule without opening into the joint. The scapula is then divided above the capsule with a saw or chisel and the coracoid process is detached, by which means he is able to remove completely the whole joint together with the capsule and articular ends of the bones.

From the point of view of a radical removal of the tuberculous tissue such an operation is certainly the most thorough, but, as has been already pointed out in the case of the hip, healthy bone is sacrificed (since the limits of the disease cannot be determined beforehand), while the newly-formed joint surfaces cannot be closely fitted to each other. In addition, the subscapular bursa must be opened, and may prove a source of infection. The use of the method should be restricted to advanced cases of diffuse disease.

The excellent functional results that Bardenheuer obtains, in spite of the unnecessary sacrifice of bone, depend on the fact that a complete removal of all the disease is effected. In our opinion, however, equally good results can be obtained by less drastic measures, combined with suitable after-treatment.

After-treatment. We agree entirely with Bardenheuer that active movements should be commenced at an early stage, if satisfactory functional results are to be

obtained. We also agree that in the shoulder, as with the hip, the after-treatment should start with extension. Bardenheuer properly applies extension with the arm strongly abducted (it may even be elevated), because the patient recovers the power of adduction well enough, thanks to the weight of the arm; while the abducted position further allows satisfactory access to a posterior wound. Elevation forwards, which is naturally combined with it when the patient is recumbent, is only of advantage for later use. For the initial exercises, the arm is kept raised up by means of a weight and pulley, so that the patient has not to contend against the weight of the arm.

Thorough drainage must be provided, the tubes being introduced through special openings. The wound, which has been well smeared with iodoform, should then be dressed with a plentiful supply of iodoform gauze, over which several layers of antiseptic gauze are applied, so that the deep dressings need not be changed for the space of from eight to ten days. In suitable cases we do not employ drainage, and obtain primary union if the cavity is filled with iodoform paste (Mosetig).

When the muscles are much atrophied, plaster bandages should be applied and a stiff joint obtained, while if sinuses are present, the wound must be treated by the open method and packed.

35. Resection of the Clavicle, and of the Sterno-Clavicular, and Acromio-Clavicular Articulations. As the clavicle is subcutaneous throughout its whole length, its excision is a simple matter, provided it can be done subperiosteally. After dividing the skin, platysma, clavicular branches of the descending superficial cervical nerves, and fascia, the periosteum is divided and reflected. The clavicle should be sawn through in the middle, as it is then easier to clear each half separately. The clavicular attachments of the sterno-mastoid and trapezius muscles are detached from the upper surface, and the clavicular portions of the pectoralis major and deltoid from its anterior surface, whilst from its under surface the subclavius muscle and the costo-clavicular ligament are to be separated.

In tumours of the clavicle (sarcoma) the incision is made over the tumour, outwards and slightly upwards, along the clavicle. The skin and fascia are dissected off the tumour, the clavicular branches of the descending superficial cervical nerves being divided, along with small branches of the external jugular vein behind the sterno-mastoid. The posterior border of this muscle is raised, and its clavicular origin divided well wide of the tumour, the clavicular insertion of the trapezius being also cut across. The clavicular origins of the pectoralis major and the deltoid are next divided, free of the disease. The periosteum can now be incised over the healthy part of the bone in front of the limits of the tumour, and reflected from the lower surface. The knife or scissors are only necessary for division of the tendinous insertion of the subclavius into the junction of the middle and outer third of the clavicle and for the coraco-clavicular and costo-clavicular ligaments. Before dividing these tough structures the acromio-clavicular joint is opened, and the outer end of the clavicle forcibly pulled upwards with a hook. The subclavian vein, which lies behind the subclavius muscle, is thus easily avoided.

In excision of the *acromio-clavicular joint* the outer end of the clavicle is freed merely by cutting through the strong ligaments upon the surface of the joint.

There is no difficulty in excising the *sterno-clavicular joint* by an anterior incision, because the meniscus facilitates the separation of the articular ends. When, however, the excision cannot be made subcapsulo-periosteally, the transverse vein at the suprasternal notch must be kept in mind in dividing the interclavicular ligament, while in dividing the clavicular portion of the sterno-mastoid the anterior jugular vein, which runs outwards behind it to open into the external jugular, is to be looked out for. In extensive division of the subclavius muscle and the costo-clavicular ligament, the close proximity of the pleura and of the subclavian vein must not be forgotten.

Tuberculous arthritis not infrequently affects both joints. Resection may also be indicated in dislocations.

36. Resection and Total Excision of the Scapula (Fig. 187). *Complete* excision

of the scapula was first performed by Langenbeck (Gies) in 1855. Ceci, and more recently Picqué and Dartigues have shown what excellent functional results can be obtained after its complete removal. A useful arm is obtained even although part of the clavicle or the head of the humerus is removed. The difference, however, between a subperiosteal and parosteal removal is very considerable, so far as the subsequent functional result is concerned. The subperiosteal operation is employed mainly in cases of acute osteomyelitis with necrosis, where the periosteum has already been separated to a considerable extent; the operation is then comparatively easy. Unnecessary injury to neighbouring parts may be avoided by beginning the dissection over the spine of the scapula and keeping close to the bone; while it is of the utmost importance that the suprascapular nerve, which is in close contact with the back of the neck of the bone, should not be injured. In such cases, as has been proved by Bockenheimer's recent experiences, almost complete regeneration of the scapula results, while the normal mobility of the shoulder is also restored. On the other hand, when we have to deal with a tumour, all hope of movement at the shoulder must be abandoned, and one must be content to preserve the valuable movements of the elbow, hand, and fingers. Total excision is really only indicated in the various forms of sarcoma; and then, to avoid recurrence, one has to remove the muscles as well, *i.e.* the muscles which are inserted into the scapula or which pass from it to the arm.

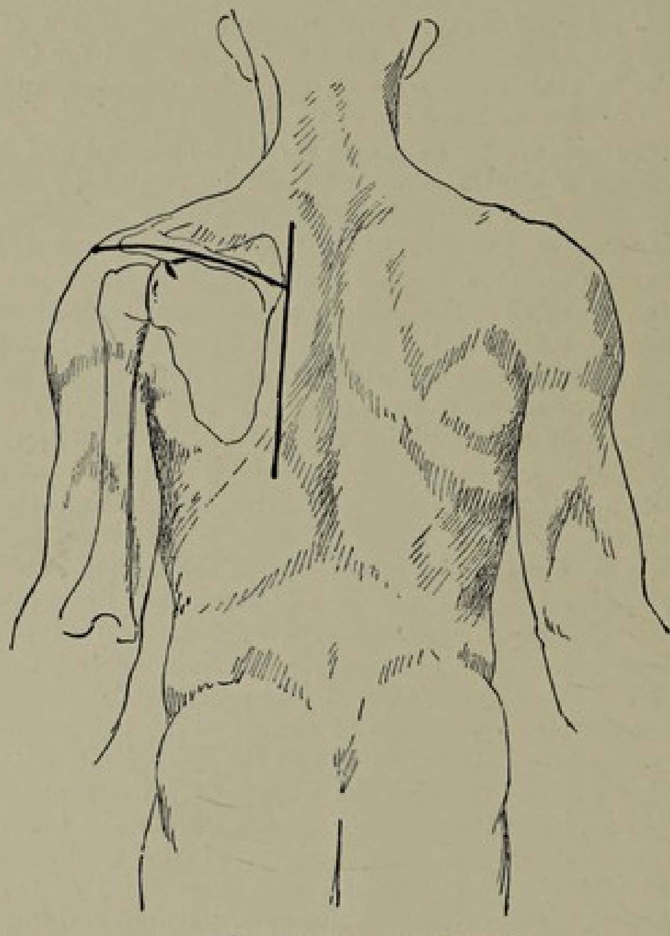


FIG. 187.—Excision of the scapula.

Excision of the Entire Scapula for Tumours. A curved incision is made along the acromion and spine of the scapula as far as its vertebral border. A second incision is carried along the vertebral border of the bone from its superior to its inferior angle. As far as the function of the arm is concerned, it is a great advantage if a considerable portion of the acromion can be retained, because the trapezius and deltoid muscles are attached, the former to its inner and the latter to its outer border. If the whole acromion is to be removed, the incision extends at once into the acromio-clavicular joint. If a portion of the acromion is to be preserved, the bone is divided with the chisel at the place selected.

The lower triangular flap is thrown back over the posterior fibres of the deltoid anteriorly, and the ascending portion of the trapezius posteriorly, as far as the upper edge of the latissimus dorsi. The finger is introduced under the exposed posterior border of the deltoid, and the muscle is divided (if the disease admits) close to the spine and acromion as far as the acromio-clavicular joint, or to the place where the acromion has been chiselled through.

In this way the posterior surface of the shoulder-joint, together with the tendons of the external rotators, is exposed in the same way as in our method of excising the shoulder-joint by the posterior incision. If the articular portion of the scapula can be retained, muscle after muscle is cut across upon an elevator, or upon the finger

introduced beneath them. If, however, the articular portion of the scapula must be removed, the tendons are detached from the head of the humerus just as in excision of the shoulder-joint, viz. the supraspinatus, infraspinatus, and teres minor from the greater tuberosity, the subscapularis from the lesser tuberosity, and farther down the united insertions of the latissimus dorsi and teres major muscles from the inner bicipital ridge.

The circumflex nerve and the posterior circumflex artery are to be avoided, or the latter may have to be ligatured at the lower border of the teres minor, whilst farther backwards the dorsalis scapulæ artery must be ligatured.

Next follows the division of the trapezius. The finger is introduced under its fibres from the place where the acromion is divided, and the muscle is detached along the acromion and spine. The acromial branches of the acromio-thoracic artery will require to be ligatured in separating the anterior part of the muscle.

By drawing downwards the scapula, which has now become more movable, the muscles attached to its upper border are separated from before backwards, viz. coraco-brachialis, short head of biceps and pectoralis minor from the coracoid process (or the process may be chiselled off) the omo-hyoid (with ligature of the suprascapular artery) and the levator anguli scapulæ at the upper angle, branches of the posterior scapular artery being ligatured.

There still remains the broad insertion of the serratus magnus at the vertebral border, in dividing which the scapula is to be rotated towards the spine. Lastly, the insertions of the thin rhomboid muscles are cut across, the posterior scapular artery, which descends along the vertebral border of the scapula upon the serratus posticus superior muscle, being ligatured if necessary.

Buchanan (1900) has collected seventy-two cases of Langenbeck's total excision of the scapula, with 15·3 per cent deaths. In ninety-two cases partial excision was performed with 18 per cent deaths.

Quénu and Renon have shown that the subsequent functional results are better if the acromial end can be retained and the remains of the capsule, as well as the stumps of the muscles, are sutured to it.

In a partial excision, especially of the scapular spine, shorter incisions along the same lines should be made. An anterior incision is only required for the removal of the coracoid process. Good functional results are obtained provided the articular and acromial portions of the scapula can be retained.

As regards the after-treatment of a total excision, the essential feature is to provide a fixed point for the head of the humerus. In the first place the head must be fixed by stitching the capsule and any available stumps of tendons to the clavicle, silk sutures being used, after which the stability and functional efficiency of the joint may possibly be increased by suture of the muscle.

The upper border of the deltoid, apart from the portion that may have been left attached to the acromion, is then stitched along with the trapezius, omo-hyoid and levator anguli scapulæ, while the muscles arising from the coracoid process are sutured to the clavicle.

It is well to follow Bardenheur's advice and lay the arm in a position of abduction and elevation, so that the function of the most important muscle may be retained.

The above precautions are still more necessary if the head of the humerus, with or without a portion of the diaphysis, has been removed along with the scapula. Even then, however, the useful movements of the elbow, wrist, and fingers are preserved.

B. AMPUTATIONS AND DISARTICULATIONS

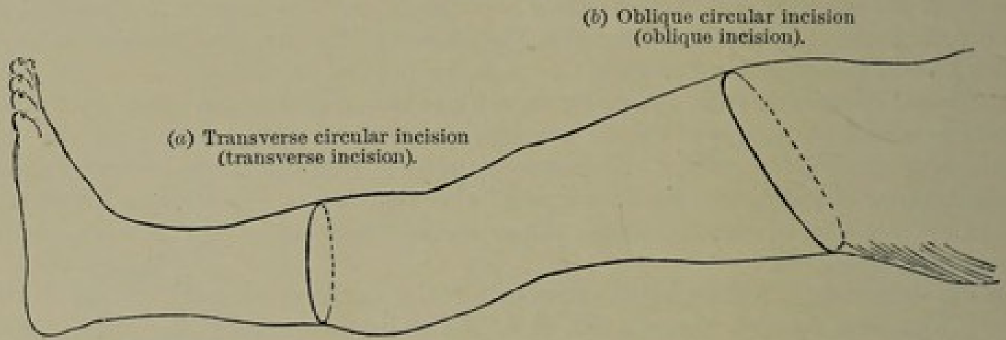
(a) Introduction

Since our last edition, the advances made in the methods of performing amputations and disarticulations lie in the direction of paying even more attention than formerly

to obtain a useful stump, Bier having given a useful impetus to the efforts in this direction. Since asepsis has been ensured and perfect healing obtained in amputations as in other wounds, more care has been bestowed on the shape of the stump as well as on provision of the best possible function. Further, greater simplicity has been attained. To illustrate this we reprint from the third edition the chapter on the evolution of the different methods of amputation, and the manner of carrying them out; and we shall describe the normal procedure which is applicable in all cases.

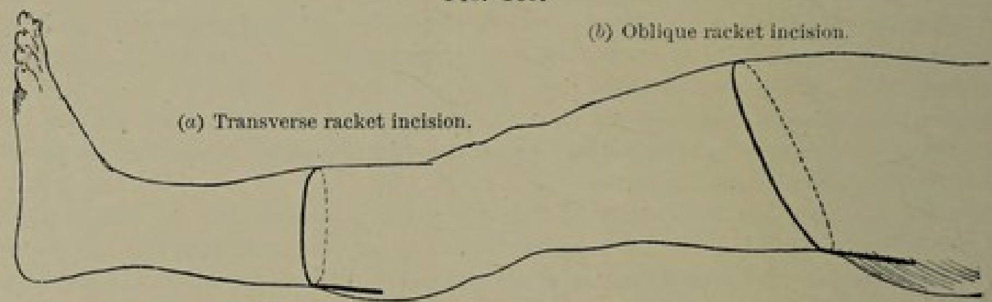
METHODS OF AMPUTATION.

FIG. 188.



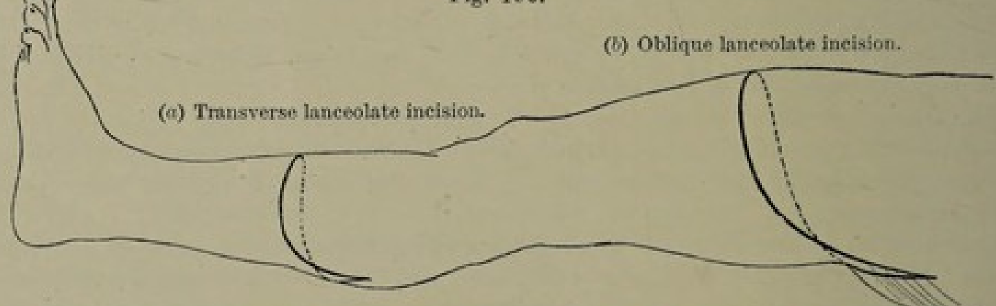
I. Fundamental type: circular incision.

FIG. 189.



II. Addition of a longitudinal incision, to simplify the operation: racket incision.

Fig. 190.



III. Angles of the racket incision rounded off so as to allow of the incision being made more rapidly by one sweep of the knife: lanceolate incision.[1]

(b) Evolution of the Methods of Amputation

The oldest method of performing amputation of the limbs, which as it were of itself was enforced upon the older surgeons, is extremely simple. A circular incision is carried down to the bone above the part of the limb to be amputated, and the soft parts are stripped off the bone, so that when the latter is sawn across they can be

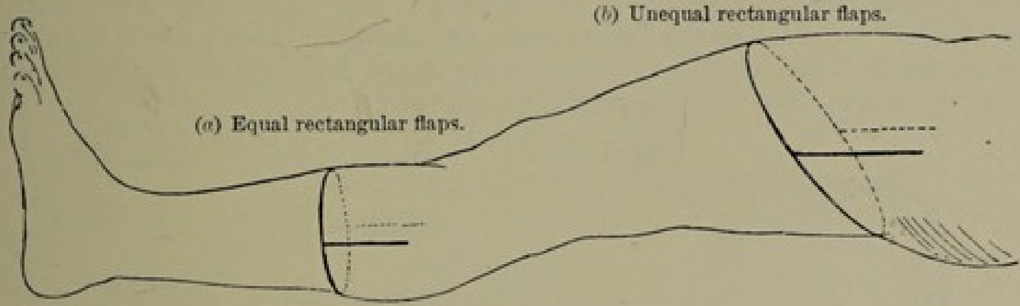
[1] Formerly termed "oval incision"; a pointed figure, however, is not an oval. The term "oval incision" would apply only to our oblique incision (Fig. 188).

made to cover the stump without any tension. If the bone cannot thus be shelled out through a transverse incision alone, a single, or two longitudinal incisions should be added, also carried down to the bone (racket and rectangular flap). This simple process has in course of time undergone so many variations that the most modern surgery has, as it were, had to rediscover it. Neudörfer, Bruns, and others have shown that the best covering for the end of the bone is obtained by placing over it the periosteum and the soft parts entire, with as little injury as possible, the soft parts being divided down to the bone, and the periosteum cut through farther up, so as to get a covering for the sawn surface.

In order to show the connection between the different methods of amputation we give in Figs. 188 to 190 a general view of the evolution of the more complicated incisions from the simple circular methods.

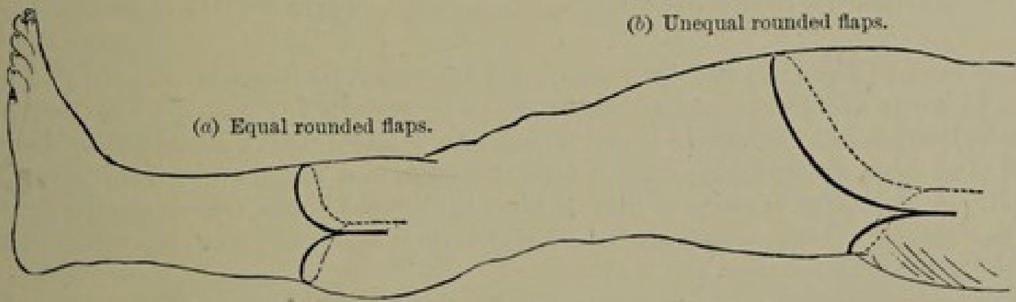
The circular method (better called the transverse method) is the oldest, and consists in carrying a transverse incision right round the limb in a plane at right angles to its long axis. If the plane is oblique to the axis of the joint, an oval incision results

Fig. 191.



IV. Two longitudinal incisions added to the circular incision : rectangular flaps.

Fig. 192.



V. Angles of the rectangular flap rounded off : rounded flaps.

(Fig. 189) (better described as the oblique method, the oval often being of an irregular form). From the transverse circular and oblique circular incisions, all other methods are derived by the addition of longitudinal incisions with rounding off of the angles formed. If a longitudinal incision be added to a circular one, a *racket incision* results, and by rounding off the corners, the so-called *oval incision*, better termed the *lanceolate incision* (as an oval with a pointed extremity is not really oval). If two longitudinal incisions are added, *rectangular flaps* are produced, and by rounding off the corners the *typical horse-shoe flap* is the result.

The *transverse circular incision*, or shortly the *transverse incision* (Figs. 188 and 193), is the fundamental type of one method of amputation. It originated as a single incision from Celsus, as a double incision, with higher division of the muscles, from Cheselden and Petit (Schede). The process of sawing the bone higher up was introduced by Louis and Boyer. According to Freres's description, Celsus divided the soft parts on one side and separated them from the bone, in fact practising what, with

some modification, has been lately recommended by Bruns and Neudörfer. The present circular method was introduced by Bell and Hay (Treves).

While this operation is simple in execution, it has a number of disadvantages which prevent it being universally employed. (1) Since in an amputation one endeavours to preserve as much as possible, the oblique incision is preferable whenever there is more healthy skin on one side than on the other, or when the skin on one side is more adapted for a covering. (2) The separation of the skin to a sufficient extent is difficult where the limb to be amputated is conical. (3) In the transverse circular incision the cicatrix comes to lie upon the end of the stump, which is not the case with the oblique incision. Figs. 193 and 194 sufficiently illustrate the different positions of the lines of suture.

It is evident, therefore, that on the above grounds the *oblique circular incision* (Figs. 188 and 194) has a far wider range of employment, because it is applicable to most cases, is easily performed, and gives a movable skin-covering free from a cicatrix over the end of the stump. The oblique circular incision is, therefore, the method to be selected in the majority of amputations and disarticulations when no special indications are to be fulfilled.

The circular incision (transverse or oblique) in one plane does not always give sufficient space for dividing the deeper parts, especially the bones; and it is on account of the mechanical difficulties that more complicated incisions are employed, viz. the addition of *longitudinal incisions* to the circular one.

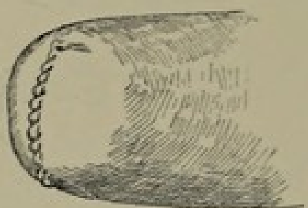


Fig. 193.—Position of the line of suture by the transverse circular incision.

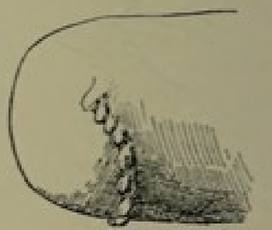


Fig. 194.—Position of the line of suture by the oblique incision.

The *racket* (Fig. 189) and its variety, the *lanceolate incisions* (Fig. 190) give better access to bones and joints, and are therefore to be preferred in difficult disarticulations, if the indication is to retain as many muscles as possible in the stump, as in disarticulation (and high amputation) at the hip, shoulder, and carpo-metacarpal joint of the thumb. A further advantage of this incision is that the larger vessels can be ligatured and the larger nerves cut across before the limb is severed. The lanceolate incision requires more practice than the racket.

Neudörfer (Wanach), and subsequently Chaput, have recommended, as the typical method for all amputations, that in which a longitudinal incision is first made down to the bone, which is then chiselled through at the upper end of the incision and removed with subperiosteal (subcortical) separation of the soft parts, the latter being then divided transversely at a lower level. This is practically a racket incision.

The flap methods (Figs. 191, 192), in the form of skin flaps (Lowdham), of skin and muscle (Ravaton), and the transfixion flaps (Vermale) are more satisfactory when the skin or subjacent muscle demand special attention upon one or other aspect of the limb, and when the oblique incision is too difficult. This is the case, for example, as regards the skin of the sole and heel, the muscles of the shoulder and hip. The disadvantage of the flap method, which applies also in a less degree to its fundamental type, the oblique circular incision, is the defective nutrition of the skin.

(c) Performance of the different Methods

The transverse circular method (Figs. 195, 196). The skin and superficial fascia are divided circularly at right angles to the axis of the limb, first upon the under and

then upon the upper segment of the circle. The assistant retracts the skin well upwards with both hands whilst the knife divides the fibres which are stretched between the superficial and deep fascia. The superficial muscles are then divided, and at the level up to which they have retracted the incision is continued through the deeper muscles down to the bone. The height at which the bone is sawn across above the skin incision is equal to fully half the diameter of the limb. The soft parts must

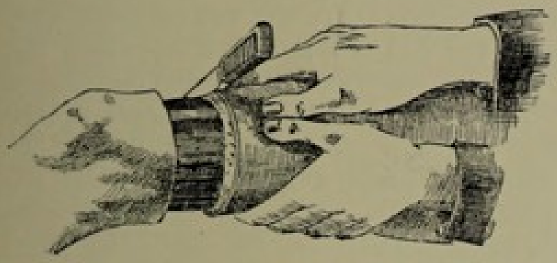


FIG. 195.—Transverse circular incision: method of retracting the skin, and position of the knife.

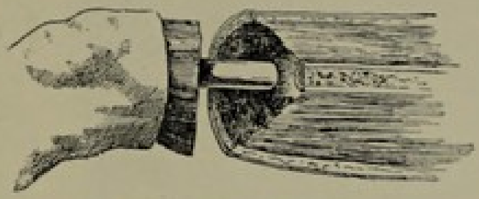


FIG. 196.—Transverse circular incision: Sagittal section, to show the hollow cone which is left after sawing through the bone.

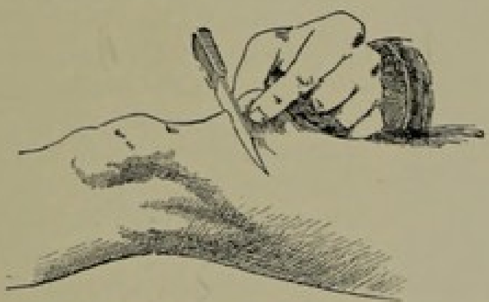


FIG. 197.—Oblique incision: the lower end made by cutting across a fold of skin raised up between the finger and thumb.

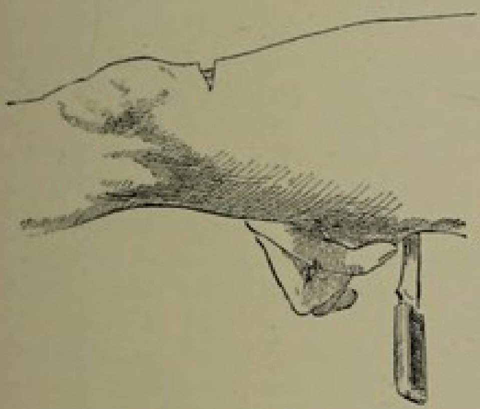


FIG. 198.—Oblique incision: the upper end made by cutting across a fold of skin raised up between the finger and thumb.

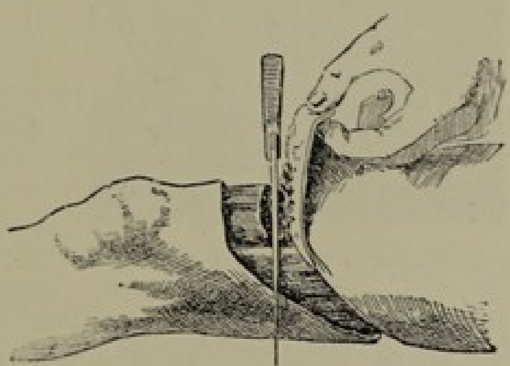


FIG. 199.—Oblique incision: position of the knife in order gradually to carry the incision deeper through the soft parts of the flap.

always be able to be approximated over the bone without the least tension. The periosteum should be divided as high up as possible, the soft parts being retracted with long gauze compresses to protect them while the bone is being sawn. The bone is sawn through 1 cm. below the level at which the periosteum is divided.

By making a series of circular incisions (the superficial parts being retracted to allow the deeper parts to be divided at a higher level), a funnel-shaped cut surface is obtained, at the bottom of which is the sawn surface of the bone. A broad apposition

of all the soft parts is ensured (Fig. 196). The muscles are stitched over the bony stump with buried sutures as far as the skin.

The oblique or oval incision (Figs. 197, 198, 199). The "elliptical" method is attributed by Treves to Sharp and Soupart, while the oblique incision which we describe has been used by Blasius. The upper and lower ends of the incision are indicated by making short incisions into a fold of skin raised up between the finger and thumb, the distal incision being made at right angles to the surface, and the proximal one parallel to the surface (Fig. 197, 198). The upper end lies at the level where the bone is to be sawn through ; the lower end lies at a distance below it equal to the diameter of the limb. After dividing the skin and fascia, the operator seizes the lower ellipse of skin with the left hand (Fig. 199), draws it upwards, and divides the muscles down to the bone, *the edge of the knife being directed towards the bone* so that a flap of skin and muscle is formed which increases in thickness towards the line of division of the bone. Periosteum and bone are treated as in the transverse circular incision. The musculo-cutaneous flap is now folded over the wound.

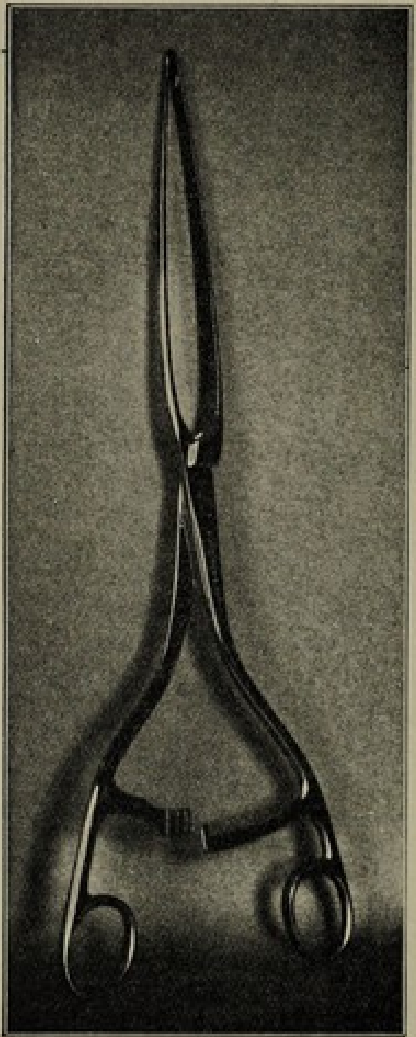


Fig. 200.—The Lynn-Thomas Forceps.

If for any reason the muscles and tendons cannot be retained, then, after the skin incision has been made, the lower end of the skin flap is seized and dissected up from the subjacent tissues to the level of the upper end of the incision, the edge of the knife being kept vertical to the muscles and never directed towards the flap. After the skin has been dissected up, the muscles and bone are dealt with in exactly the same way as in the transverse circular method.

The racket incision and its modification, the lanceolate incision (Figs. 189, 190). Malgaigne is the originator of the racket method, Scoutetten of the lanceolate incision. It consists in the addition of a longitudinal incision directed upwards from a transverse (or oblique) circular incision, the longitudinal incision extending upwards to the level at which the bone is to be divided. When possible the longitudinal incision is placed over an intermuscular septum which separates two areas of nerve-supply, extends down to the bone, avoiding the vessels and nerves, and divides the periosteum, which is then separated. Bleeding vessels are ligatured, and larger vessels are directly sought for in order to diminish the bleeding from the subsequent circular incision. In disarticulations the joint is opened by the longitudinal incision and the capsule separated from the bone.

Neudörfer first divides the bone with a chisel through the longitudinal incision and shells it out subperiosteally down to the level at which the circular incision is made. At this stage Lynn-Thomas's compression forceps (tourniquet) can be applied with advantage to control the bleeding (Fig. 200). The skin is then cut through transversely or obliquely and retracted, after which the muscles are divided and the bone is sawn across, if this has not already been done, as Neudörfer advises. The muscles are then carefully stitched in layers so that the coverings of the stump may be freely movable.

Just as the oblique incision is the most important and most universal method of amputation in simple cases, so is the *racket incision* the type of amputation for all

cases in which special value is placed upon retaining the muscles in the stump, and consequently the maximum of movement, especially in the neighbourhood of muscular joints such as shoulder, hip, thumb, and elbow. The racket method provides actively movable stumps when the bone has re-formed, or even if the bone has been entirely removed, and the effect is enhanced if the muscles of antagonistic action have been sutured over the end of the stump.

The lanceolate incision, in which the angles of the racket incision are rounded off, is the more convenient and elegant modification of the latter process, if there is no question of retaining the periosteum.

The circular methods with two lateral incisions, or *the double flap methods* (Figs. 189 and 190), are modifications of the simple types for the purpose of simplifying the execution of the operation. They are therefore everywhere applicable when the simple circular incision is difficult to perform on account of the density and tension of the skin, or on account of the breadth of the ends of the bones, especially in amputations at the ankle-joint.

The fundamental type consists of two longitudinal incisions placed opposite one another, and united at their lower ends by a circular incision. If this circular incision lies transversely, two rectangular flaps of equal length are the result. If it is placed obliquely, the flaps are of unequal length. Teale, for example, employed the flap method in the strict sense of the term: in making the flaps he dissects up all the soft parts as far as the level at which the bone is sawn across. As a rule, however, the flaps are rounded off as they are cut, so that only a portion of the longitudinal incisions is retained, and instead of a circular incision, we have two curved incisions which join the longitudinal ones at an acute angle. The mistake usually committed by beginners is that they make the two curved incisions join one another at too wide an angle. It is therefore desirable that less experienced operators should begin by making the two lateral incisions, and then connect them in front and behind by two curved incisions. The skin and fascia are divided, and just as in the simple oblique incision, the lower edge of the flap is raised up and the muscles are divided obliquely down to the bone. Two oblique raw surfaces are thus obtained, which in the case of flaps of equal length are applied to one another. With flaps of unequal length the larger one (generally the anterior) covers the main part of the wound surface. When two equal flaps are made, their length should correspond to half the diameter of the joint, while a single flap equals the diameter. When the oblique incision is used, the muscles are occasionally not required in the flap, the latter then consisting only of skin and fascia.

Mention must be made of that variety of the flap method in which the parts are *transfixed* by a double-edged knife. The limb is transfixed, and the flaps are formed by carrying the knife downwards along the bone, and dividing the muscles and skin in an arched direction towards the surface, first on one aspect and then on the other. This rapid method produces a very clean wound, but it has lost its importance since the introduction of anæsthetics and of Esmarch's prophylactic arrest of hæmorrhage.

After removal of the limb the vessels are caught with Kocher's artery forceps and ligatured with fine silk, while the nerve-trunks are sought for, drawn forwards, and cut across as high up as possible, so as to be removed from the scar and prevent any irritation from pressure or adhesions. Severe pain may result from involvement of the nerve-end in the scar. The muscles are then sutured in layers and the skin is closed with a continuous suture. When the wound surfaces cannot be brought into complete apposition and sutured in their whole extent, a glass drain (with large lateral openings) is introduced through a small special opening as directly as possible into the cavity which is left.

(d) Methods of obtaining functionally useful Stumps

In the upper limb a stump is functionally good when it can control its artificial limb without giving rise to pain, while in the case of the lower limb it must in

addition be capable of bearing weight, *i.e.* a good stump must be able to bear the direct pressure of the artificial limb when the body weight is imposed on it. There is thus some difference between the essentials of a good stump in the upper and in the lower extremities, as a stump which might prove eminently suitable for the arm is under similar conditions quite useless in the leg.

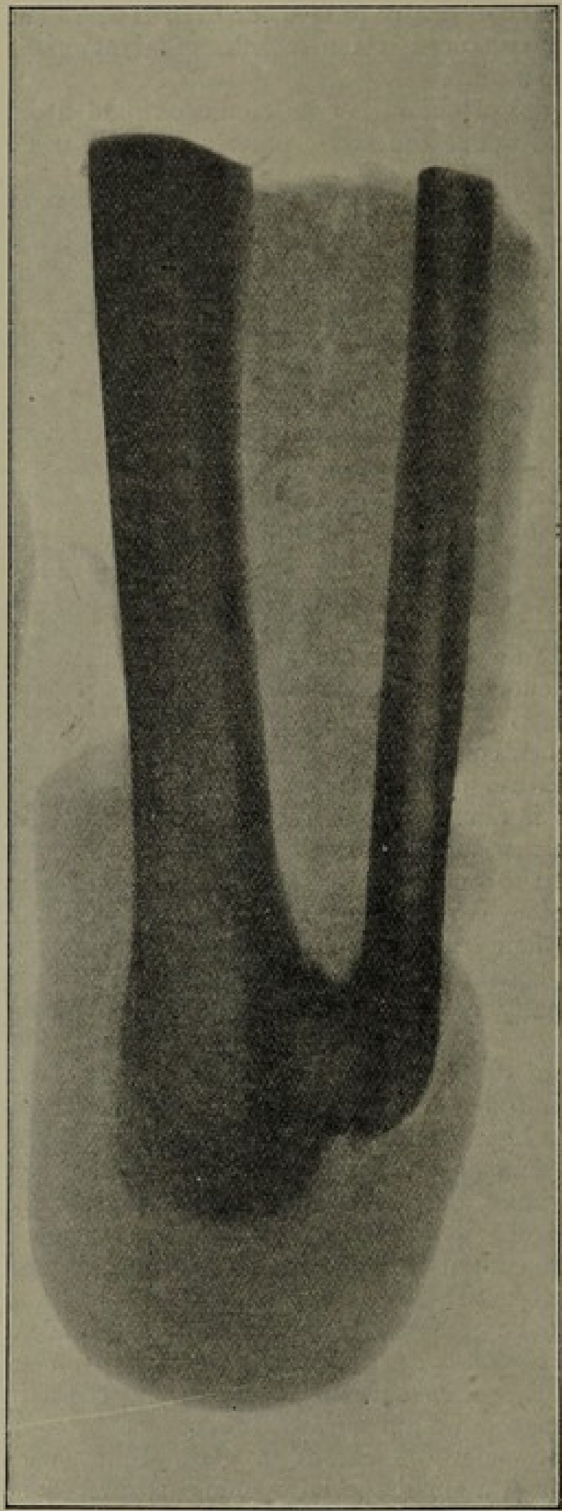


Fig. 291.—Skiagram of stump, one and a half years after osteoplastic amputation.

Much attention has recently been paid to the importance of this weight-bearing capacity and its introduction has led to great practical improvements. Bier, who was the pioneer in this movement, was the first to show how the diaphysis of a bone can be made capable of bearing weight, although his operation is now regarded as too complicated in certain cases.[1] That there was much room for improvement is shown by Crainer[2] who collected 96 cases of amputation through the thigh and leg, 70 of the stumps being bad and only two capable of bearing weight.

While the majority of surgeons prefer to use a periosteoplastic method of amputation through the shaft of a bone, a method introduced by Walther in 1813 and improved by Ollier (Schede), Bier was the first to introduce on principle the osteoplastic process, originally suggested by Pirogoff, and first applied by Gritti.

The theory on which Bier founded his method, namely, that the raw surface of a bone is and remains tender, and that therefore the medullary cavity must be covered by a flap of bone which is in normal connection with its periosteum, has been proved to be unsound. Thus, in his original method, he used to construct what was practically an artificial foot out of the periosteum turned round in the form of a flap, but later along with v. Eiselsberg he devised the simpler form of osteoplastic flap to replace the subperiosteal operation he had abandoned. Hirsch next came forward with his observations that useless stumps of various types could be made capable of bearing weight by treatment with gymnastics,[3] massage, and gradually increasing pressure. Honsell (of Bruns's clinic) has confirmed this fact for stumps formed by the sub-periosteal method.

[1] The first communication, *D. Zeitsch. f. Chir.* Bd. 34.

[2] *Arch. f. Orthopädie*, Bd. 3.

[3] *D. med. Wochenschr.*, 1899, No. 47.

In opposition to Bier's views, Hirsch and Bunge [1] have correctly shown that the protection of the raw end of the bone from pressure is of far less importance than the removal of all sensitive structures at the operation, especially the periosteum and, according to Bunge, also the marrow. This view culminated in the introduction of the aperiosteal method of amputation.

In the latter method it has been conclusively proved by Bunge, v. Eiselsberg (Ranzi), Moskowicz, Amberger, Manninger, and Steiger [2] (of our clinic), that the

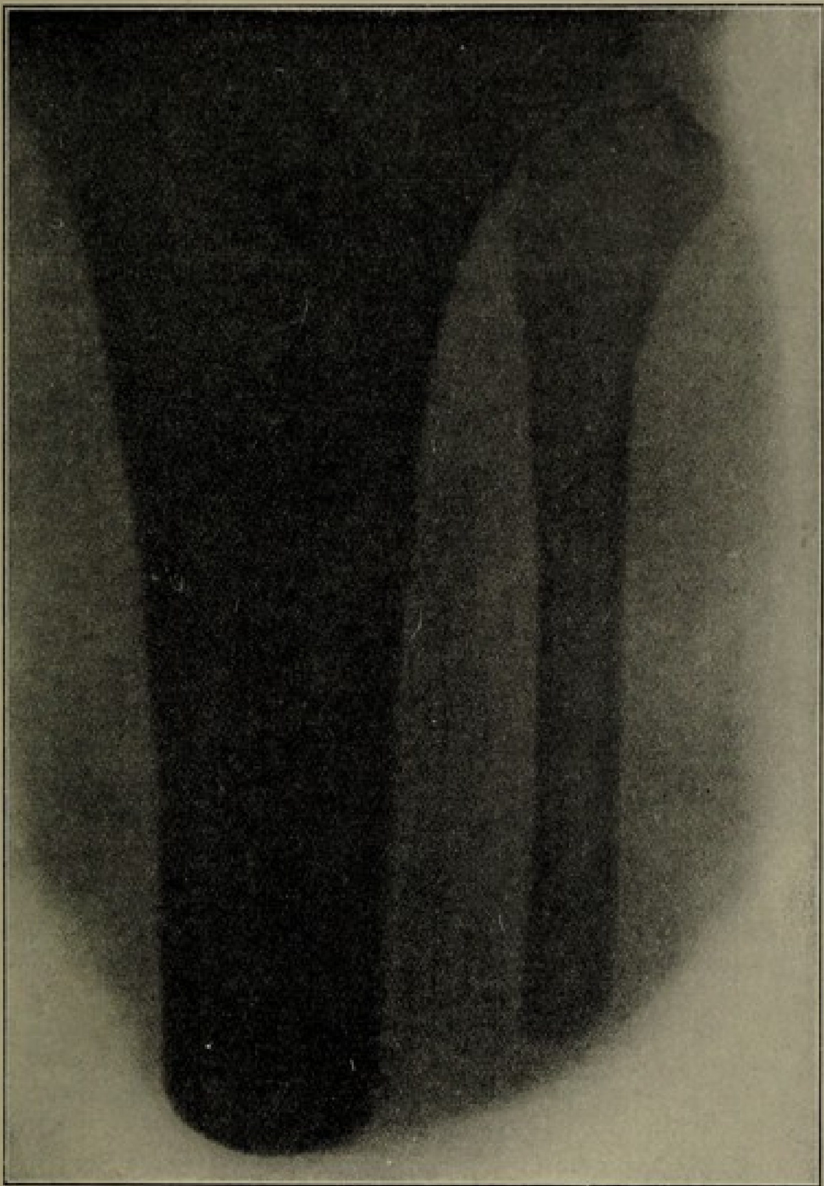


FIG. 202.—Skiagram of stump three and a half months after aperiosteal amputation. Very good result in regard to bearing pressure.

cicatricial sawn end of the bone is not in itself tender, even though the medullary cavity has been left open.

Tenderness is due much more to excessive growth of the periosteum (perhaps also in the marrow, Bunge) which leads ultimately to the production of exostoses, and can most easily be prevented by a complete removal of the periosteum covering the end of the stump, although the experience of Hirsch and ourselves also shows that exostoses can be prevented by accustoming the limb early to bearing weight on its surface.

[1] *Verhandlungen d. deutsch. Gesellsch. f. Chirurgie*, 1900, ff. [2] Bern Dissertation, 1903.

We here reproduce some characteristic radiographs which have been published by Steiger in our clinic. Fig. 201 represents the appearance after an osteoplastic amputation of the leg (Bier and Eiselsberg method), in a man aged forty-six. As some necrosis occurred and a sinus formed, a second amputation was performed. The stump after the first, *i.e.* osteoplastic, operation was well rounded, the bones united, and there was no tenderness on pressure. At the second operation an aperiosteal amputation (Bunge) was performed. The result is excellent and the stump bears the weight of the body without any pain. As Fig. 202 shows, the stump is smooth, round, and devoid of any exostoses.

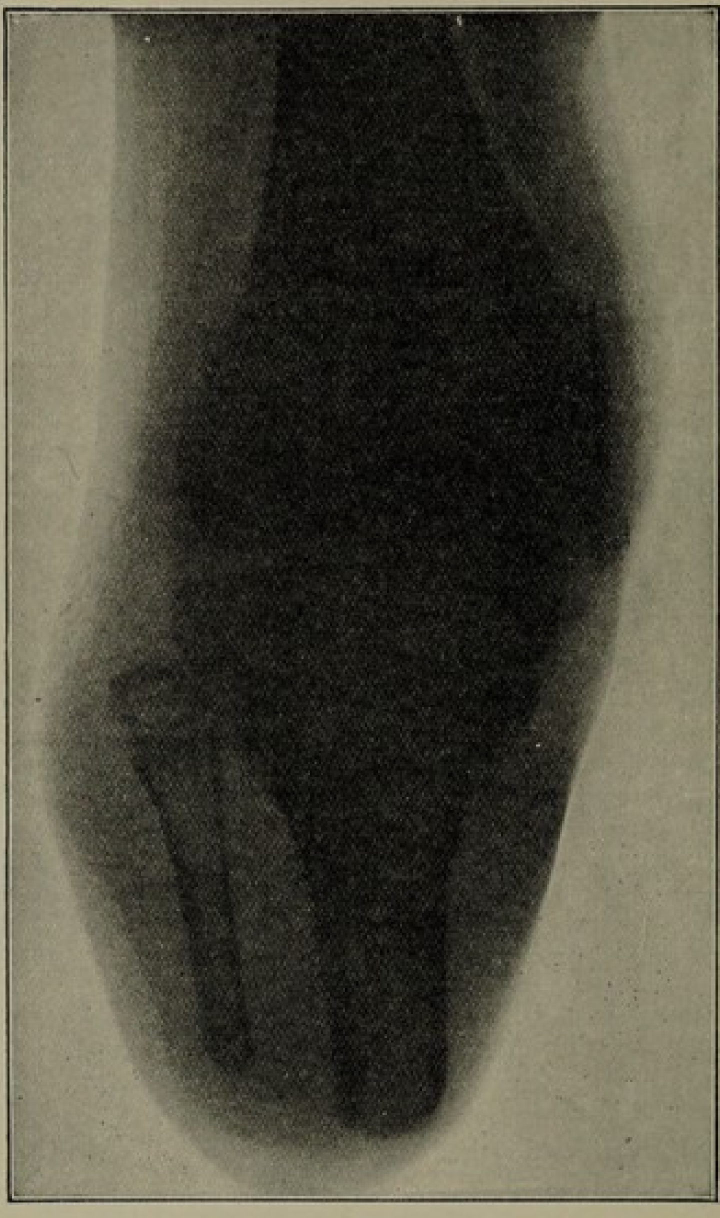


Fig. 203.—Secondary aperiosteal amputation of leg. Excellent weight-bearing stump (Fankhauser).

Figs. 203 and 204 give a further comparison between the aperiosteal and subperiosteal methods.

In the case of the child (Fankhauser) eleven years old, the leg was amputated elsewhere by the subperiosteal method without, unfortunately, a radiograph of the stump having been taken. A second amputation was found necessary owing to pain. The result of this typical aperiosteal stump (Fig. 203) was perfect.

The appearances of the subperiosteal stump from a man fifty-one years old are quite typical (Fig. 204). In spite of the fact that the stump is well rounded, an exostosis formed which was tender on pressure and prevented a bucket limb being worn.

That perfect stumps can be obtained by the subperiosteal method is shown by the radiograph in Fig. 206, which represents the case of a man who had an osteoplastic amputation on one side (Fig. 205) and a subperiosteal amputation on the other side (Fig. 206). Both stumps are well rounded off, are not tender, and bear weight admirably.

Steiger has investigated and compared 21 cases of amputation through the leg and 15 cases of amputation through the thigh from our clinic, in which various methods were used. His observations show that satisfactory results are obtainable by all three methods, viz. aperiosteal, subperiosteal, and osteoplastic, provided (1) that the operation is correctly performed, (2) that primary union occurs, and (3) that the stump is at an early stage accustomed to bear weight and can thus adapt itself rapidly to its new function.

The following questions must be considered :—

(1) Which method can be most relied upon to give a stump which can bear weight in the event of complications being present, especially in the healing of the wound? The answer is not difficult. With the osteoplastic method there is most chance of necrosis, the subperiosteal method leads to exostoses as the result of inflammation, while only the aperiosteal method can furnish a useful stump in the presence of such complications. Ranzi and Auffenberg,[1] from v. Eiselsberg's clinic,

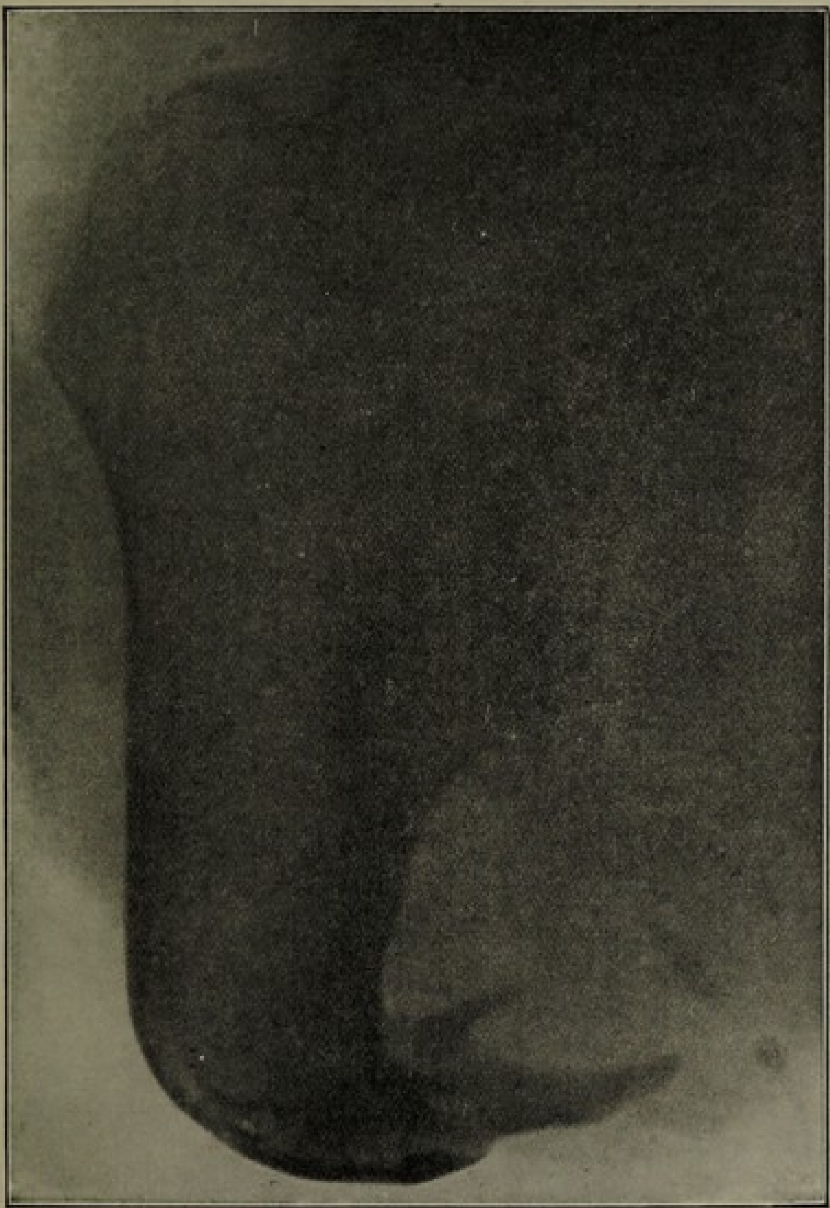


Fig. 204.—Skiagram, after subperiosteal amputation through the thigh.

expressly state that even when the wound suppurates, good functional results are still obtained by Bunge's aperiosteal method.

(2) Which method is the easiest and best adapted for inexperienced surgeons, *e.g.* in the field? Here also the answer is not difficult. The osteoplastic method (as can be seen in every operative course) is difficult, and requires practice and care. The aperiosteal method is the simplest and the most natural, inasmuch as the bone projects free from periosteum.

Bunge's aperiosteal method should therefore be regularly employed for all amputa-

[1] *Wiener klin. Wochenschr.*, 1905, No. 51.

tions through the shaft of a long bone. When primary union is obtained, and consequently the stump is at an early stage accustomed to bearing pressure, excellent results are obtained. Bunge maintains that the functional results are also good even

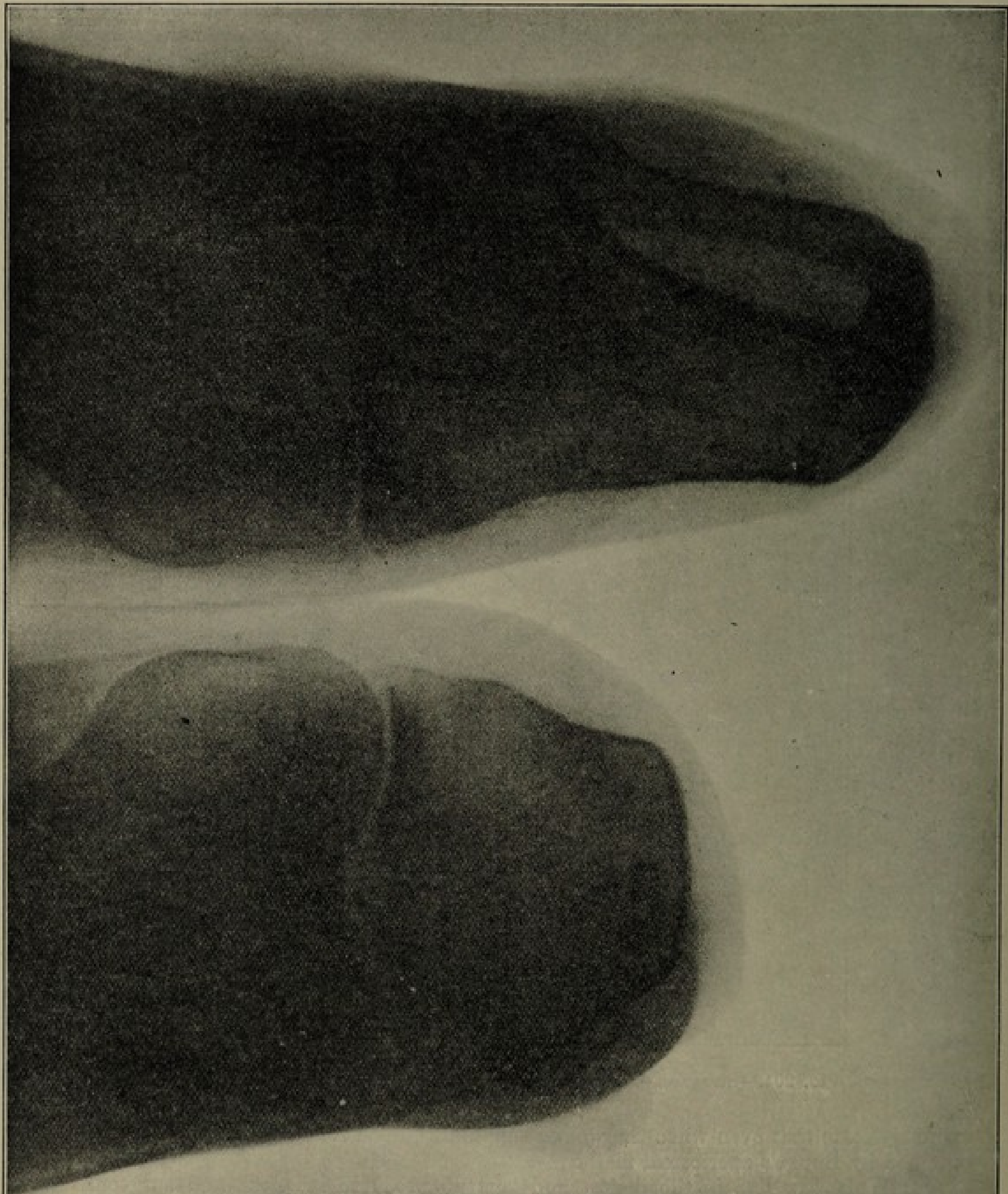


FIG. 205.—Osteoplastic amputation.

FIG. 206.—Subperiosteal amputation.

when no care is taken regarding the position of the scar and no special after-treatment is adopted.

If this were so, the measures for the subsequent utility of the stump that Hirsch adopts, viz. massage, etc., would be superfluous except in regard to its pressure-

bearing function. It is better, however, not to count on this, for there is no doubt that, as regards the question of bearing pressure on the stump, great care must be taken to ensure that the cicatrix will not be exposed on the end of the limb, *i.e.* an oblique or flap incision must be used. We can only depart from this rule in the case of a high amputation or disarticulation of the thigh, because then the artificial limb takes its purchase from the pelvis. In every amputation the nerves must be cut short, in order to prevent the possibility of their becoming adherent in the cicatrix.

There are two points which must be observed in all amputations and disarticulations: first, to avoid a painful stump, and second, to prevent atrophy. Asepsis is, of course, an essential, and fine non-sensitive scars both in the soft parts and in the bone, the periosteum of which is very sensitive to inflammation, are only obtained by a strict aseptic technique. A painful stump is really caused by the sensitiveness of the scar. The edges of the wound must be clean cut and stitched without tension or pressure, while absolute arrest of hæmorrhage is important in relation to asepsis in amputation as in all operations elsewhere.

If asepsis is secured, the scar must be protected from every form of mechanical injury, especially from pressure and tension, if the stump is to be painless. Nerve cicatrices—so-called amputation neuromata—give rise to the greatest pain. We have already stated how they can be avoided. Further, the cicatrix in the skin must be so placed that it is not exposed to pressure between the end of the bone and the artificial limb. It should not be adherent to the cicatrix in the deep tissues, and especially must not be continuous with that in the muscle and bone. To avoid these dangers the deep fascia should be carefully sutured by itself and if possible the superficial and deep cicatrices should not be made parallel.

Similarly the cicatrix in the muscle ought not to be placed between the bone and the surface of the artificial limb, and the same rule applies even more forcibly to the position of the cicatrix in the periosteum, which, according to Lennander, is the only sensitive part of bone. Whether the marrow is sensitive or insensitive has not been definitely determined. Care must be taken, therefore, that there shall be no periosteal scar exposed to pressure. Hence it is better to remove the periosteum entirely from the end of the stump. It is certainly not a matter of indifference whether the edges of the bone are left sharp or are rounded off, as the latter method prevents harmful pressure.

It is a recognised fact that when a long bone is sawn through its epiphysis, the stump is readily adapted to bearing pressure, for here, as in disarticulations, the end of the bone is very easily rounded off.

Muscular atrophy, on which the production of a conical stump depends, is prevented by providing a new insertion for the muscles. When the muscles cannot be sutured directly to the bone, they should be stitched over the end of the stump, *i.e.* those that have an antagonistic action. One advantage of disarticulation is that the normal insertions into the epiphysis are retained.

This is a point to which hitherto no special attention has been paid. The suggestion made by Wilms[1] of covering the end of the bone with a tendon and stitching the latter to the periosteum has been successfully carried out by Dichel, the tendo Achillis being employed in the case of the leg and the quadriceps in that of the thigh. Like Bunge and others, we cannot attribute the advantage of this procedure simply to the fact that it forms a cushion over the end of the bone. We are inclined to the belief that the interposition of the tendon prevents the formation of cicatricial adhesions between the raw end of the bone and the wound in the soft parts. In this sense, the operation which has been already put in practice by Duval and Laborie finds its justification.

Early exercise (Hirsch) is a further means by which atrophy may be prevented, but it depends entirely on primary union and the freedom from pain. It acts by stretching adhesions much in the same way as peristalsis acts after laparotomy.

[1] *Centralbl. f. Chir.*, 1901.

(e) Amputations of the Foot

37. **Removal of the Toes and Individual Metatarsal Bones** (Fig. 207). As a rule it is advisable not to perform partial amputation of a toe, but to disarticulate it at the metatarso-phalangeal joint, as otherwise the stump is only an inconvenience.

Amputations and disarticulations of the toes are analogous to those of the fingers. For the phalanges and interphalangeal joints the oblique circular incision is indicated, whilst for the metatarsi and metatarso-phalangeal joints the racket incision (the handle on the dorsum) is made.

In the case of the great and little toe the dorsal portion of the incision is not placed over the middle of the phalanx and metatarsus, but more towards the middle line of the foot, so that the cicatrix may be out of reach of lateral pressure. The resulting scar occupies as good a position as that in Farabœuf's amputation by internal and external plantar flaps.

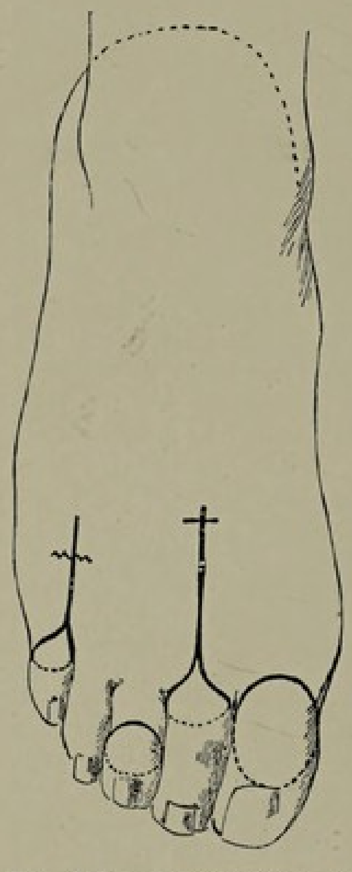


Fig. 207.—Disarticulation of the great toe at the metatarso-phalangeal joint, and of the 2nd toe along with its metacarpal bone: amputation through the 3rd toe, and through the 5th metatarsal bone.

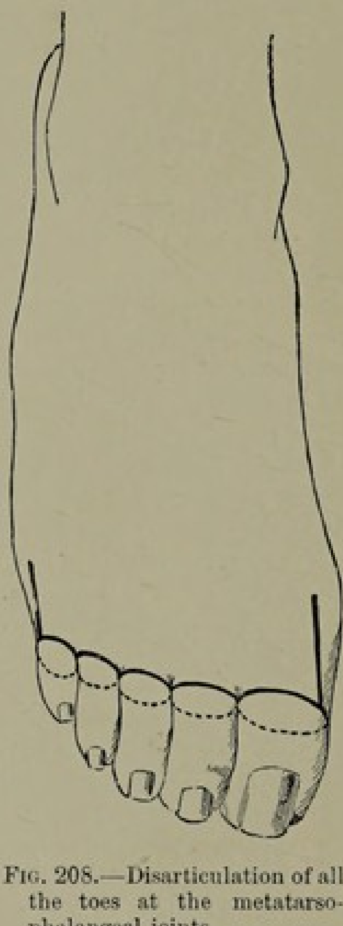


Fig. 208.—Disarticulation of all the toes at the metatarso-phalangeal joints.

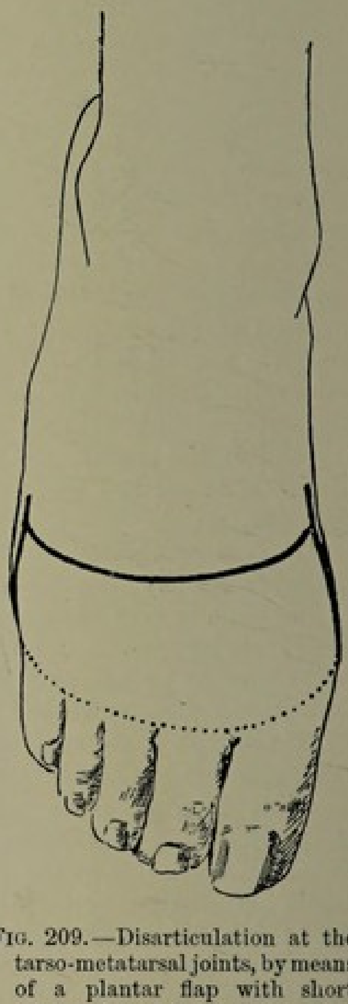


Fig. 209.—Disarticulation at the tarso-metatarsal joints, by means of a plantar flap with short convex dorsal incision.

38. **Disarticulation of all the Toes (Metatarso-Phalangeal Disarticulation)** (Fig. 208). Each toe is dealt with separately as follows:—It is dorsiflexed, and an incision is carried round it where it emerges from the general cutaneous envelope of the foot. When complete, all the incisions should unite at the webs. Upon the plantar aspect this incision runs exactly along the furrow between the digits and the

ball of the toes. A dorso-lateral incision is added over the metatarso-phalangeal joints of the great and little toes. In this way two rectangular flaps are formed.

The foot being held at right angles, the extensor tendons are divided as high up as possible, the lateral ligaments and the dorsal and plantar portions of the capsule are divided with a small knife, and, lastly, the plantar tendons. The dorsal and plantar tendons are then stitched together or to either side of the joint capsule.

39. Amputation through the Metatarsus (Fig. 209). This operation has the advantage over the tarso-metatarsal disarticulation that the insertions of the chief muscles of the foot are all retained, not merely the tibialis posticus and peroneus longus, but also the tibialis anticus and the peroneus brevis and tertius. Hence the foot retains its normal movements in all directions. It also provides a very serviceable

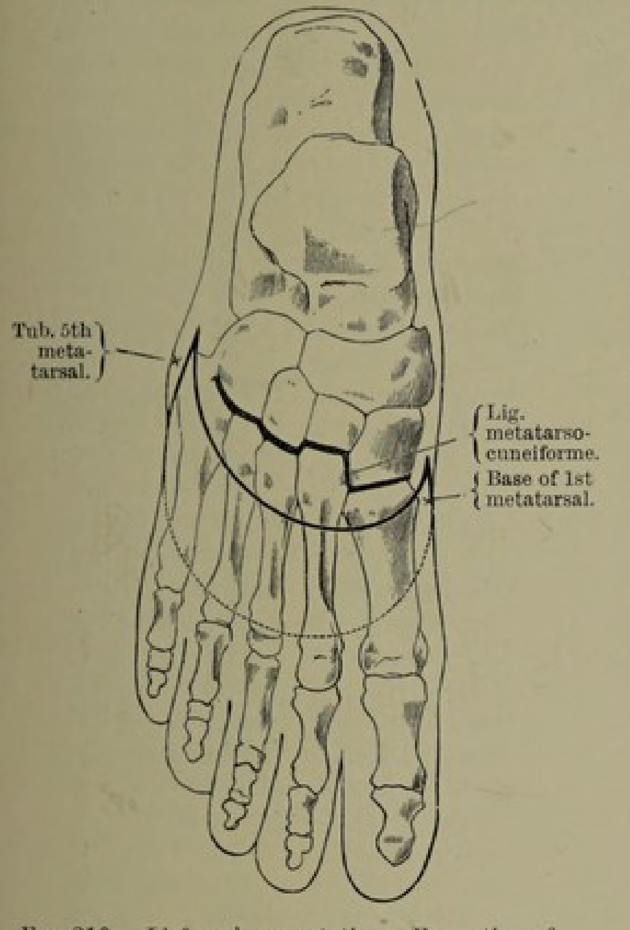


FIG. 210.—Lisfranc's amputation. Formation of dorsal and plantar flaps (dorsal view).

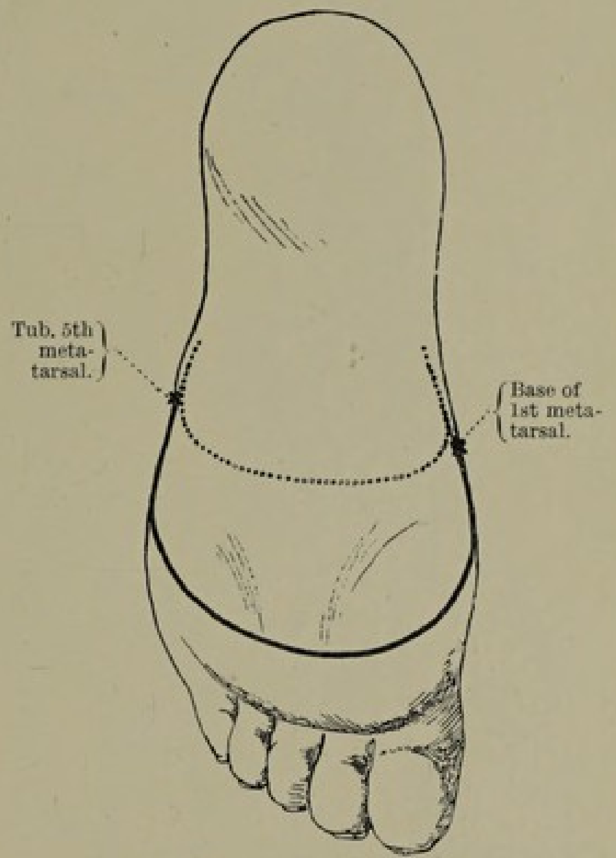


FIG. 211.—Lisfranc's amputation (plantar view).

support, as the important projection at the base of the fifth metatarsal is left, and the only one which is wanting is that of the head of the first metatarsal.

A flap is taken from the sole. The incision, which should begin and terminate slightly on the dorsum, is carried across the sole, in the furrow between the digits and the ball of the toes, as in disarticulation of the toes, while the upper extremities of the incision extend 1 cm. above the level at which the bone is to be divided. The flap is then dissected up off the bones, and a short dorsal flap, extending 1 cm. below the line of division, is cut, after which the metatarsal bones are one by one freed and cut across.

40. Disarticulation at the Tarso-Metatarsal Joints—between the metatarsus anteriorly and the three cuneiforms and cuboid posteriorly (Lisfranc's operation) (Figs. 210 and 211).

The line of the joint lies immediately behind the tuberosity of the fifth metatarsal on the outer side of the foot. The guide on the inner side is the slight prominence of

the base of the first metatarsal. With a finger of the left-hand on each of these fixed points, an incision is carried along each side of the foot, and then across the sole at the level of the ball of the toes, thus forming a rounded flap on the sole. This flap, which is thicker posteriorly, is then dissected back as far as 1 cm. in front of the line of the joint. A convex incision is then made on the dorsum, 1 cm. in front of the line of the joint, and, after retraction of the skin, the periosteum is divided close to the important tendon insertions, and pushed back with a raspatory as far as the joint.

The line of the joint is convex forwards and outwards, having an upward indentation corresponding to the retreating middle cuneiform bone, which lies, as compared with the internal cuneiform, as much as 2 to 3 mm. behind the convex joint line, and 1 cm. behind it as compared with the external. The joint is opened opposite the first, third, fourth, and fifth, and lastly opposite the second, metatarsal. The

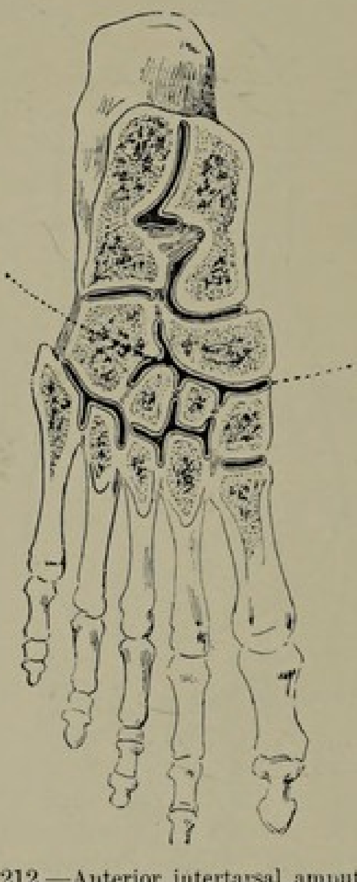


Fig. 212.—Anterior intertarsal amputation (Jäger). Horizontal section of foot (after Heitzmann).

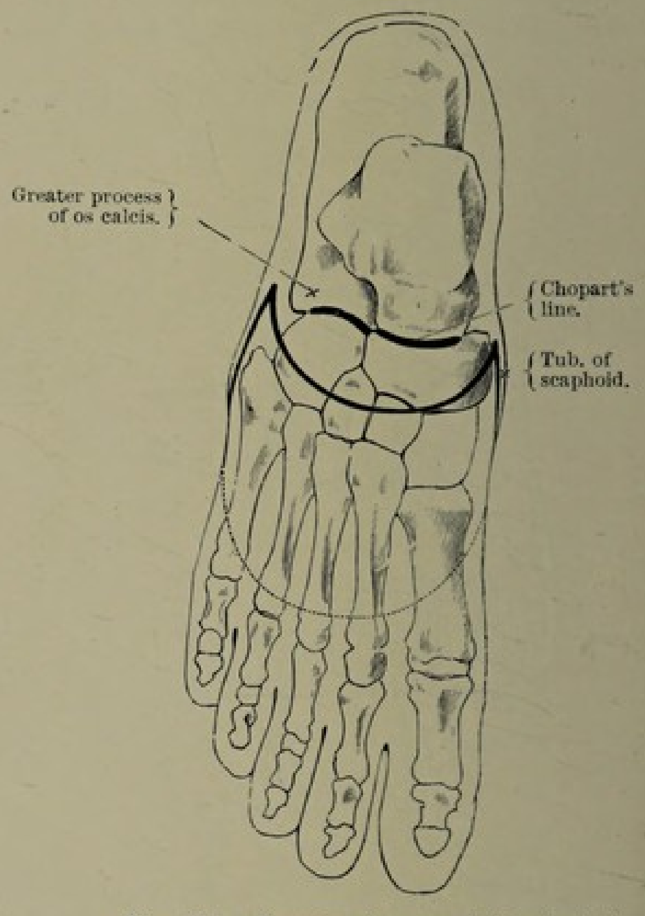


Fig. 213.—Posterior intertarsal disarticulation (Chopart). (Dorsal view.)

strongest ligament is that between the internal cuneiform and the base of the second metatarsal (Fig. 210), and it is only after this has been divided that the joint can be opened out. Division of the base of the second metatarsal in a line with the other joints is rather an advantage than otherwise.

As in all operations upon the foot, the vessels are retained in the plantar flap.

In cases where there is an insufficient skin covering, removal of the projecting internal cuneiform (Hey and Farabœuf) does not interfere with the functional activity of the foot any more than does the typical Lisfranc's operation, as the insertion of the tibialis anticus is still retained, or the tendons may be again stitched in accurate position.

41. Anterior Intertarsal Disarticulation (Jäger, Bona) (Fig. 212), between the three cuneiform bones anteriorly and the scaphoid posteriorly, the cuboid being sawn across. The operation is performed in a manner similar to Lisfranc's, but the plantar flap is $2\frac{1}{2}$ cm. shorter. The method has an advantage over Chopart's amputation

in retaining the strong ligaments which pass from the os calcis to the cuboid and scaphoid bones.

The Bona-Jäger operation is a type of one of the "irregular" amputations of the foot, because here amputation is combined with disarticulation. But even these irregular types are justifiable, as every case must be considered on its own merits, many of the tendinous insertions and supporting bony parts being preserved. We have already referred to the removal of the anterior half of the internal cuneiform bone. Similarly, disarticulation of the first metatarsal can be performed instead of Lisfranc's amputation, the other metatarsals being sawn across, and the valuable support of the tuberosity of the fifth metatarsal retained. Further, it is sometimes an advantage to remove only the first three metatarsals with the three cuneiform bones, and to retain the fourth and fifth with the cuboid; or, on the contrary, to remove the latter bones and leave the first metatarsal and the cuneiforms. These cases are exceptions to the rule of amputating the foot transversely.

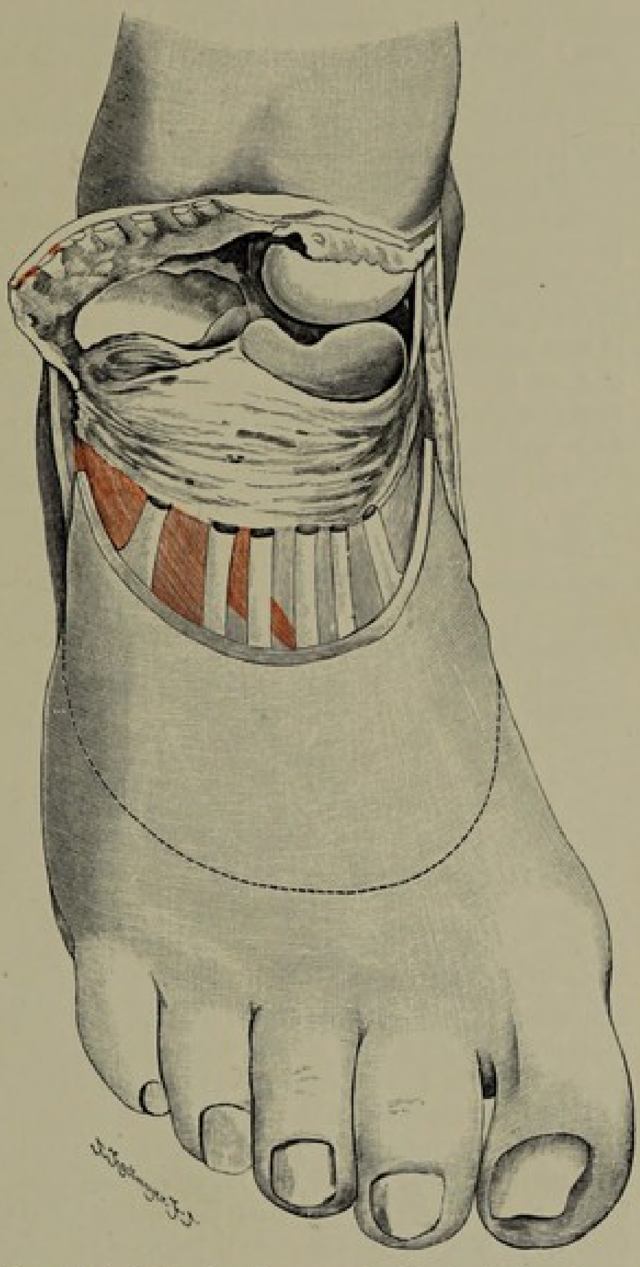


Fig. 214.—Posterior intertarsal disarticulation by a plantar flap and convex dorsal incision. The skin on the dorsum is retracted; the tendons are divided and the joint is opened, exposing posteriorly the articular surface of the head of the astragalus and the os calcis. Anteriorly are seen the articular surface of the scaphoid and part of the cuboid.

42. Posterior Intertarsal Disarticulation (Chopart's operation) (Figs. 213 and 214). The disarticulation takes place between the os calcis and astragalus posteriorly and the cuboid and scaphoid anteriorly. The operation often results in a bad stump from the foot assuming the equinus position, and pressure occurring at the anterior and lower part of the os calcis. This is easily understood since all the tendons on the dorsum of the foot have been divided, while the powerful tendo Achillis is left intact. It is necessary, therefore, to elongate the tendo Achillis, so that the stump may be retained at right angles to the leg until the extensors have gained a firm attachment to the deeper part of the cicatrix. Instead of waiting for this, the ends of the tendons may be sutured at once to the periosteum and ligaments on the dorsum with the foot at right angles.

Internally the joint line lies behind the projecting tubercle of the scaphoid, externally in front of the ridge on the greater process of the os calcis. The operation is performed by making two rounded flaps, the dorsal extending a thumb's-breadth in front of the line of the joint.

The dorsal tendons are cut with the foot at right angles. The dorsal incision is carried down to the bone across the scaphoid and cuboid, the joint capsule being then stripped back for a distance of 1 cm. The joint between the head of the astragalus and the scaphoid, which is convex downwards, is then opened from above. Towards the outer border of the foot the knife must be directed towards the toes, for the outer part of the calcaneo-cuboid joint is concave anteriorly, *i.e.* the line of the joint is ~ shaped. If the knife be carried too far back, it will open the astragalo-calcanean joint.

The chief structures which unite the bones are the inferior calcaneo-scaphoid and the calcaneo-cuboid ligaments.

When the foot has been disarticulated the extensor tendons (tibialis anticus, the extensor longus digitorum, and the peroneous tertius) should be sutured to the dorsal periosteo-capsular flap, the foot being held at right angles.

Hoffmann[1] has described a modification of Chopart's operation, suggested by Witzel, where the toes are retained. A rectangular area of skin containing the sinuses is first excised from the dorsum, the bones are then disarticulated at Chopart's joint, and at the metatarso-phalangeal joint (or the metatarsals sawn across), and the toes along with the skin of the sole are retained: the latter is redundant and folded at first, but soon shrinks.

43. Intertarsal Amputation. When the soft parts are insufficient for a Chopart's

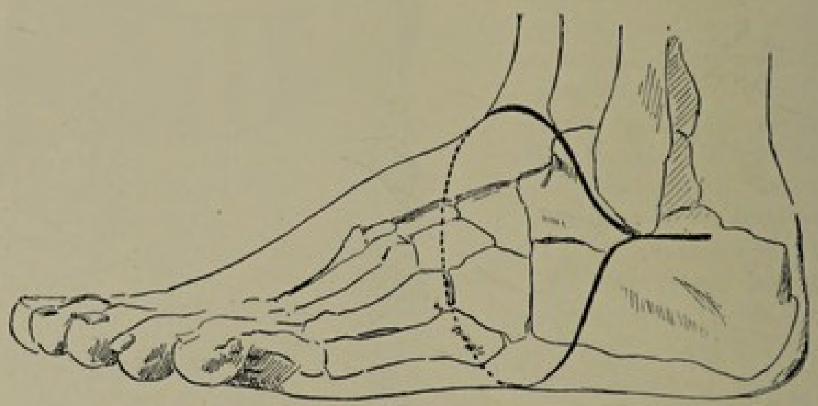


FIG. 215.—Subastragaloid disarticulation (Malgaigne, Textor).

amputation, the articular surfaces of the astragalus and os calcis are sawn off after disarticulating as in Chopart's operation. A movable stump may still be obtained, as the capsule of the ankle-joint (which does not extend farther forwards than 1 cm. behind the cartilage of the head of the astragalus) need not be opened.

44. Subastragaloid Disarticulation (Malgaigne, Textor) (Fig. 215). A racket-shaped incision is made, the handle being placed horizontally immediately behind and below the tip of the external malleolus, and the circular incision carried round the foot at the level of Chopart's joint. The incision is somewhat similar to that of Perrin and Chauvel, and is closely allied to Farabœuf's internal plantar flap.

The joint between the astragalus and scaphoid is opened from the dorsum without opening the calcaneo-cuboid joint. A narrow knife is then passed backwards and slightly upwards beneath the head of the astragalus so as to divide the strong interosseous ligament between it and the os calcis. The soft parts are then dissected from the os calcis, first from its upper surface, then from its outer and under surfaces, and lastly from its inner and posterior surfaces. The greatest difficulty is met with at the inner side in clearing the projecting sustentaculum tali.

If the soft parts are insufficient, the projecting head of the astragalus may be sawn off. The astragalus fits well into the heel cap. The stump bears weight excellently.

45. Subastragaloid Osteoplastic Amputation. This operation, introduced by Hancock, consists in sawing off the tuberosity of the os calcis, and applying it to the

[1] *Deutsche med. Wochenschr.*, January 1899.

lower surface of the astragalus, from which the articular cartilage has been sawn off. The circumstances in which this operation is called for are exceptional.

Ssabanejeff has also recently described an osteoplastic subastragaloid amputation.

46. Disarticulation at the Ankle-Joint (Syme's operation) (Figs. 216-220). This operation was performed by Syme by means of a flap taken from the heel. The

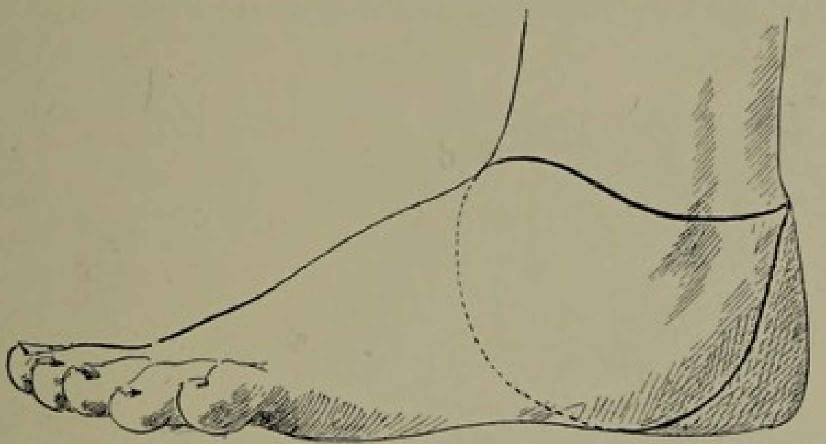


FIG. 216.—Disarticulation at the ankle-joint by means of an internal flap (Syme's amputation modified).

disadvantage of the method is that after the heel flap has been brought into position a cavity still exists between it and the bones.

The racket incision is preferable, the flap, which is taken from the inner side of the foot, commencing at the tip of the external malleolus (Fig. 216). This method resembles most the internal flap recommended by Farabœuf, and the methods of

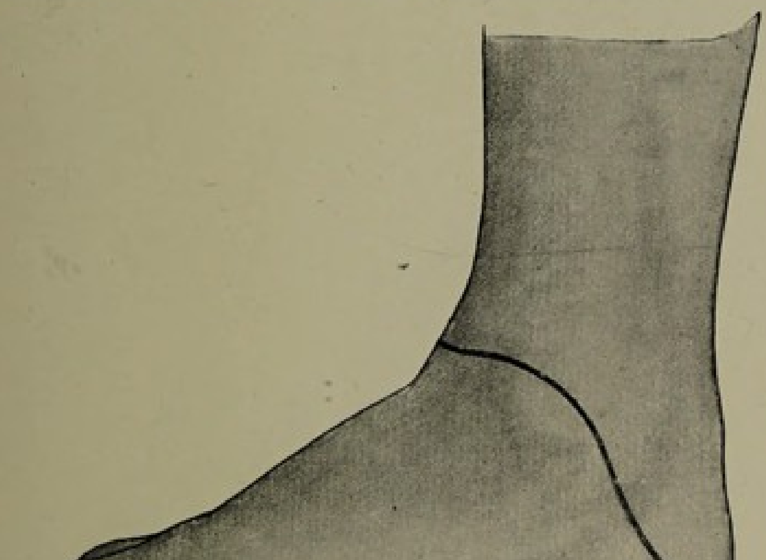


FIG. 217.—Guyon's wave-cut for disarticulation at the ankle.

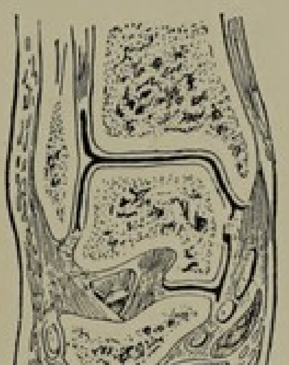


FIG. 218.—Coronal section through the ankle-joint (Henle).

Roux and Verneuil. According to Tauber, J. Bell used an internal heel flap in 1885. After dividing the skin, the strong bands of the external lateral ligament, the peroneal tendons, and the extensor tendons are cut across at the level of the retracted skin. The ankle-joint is opened, and the inner aspect of the os calcis is dissected from above downwards from the internal flap by keeping close to the bone. The malleoli are cleared and divided obliquely, but the cartilaginous covering of the tibia is left intact.

Poncet has shown that a very good stump can also be obtained by means of a dorsal flap. Guyon's wave-shaped incision is still better (Fig. 217), extending from the front of the ankle-joint backwards to the lower part of the tip of the os calcis. When enough skin cannot be secured to cover the epiphysis and the articular surface of the end of the tibia, Samter has turned down a strip of skin from the leg which he places over the wound like a stirrup, leaving the rest of the raw surface to granulate.

FIG. 219.—Disarticulation of the ankle-joint by an internal flap (inner side of foot). The joint has been opened above: the edges of the wound are gaping.

47. Osteoplastic Amputation of the Foot (Pirogoff) (Fig. 221). Pirogoff's operation derives its importance from the fact that it was the first osteoplastic operation introduced. It dates from 1854.

The tuberosity of the os calcis is sawn off and applied to the sawn surface of the tibia and fibula. The great advantage of retaining the tuberosity of the os calcis is that it fills the cavity or cup in the heel flap, and that the skin of the latter is well nourished. It is thus preferable to the original operation of Syme.

The simplest and best method of performing the operation is as follows:—Tenotomy of the tendo Achillis is first performed. The foot being held at a right angle, an incision is carried from the middle of one malleolus vertically downwards in the axis of the leg and across the heel to end at the middle of the opposite malleolus (stirrup incision). The whole of the incision extends down to the bone so as to divide all the tendons completely. Its extremities are united by a second incision passing

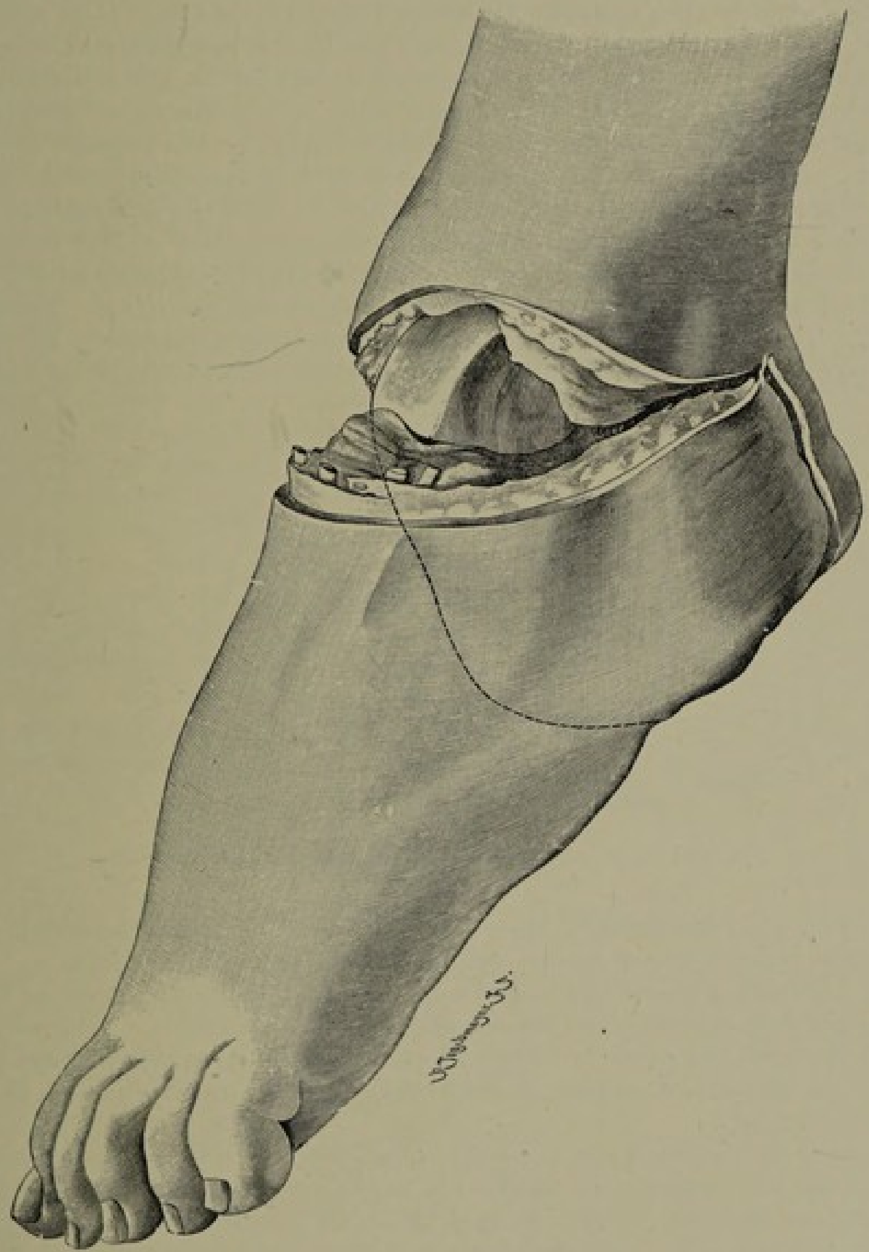


FIG. 220.—Disarticulation of the ankle by an internal flap (outer side). The joint is opened in front and externally; the head and outer surface of the astragalus and the tip of the external malleolus are exposed.

forwards across the dorsum of the foot exactly at right angles to the stirrup incision, and reaching a full thumb's-breadth in front of the line of the ankle-joint. It is carried through the skin and fascia only, the extensor tendons being divided at its retracted edge.

The ankle-joint is now opened from the front, the lateral ligaments are divided, and the astragalus is exposed as far back as its superior surface. The tuberosity of the os calcis is then sawn off vertically immediately behind the astragalus in the same

plane as the heel incision, and is turned upwards along with the skin of the heel. The malleoli are freed and sawn off 1 cm. above the line of the joint. It is unnecessary to preserve the periosteum as osseous union is obtained. The sawn surfaces are brought into accurate apposition by suturing the flap. The subsequent gait is excellent.

In order to avoid the tilting of the os calcis, which in our opinion is very considerable, many surgeons have sawn the os calcis obliquely (Günthner, Sedillot, Schede, Volkmann), or horizontally (Busk, Bruns, Pasquier, Lefort), or in a curved or angular direction (Bruns, Böckel). Küster considers Lefort's method of sawing the os calcis horizontally far better than the typical Pirogoff operation, because in the latter the thin skin of the heel is easily abraded. We regard this as unusual: our patients always find the stump extremely useful. It depends entirely on the manner in which the operation is performed. Küster proposed not to saw the os calcis at all, but to disarticulate the foot along with the astragalus, and to place the os calcis directly below the leg (intercruro-calcanean disarticulation). He employs a convex incision 1 cm. below the malleoli as far as the prominence of the fifth metatarsal, with a somewhat shorter dorsal convex incision across the astragalo-scaphoid joint. The astragalus is removed. The lower flap is brought up over the anterior surface of the os calcis.

If the os calcis is to be sawn horizontally, it is advisable to make an oval incision

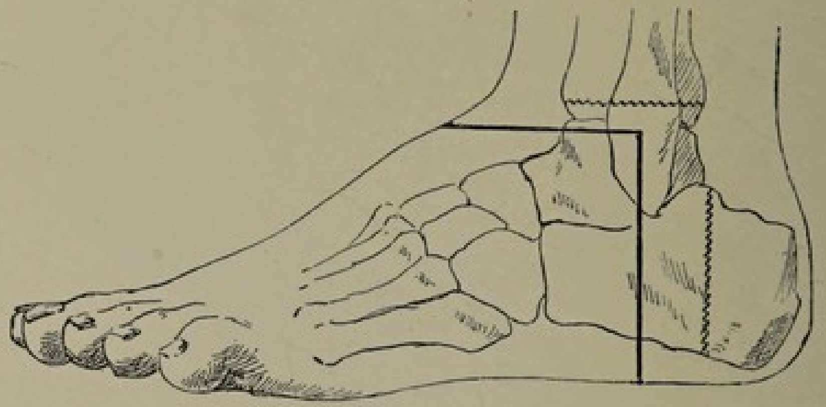


FIG. 221.—Osteoplastic disarticulation of the foot (Pirogoff).

beginning (Fig. 215) horizontally below the tip of the external malleolus. Through this horizontal incision access is obtained for sawing through the bone.

Tauber has further modified Pirogoff's operation by making an internal flap similar to that described in the previous section under Syme's operation. Instead of turning up the soft parts off the os calcis in the internal flap, he saws through the latter bone in the sagittal plane, and applies the inner half to the sawn ends of the bones of the leg.

All these modifications have a disadvantage over the method first described, viz. that part of the scar comes to lie nearer the under surface of the foot.

The original Pirogoff method is still the best, because the tuberosity of the os calcis is most frequently unaffected both in diffuse tuberculous disease of the joint and in injuries.

(f) Amputations of the Leg

48. Amputation of the Leg (Figs. 222-227). In the description of amputations in general we have already alluded to the incisions that may be used in amputating through the leg, and have also shown how stumps in this region can be obtained which are capable of bearing weight. An aperiosteal amputation should be performed at all levels.

The lines of incision at the various levels are shown in Figs. 222 and 223.

The longer flap is always taken from the front unless there are special reasons to

the contrary. At the ankle, it consists only of skin and fascia, while even farther up the flap largely consists of skin and fascia as there is no muscle on the inner surface of the tibia.

For this reason and to prevent pressure of the flap on the spine of the tibia, the longer flap should be taken in the middle third from the antero-external aspect of the leg. Farabœuf also speaks highly of an antero-external flap.

After dissecting up the flap as far as the upper end of the incision the muscles, which have not yet been divided, are cut transversely. One has to be careful in the interosseous space to cut exactly transversely so that the vessels may not be injured in their long axis.

The periosteum is then divided by a circular incision, and pushed downwards for a distance of 1 cm., at which level the bone is sawn through, thus leaving a projecting end of bare bone. Sharp edges, especially the anterior border of the tibia, should be rounded off, while the fibula should always be divided 1 to 2 cm. higher than the tibia so that it may not project into the soft parts.

In the region of the upper and lower epiphyses the bone should be sawn convexly as in Fig. 222, and the sharp margins rounded off with cutting forceps. Here, where there are no muscles, the deep fascia is brought directly over the sawn surface of the bone so that the skin may be freely movable. Wilms attains the latter object by interposing the tendo Achillis between the flap and the end of the bone. We merely mention that Ollier and Kummer use the skin of the heel as a covering for the stump to ensure that it will be able to bear weight, while Kummer waits until it has become contracted by the formation of granulation tissue.

It is convenient here to describe the typical osteoplastic method, which, although it affords good results, is not so simple as the aperiosteal method.

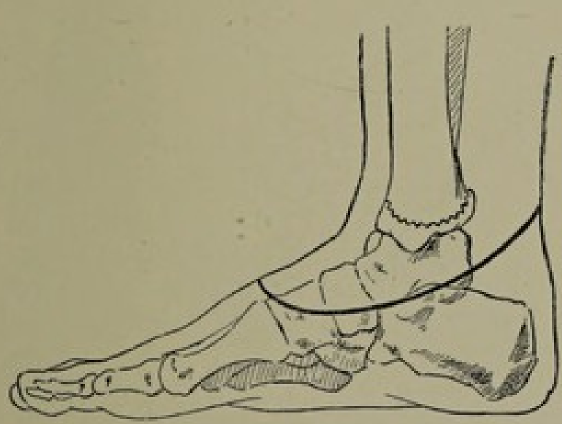


Fig. 222.—Amputation through the malleoli.

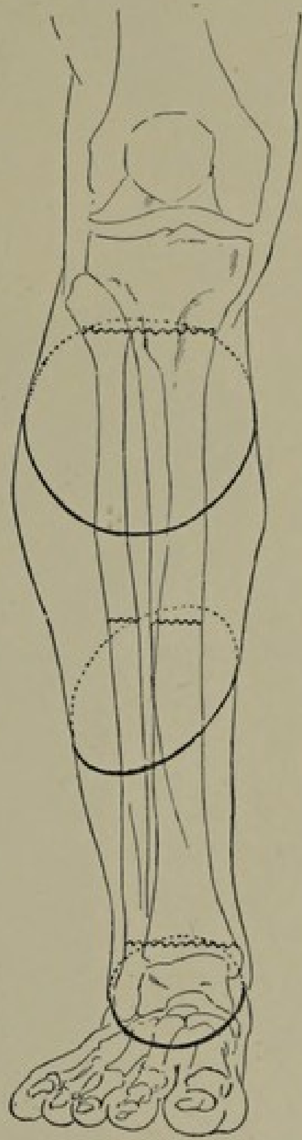


Fig. 223. — Amputations through the leg below the knee, in the middle third, and through the malleoli.

We pointed out, in discussing amputations in general, that Bier first adopted a complicated method which was subsequently simplified by Lanz and Gleich. We agree to a large extent with Storp and Bunge's description of the method as performed by Eiselsberg, with, however, a few modifications.

Bunge describes the very simple operation as follows:—An antero-internal skin flap is dissected up, the centre of the flap corresponding to the inner surface of the

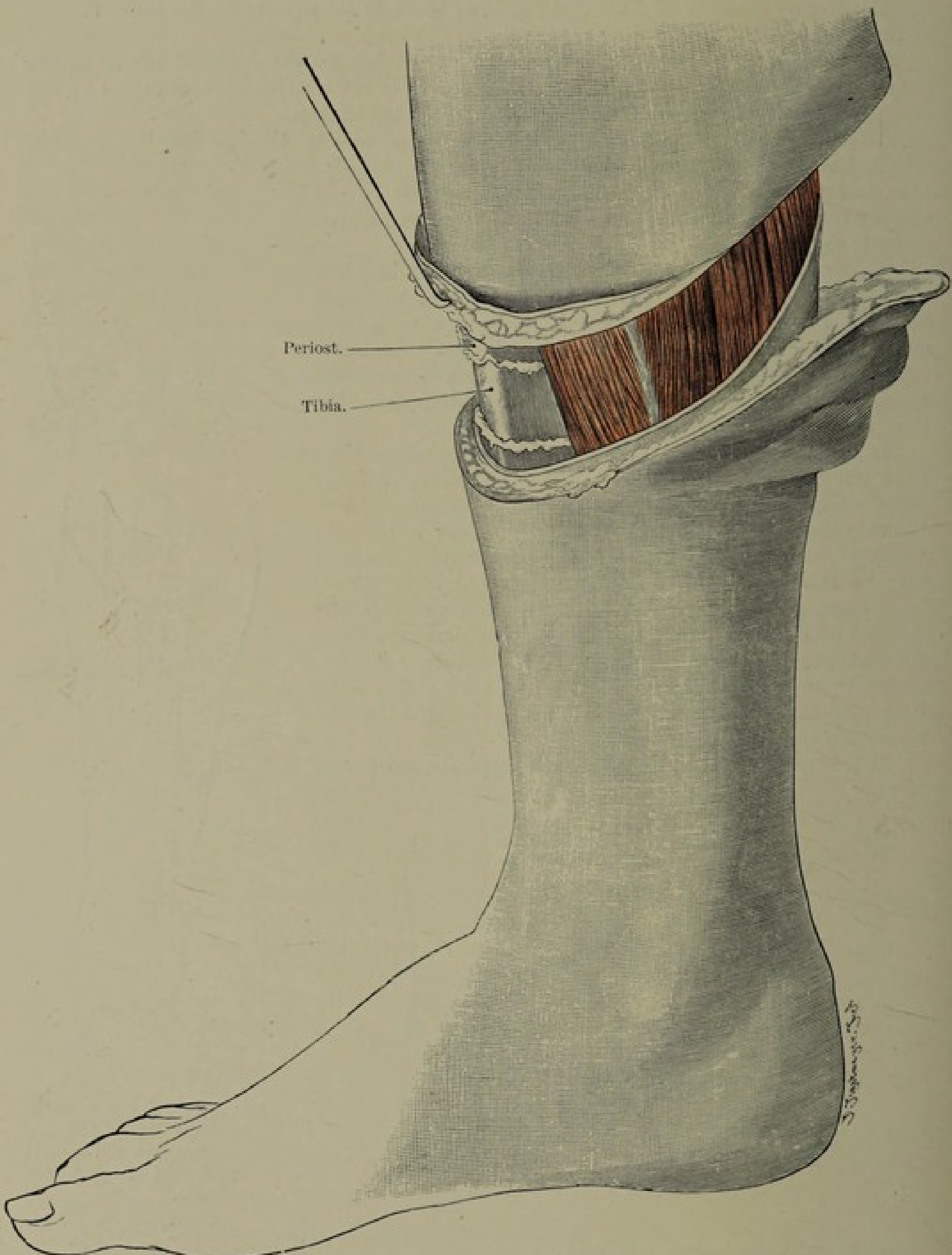


FIG. 224.—Osteoplastic amputation of the leg. An oblique incision is made through the skin and fascia, which are retracted ; the periosteum of the tibia is divided and stripped slightly upwards.

tibia. Then the periosteum is divided transversely at the level of the apex of the flap, and two lateral incisions are carried upwards through the periosteum 3 mm. behind the anterior and internal border of the tibia. The periosteum having been separated upwards for a short distance, a wedge is removed from the surface of bone

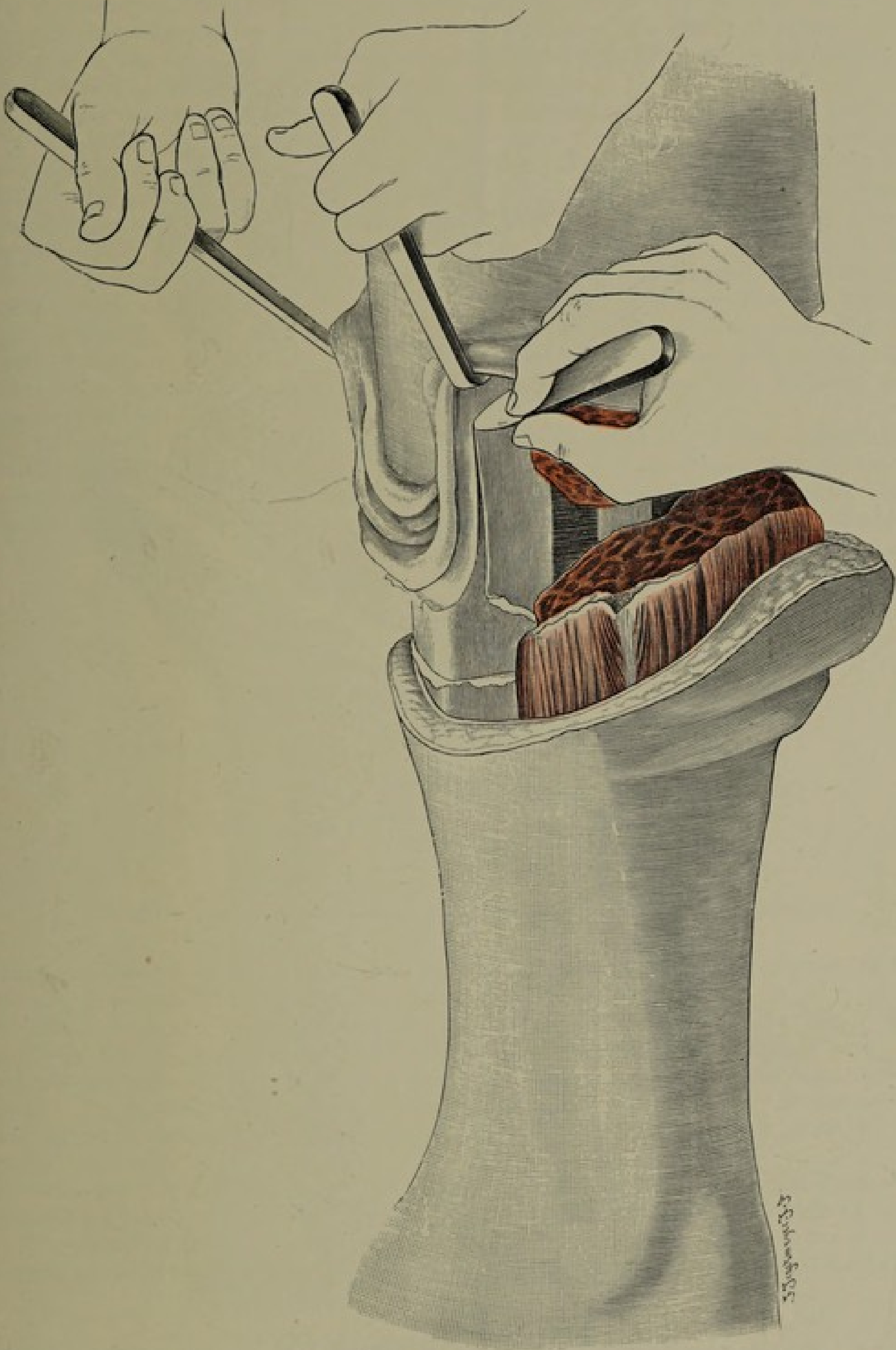


FIG. 225.—Osteoplastic amputation of the leg. The skin edges are retracted upwards; the periosteum is incised along the line at which the bone is to be sawn.

thus laid bare, so as to allow the blade of the saw to be applied parallel to the inner surface of the tibia, from which a layer of bone is removed subjacent to the rectangular flap of periosteum. This layer is next broken across with an elevator at its base, at

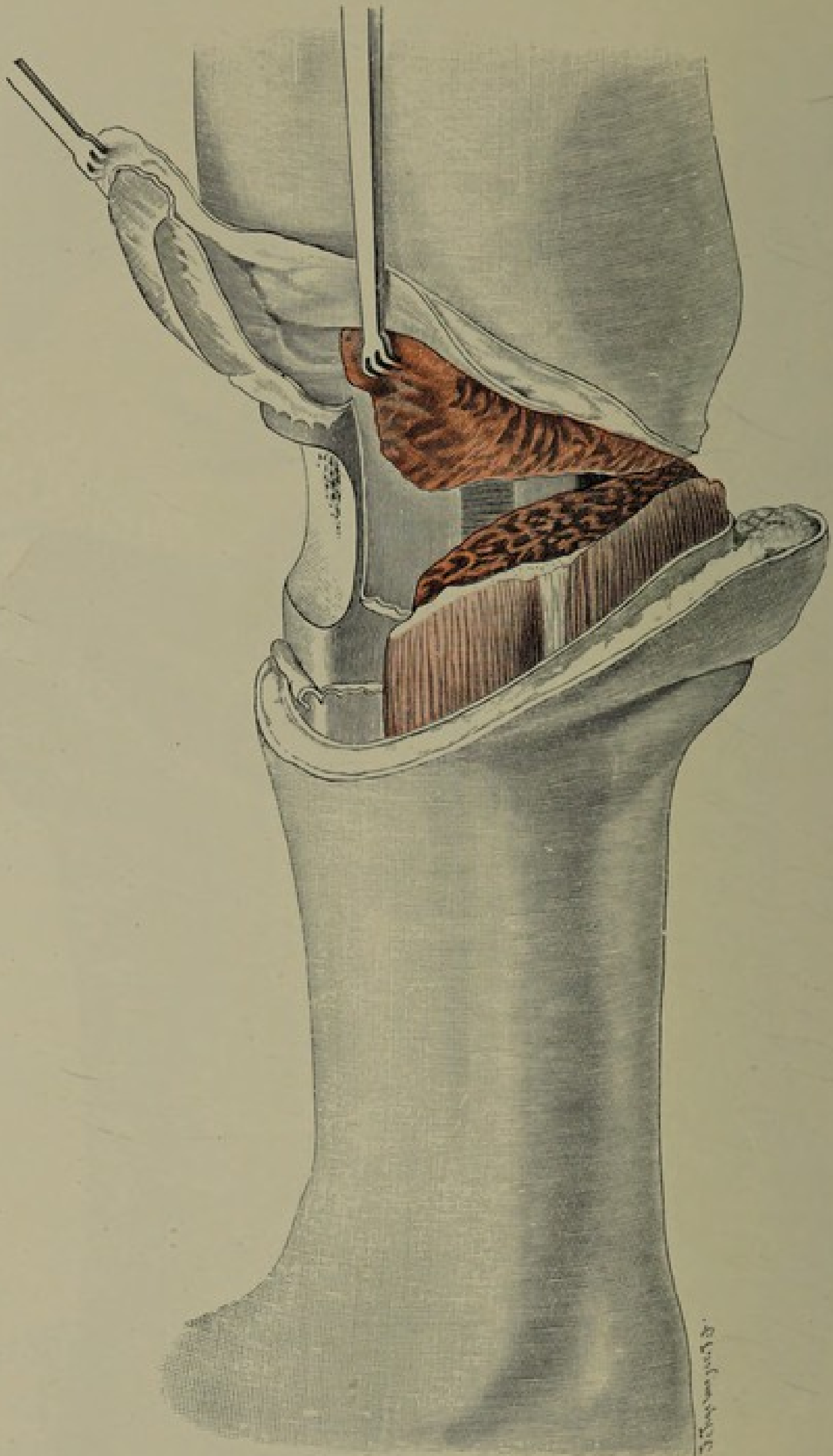


FIG. 226.—Osteoplastic amputation of the leg. A flap has been turned up consisting of skin, periosteum, and bone ; the periosteum has been stripped rather higher than the base of the flap of bone.

which level the periosteum is separated still farther upwards and the soft parts divided circularly. The bones are then sawn across and the osseous flap is sutured over the sawn surface of the tibia.

The principle formulated by Storp can be carried out in a simple way by retaining

the continuity of the osteoplastic flap with the skin. This may be done by chiselling the periosteo-osseous flap parallel to the inner surface of the tibia and reflecting it up along with the skin, the periosteum covering the lateral and posterior surfaces of the tibia as well as that of the fibula being also retracted.

It is desirable (and not difficult) to retain the continuity of the deeper parts with the skin, otherwise necrosis of the latter frequently occurs. Figs. 224, 226, show how this may be done, the saw being still used. The disadvantage of the chisel is that it often causes considerable splintering. We consider it unnecessary to provide an osteoplastic covering for the fibula. All that is required is to see that it does not project: if it does, it should be sawn higher up. We make an oblique incision through skin and fascia as in Fig. 224, but only reflect the skin sufficiently far up to enable us to divide the muscles transversely down to the bone. The skin over the tibia is then retracted with hooks, the periosteal flap is mapped out as in Fig. 225, and the strip of bone is removed with a saw, leaving a concave surface (Fig. 226). The fibula is now divided at a higher level, after which the tibia is sawn across convexly so that it will fit the flap.

In regard to the various methods of dealing with the thick muscles of the calf, we would simply mention that Treves, following Hey and Lee, utilises them in the flap posteriorly—a posterior musculo-cutaneous flap. In this way a smooth wound surface is obtained, if the large muscles of the calf alone are made use of. Teale and

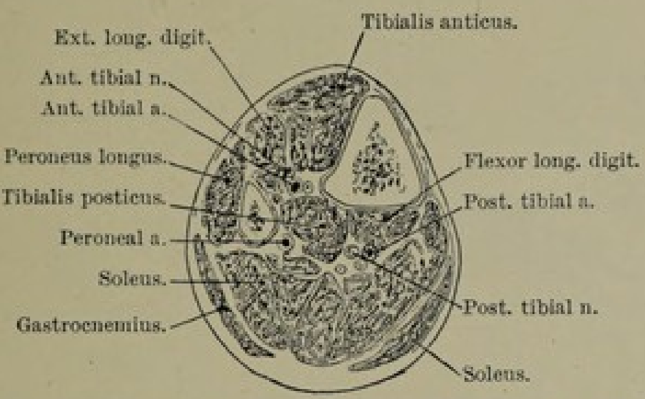


Fig. 227.—Transverse section through the leg above its middle (from a photograph).

Bruns endeavour to make the wound surfaces smaller by combining circular or semicircular incisions with a longitudinal incision down to the bone.

Teale makes a large anterior and a small posterior rectangular flap. Bruns employs the original operation of Celsus, *i.e.* circular incision through skin, with circular division of the muscles at a higher level and subperiosteal shelling-out of the bone. In the description of amputations in general, we have already mentioned that the racket or double flap incisions are very suitable when thick masses of muscle have to be dealt with.

The anterior and posterior tibial vessels—the former lying upon the interosseous membrane, the latter upon the deep muscles of the calf—are met with along the whole length of the leg, and in addition, in the lower two-thirds, the peroneal artery, which lies between the flexor longus hallucis and the posterior surface of the fibula.

(h) Amputations at the Knee

In the knee, just as in other joint regions, amputation as high as possible through the bones on the distal side of the joint is preferable to disarticulation, provided the tendon insertions into the upper end of the tibia and fibula are preserved (*vide* the excellent stump as regards weight-bearing, illustrated in Fig. 205); if these are not retained, there is no object in the amputation. A second important point in deciding which of the numerous methods is to be employed is whether the joint is healthy or

not. Ssabanejeff has shown that even when the joint is diseased, a form of high amputation through the leg, which admits of the removal of the diseased synovial membrane, is still possible. After consideration of these two main points, all methods which guarantee a stump capable of bearing weight can be employed. On these principles we describe the different methods.

The question is still undecided whether or not it is advantageous, provided the knee-joint is healthy, to retain the capsule, while the same remark applies to the preservation (or non-preservation) of the patella. The latter is always of use when an artificial limb is fitted. In view of the comparatively small amount of muscular tissue in the region of the knee, the flap consists merely of skin and fascia, at least on the anterior surface. The oblique incision is to be preferred as the large size of the condyles of the femur requires that special care be taken to provide an ample covering of skin.

49. Disarticulation at the Knee (Figs. 228, 229). This is performed if the joint is in a healthy state, but amputation higher up is necessary if it is diseased. By retaining the capsule of the joint along with the synovial membrane (Socin) a freely movable covering for the stump is provided; but the same can be obtained if the flaps

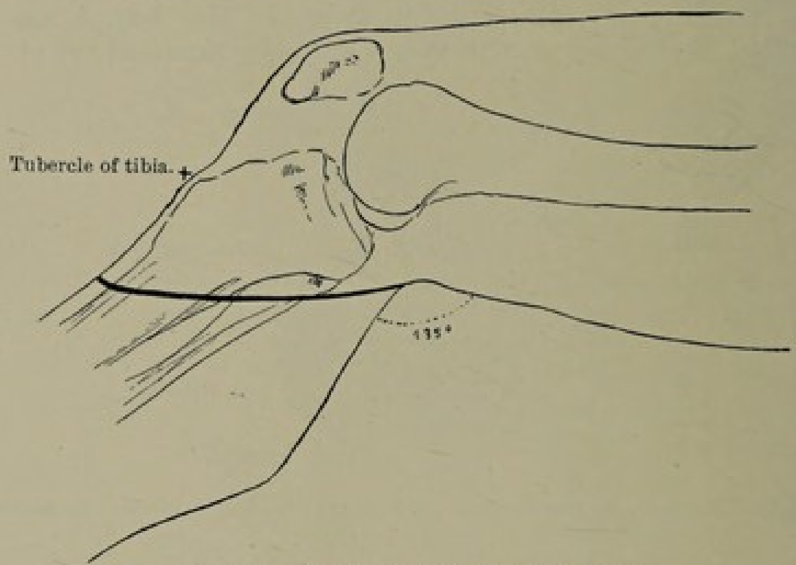


FIG. 228.—Disarticulation at the knee-joint.

are carefully stitched and asepsis is complete. Owing to the great breadth and thickness of the condyles there must be no lack of skin taken from the sides. For this reason the oblique incision is more suitable than any of the flap methods. An excellent stump is got if aseptic healing occurs.

(*a*) *Retaining Capsule and Patella.* An anterior flap is obtained by making an oblique oval incision, beginning posteriorly opposite the level of the joint, and ending anteriorly four fingers'-breadth below the tubercle of the tibia. If the leg be held with the knee half-bent (making an angle of 135° with the thigh), the incision falls in the continuation of the long axis of the thigh (Fig. 228). After dissecting up the skin and fascia, the capsule with the ligamentum patellæ, the semilunar cartilages, and lateral ligaments, are cut through anteriorly and laterally; the crucial ligaments are separated from the spine of the tibia; the posterior part of the capsule is cut through along the tibia, and the operation is completed by making a transverse incision through the soft parts posteriorly. The chief vessels requiring ligature are the popliteal artery and vein, but the articular arteries and branches to the gastrocnemius may also require tying. The popliteal nerves are pulled out and cut across high up.

When the cavity of the joint is retained it is necessary to introduce into it a drainage tube through a special opening on each side of the patella. The skin wound can then be completely closed.

(*b*) *With Removal of the Capsule and Patella.* Oblique incision as above. The fascial flap is dissected up to above the level of the patella, where the quadriceps tendon and insertions of the vasti to the patella are cut through. The synovial pouch underneath the quadriceps is dissected up on its outer side, separated from the front of the femur and divided at the margin of the cartilage. The crucial ligaments are severed close to the femur, the lateral ligaments are divided below the condyles, and the posterior part of the capsule is removed, after which the soft parts in the popliteal space are then divided from without.

The method of making an anterior flap is not so satisfactory as the oblique incision. Treves prefers two lateral flaps (Stephen Smith's operation), consisting of skin and fascia only, and this method is very popular with many surgeons.

The skin cicatrix, however, rests below on the end of the bone, while with our oblique incision it is entirely on the posterior aspect, even more so than it is after a circular incision.

Miller, with the knee fully extended, makes a circular incision round the limb 2½ inches below the condyles. The soft parts retract so much on the flexor surface that it is only necessary to dissect up the flap on the extensor surface. A posterior scar results.

Bier declares that disarticulation at the knee gives an exceedingly good stump

FIG. 229.—Section through the knee-joint at the level of the condyles of the femur.

because there is no bony scar formed. When there is plenty of skin it is to be preferred to all other methods.

All methods which result in a scar being left on the under surface of the stump are not so satisfactory. Naturally a posterior oblique incision may be employed if the skin in front is deficient.

(i) Amputations through the Thigh

These are among the most common amputations and are undertaken for injuries (complicated fractures and crushes) gangrene, and in suppurative and diseased conditions of the knee-joint. The choice of method largely depends on the level at which the amputation is to be performed. In the lower third where the muscles are scanty the coverings for the ends of the epiphysis and juxta-epiphyseal regions consist simply of skin and fascia. The stump, however, is functionally good, provided that the bone is rounded off, that the cicatrix lies posteriorly (oblique incision), and that the mobility of the skin is maintained by covering over the sawn surface of bone with a layer of deep fascia. In this respect the conditions are similar to those in disarticulation at the knee.

In the middle of the thigh one should still attempt to procure a stump adapted for bearing weight. All incisions therefore such as the circular and double flap incisions, in which the cicatrix generally lies over the end of the stump, are to be avoided as a rule. On the other hand, a long anterior flap is very suitable, as, owing

to the conical character of the limb in this situation, the oblique incision is more difficult. Simplification of the incision through the muscles (by making a circular incision through them in one plane as in the old Celsus operation) is recommended

Fig. 230.

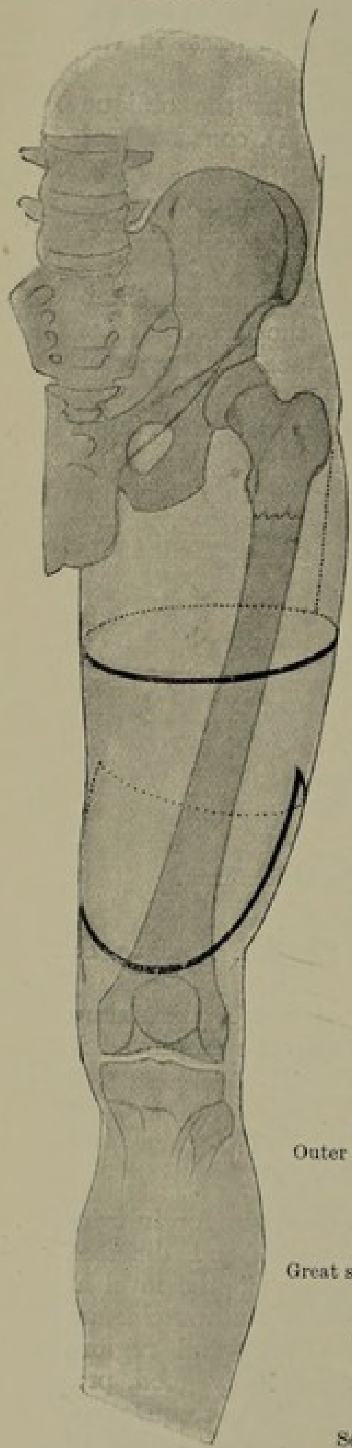


Fig. 231.

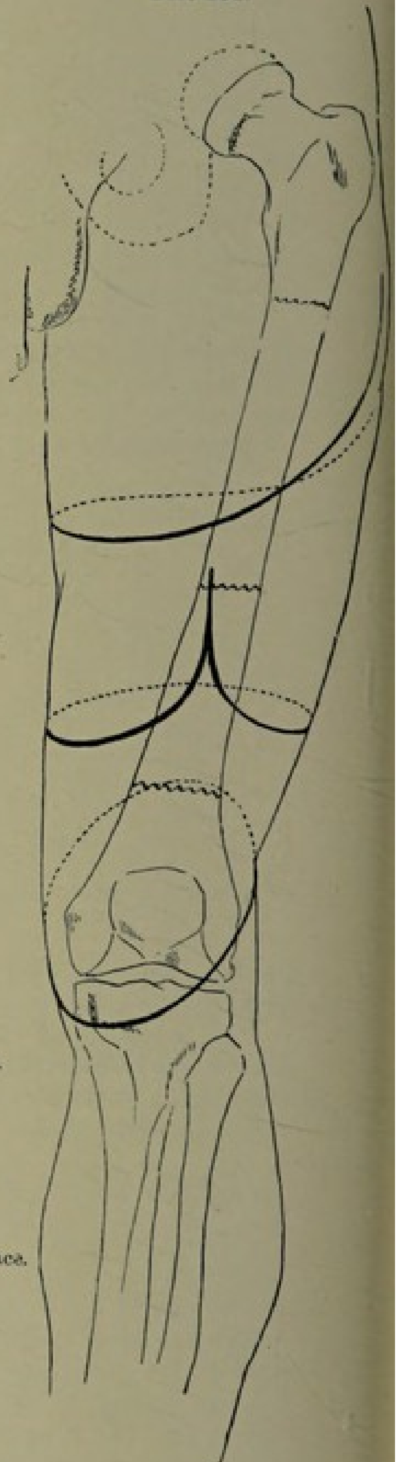
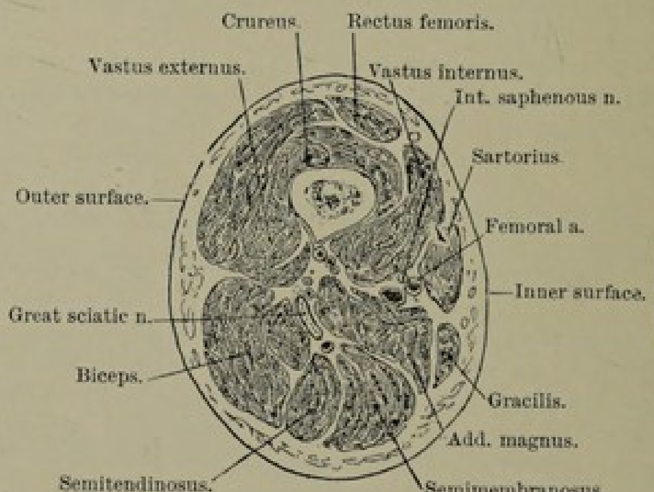


Fig. 230. — Flaps for amputation through the lower third of the thigh; and for amputation through the upper third (racket incision).

Fig. 231.—Amputation of the thigh below the trochanters; through the middle of the femur; above the condyles (supracondyloid).

Fig. 232.—Transverse section through the thigh (from a photograph).

Fig. 232.



here as it was in the case of the muscular portion of the middle of the leg (Bruns), a flap of skin and fascia only being placed over the large cut surface of the muscles. If the muscles are atrophied, the anterior flap of skin and fascia should contain the whole thickness of the quadriceps.

When the artificial limb takes its purchase from the pelvis, a weight-bearing stump

is no longer necessary, and the steps of the original Celsus operation should be followed, *i.e.* the successive circular division of skin and fascia, then of muscles, and subperiosteal division of the bone. The popular methods of making lateral flaps, specially recommended by Esmarch, are equally good, as they result in a smooth wound, provide for good drainage, and are simple to perform, *e.g.* in war, where there is uncertainty as to the subsequent course of the wound.

In the upper portion of the thigh the conditions are different. Here there is no question of pressure of the artificial limb on the stump, and a stump capable of bearing weight is not required. All the more care, however, must be taken to provide a muscularly strong stump.

The position of the scar is here of secondary importance compared with the preservation of the muscles and soft parts. The racket and its modification, the lanceolate, incision is the best method to employ. The longitudinal portion of the incision is carried down to the bone along the posterior border of the vastus externus, the periosteum is dissected off the bone, and the latter divided according to Neudorffer's method, or with a Gigli saw. The bone is then shelled out downwards and, after retraction of the skin upwards, the muscles are cut through with a single circular sweep rather more than half the diameter of the limb below the level of division of the bone.

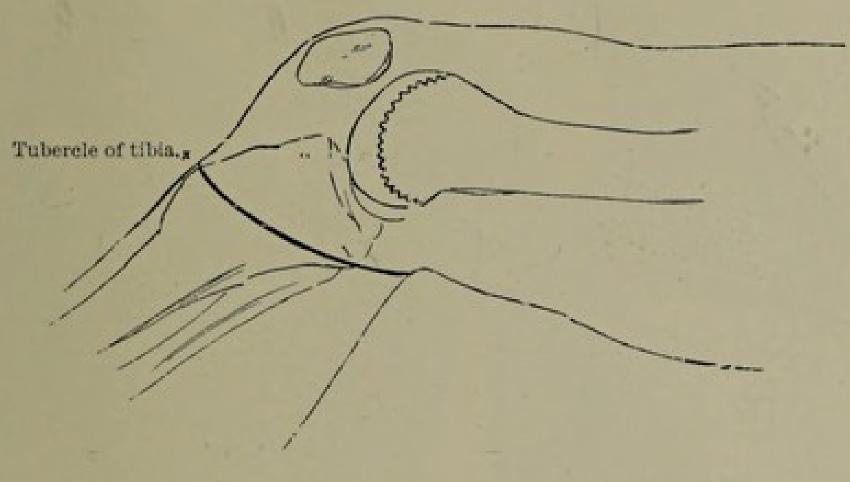


Fig. 233.—Amputation through the condyles (Carden).

50. Amputation of the Femur through the Condyles (Carden and Buchanan) (Fig. 233). Buchanan, in amputating at the lower end of the femur in children, simply separated the lower epiphysis of the femur.

Carden sawed off the condyles in a curved direction through their greatest breadth, obtaining in this way an excellent stump, and one well adapted for bearing weight Amputation through the condyles should take the place of disarticulation at the knee when the joint is diseased and removal of the synovial membrane is necessary. This indication calls for a different method of performing the operation. Here also the oblique incision is prolonged anteriorly so as to place the scar well away from the stump. The incision begins posteriorly at the level of the epicondyles and reaches down to just below the tubercle of the tibia. The flap, consisting of skin and fascia, is dissected upwards to above the patella: the quadriceps is here divided down to the synovial membrane of the joint, which is exposed and freed as far as its upper limit without opening the joint, and then stripped downwards off the bone to below the epicondyles of the femur. An incision is then carried round the femur down to the bone, from the upper border of its trochlear surface through the lateral ligaments just below the epicondyles, and transversely across its posterior surface immediately above the synovial pouches posteriorly behind the condyles. The lower epiphysis of the femur is sawn through convexly along this line, and the soft parts on the posterior aspect of the limb are divided.

The stumps which we have seen from this operation (and our teacher Lücke was very fond of the method) were all painless,[1] and bore pressure exceedingly well, in spite of the fact that the bone cicatrix was directed downwards. Moreover, the skin was always freely movable upon the stump, because the fascia was placed over the sawn surface of the bone, and the scar lay entirely on the posterior aspect of the stump.

51. Osteoplastic Amputation of the Femur through the Condyles (Ssabanejeff). Ssabanejeff has devised a form of *osteoplastic amputation* through the condyles in which the anterior flap contains a piece of bone sawn from the anterior surface of the

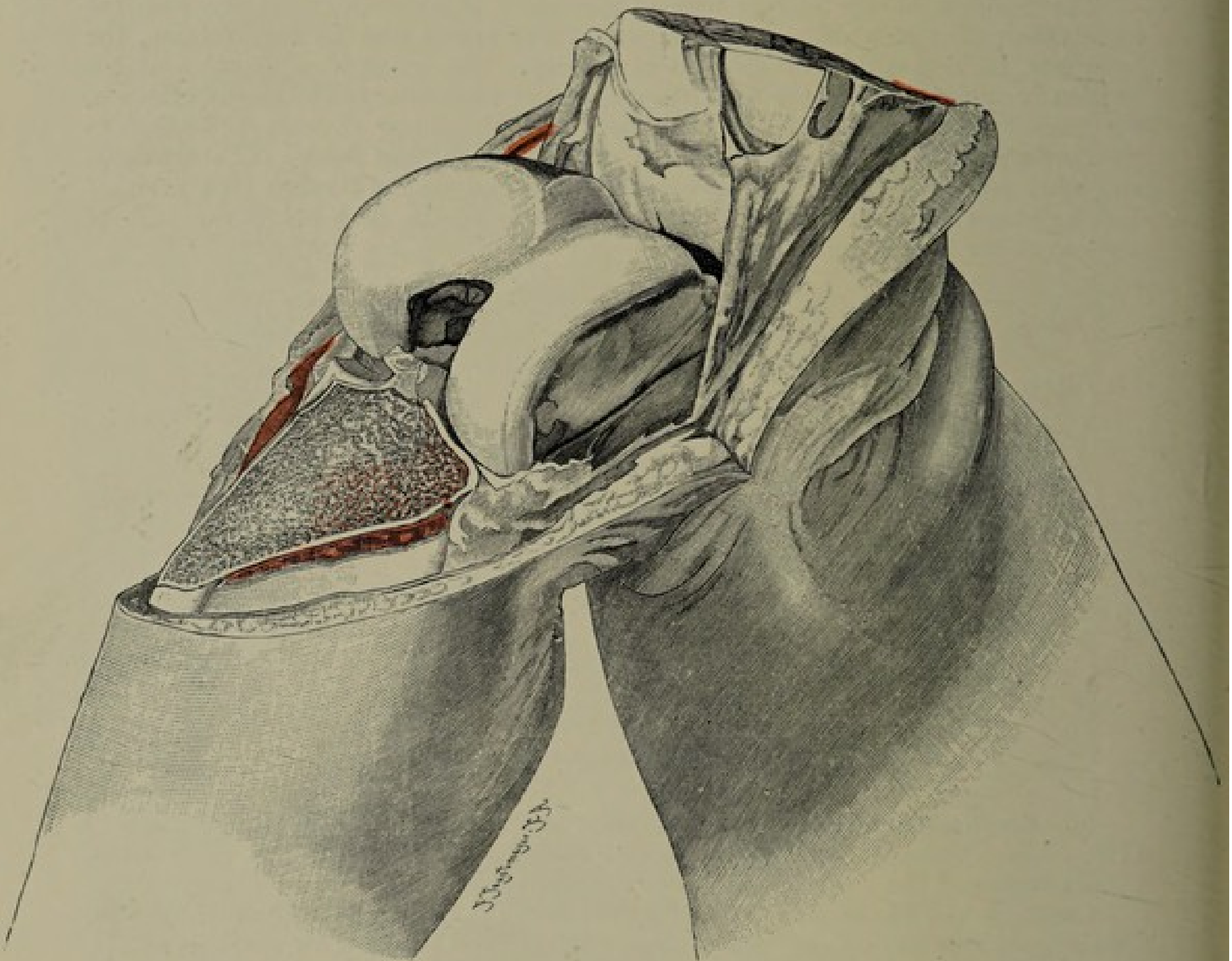


FIG. 234.—Osteoplastic amputation through the condyles of the femur (Ssabanejeff). An oblique incision has been made through skin and fascia as in Carden's amputation (Fig. 233). The tibia is sawn through obliquely upwards and backwards as high as the head of the fibula, and the flap containing the upper section of the bone is thrown backwards. The line of section through the condyles of the femur is shown.

tibia. After retraction of the anterior flap the saw is applied close to its anterior edge and carried in an oblique, or, better, slightly concave direction backwards to the posterior surface of the tibia, so as to remove from it a cap of bone (Fig. 234). The flap containing the piece of bone is reflected upwards as in the operation just described, after dividing the capsule and the lateral ligaments. The condyles of the femur are then divided obliquely as Fig. 234 shows, *i.e.* from above downwards and

[1] We must point this out in opposition to Bier, who disapproves of Carden's operation. We have seen a large number of excellent stumps capable of bearing pressure. Unfavourable criticism must be due to variations in execution and after-treatment.

backwards, after which the soft parts posteriorly are cut through transversely at the level of the joint.

In this way the skin and bone (anterior surface of tibia) most accustomed to bear pressure are both brought below the face of the stump, which is therefore an excellent one. The capsule, as well as the insertions of the sartorius, gracilis, and, if necessary, the biceps, are retained. We are indebted to Djelitizin for the idea of sawing the tibia obliquely instead of vertically as originally proposed by Ssabanejeff. Abrashanow has introduced a reverse operation, viz. the formation of a posterior flap containing the posterior half of the tuberosities of the tibia, which are applied to the horizontal and frontal sawn surfaces of the femur and patella.

These methods may be applicable when a portion of one of the bones containing a focus of disease must be removed. According to Hilgenreiner, Wölfler has tried them on the living subject and has obtained good and permanent functional results.

52. Supracondyloid Amputation. When sufficient skin cannot be got to cover the condyles a supracondyloid amputation must be performed. The amputation can be performed either by an oblique incision or by the flap method. In the latter case

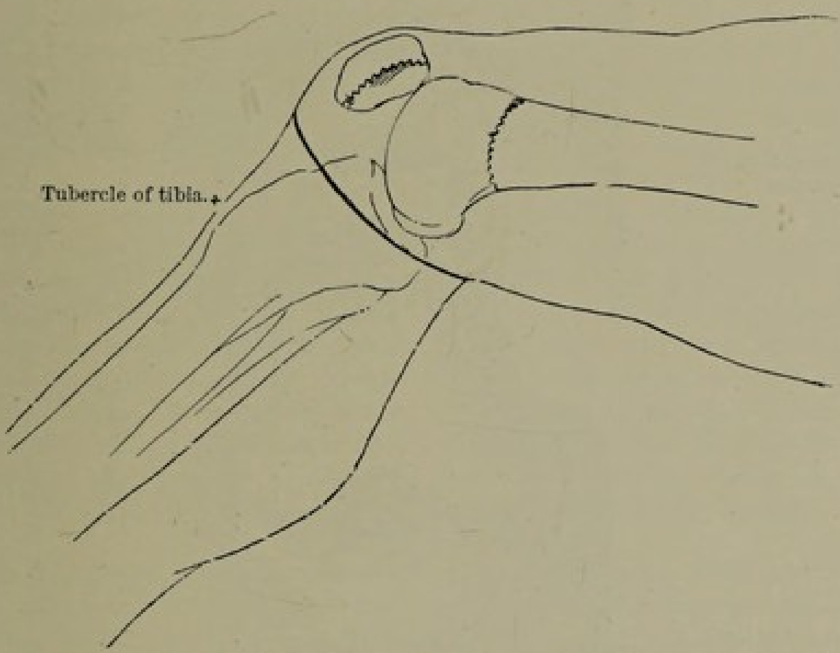


FIG. 235.—Osteoplastic supracondyloid amputation (Gritti).

the flap should be taken from the antero-internal aspect (Fig. 231), because if a purely anterior flap be made, the adductors pull the femur inwards and forwards and cause it to press against the inner corner of the wound. A favourite amputation with many surgeons is Spence's method, modified by Farabœuf, in which a large anterior and a small posterior flap are made, the latter being replaced by a mere convex incision. In this method also we prefer to make the anterior flap slightly on the inner side.

A good stump capable of bearing pressure is obtained after amputation above the condyles, by sawing the bone convexly and rounding off the corners. If the skin (*i.e.* a flap of skin and fascia) is not to be trusted on account of adhesions, infiltration or defective nutrition, it is well, according to Wilms, only to dissect up the skin to the upper border of the patella, to divide the quadriceps tendon at this point, and then to continue the formation of the flap obliquely upwards through the vasti. The quadriceps tendon is stitched to the periosteum behind, so that the end of the bone is covered.

53. Osteoplastic Supracondyloid Amputation of the Thigh (Gritti) (Figs. 235 and 236). An oval incision is made with its upper end situated posteriorly above the prominence of the condyles, its lower end anteriorly three fingers'-breadth below the

patella. The ligamentum patellæ is divided obliquely and a portion retained for subsequent suture. The knee-joint is now opened, and the capsule detached upwards along with the skin flap above the condyles, where the periosteum is divided all round and stripped off the bone two centimetres higher, *i.e.* the level of division of the bone. The femur is sawn through transversely immediately above the condyles, preferably leaving a convex surface. The cartilage is removed from the patella in such a way as to leave a concave osseous surface, which is applied to the convex sawn surface of the femur and held in position by a few sutures which unite the margin of the patella and the patellar ligament to the periosteum of the femur.

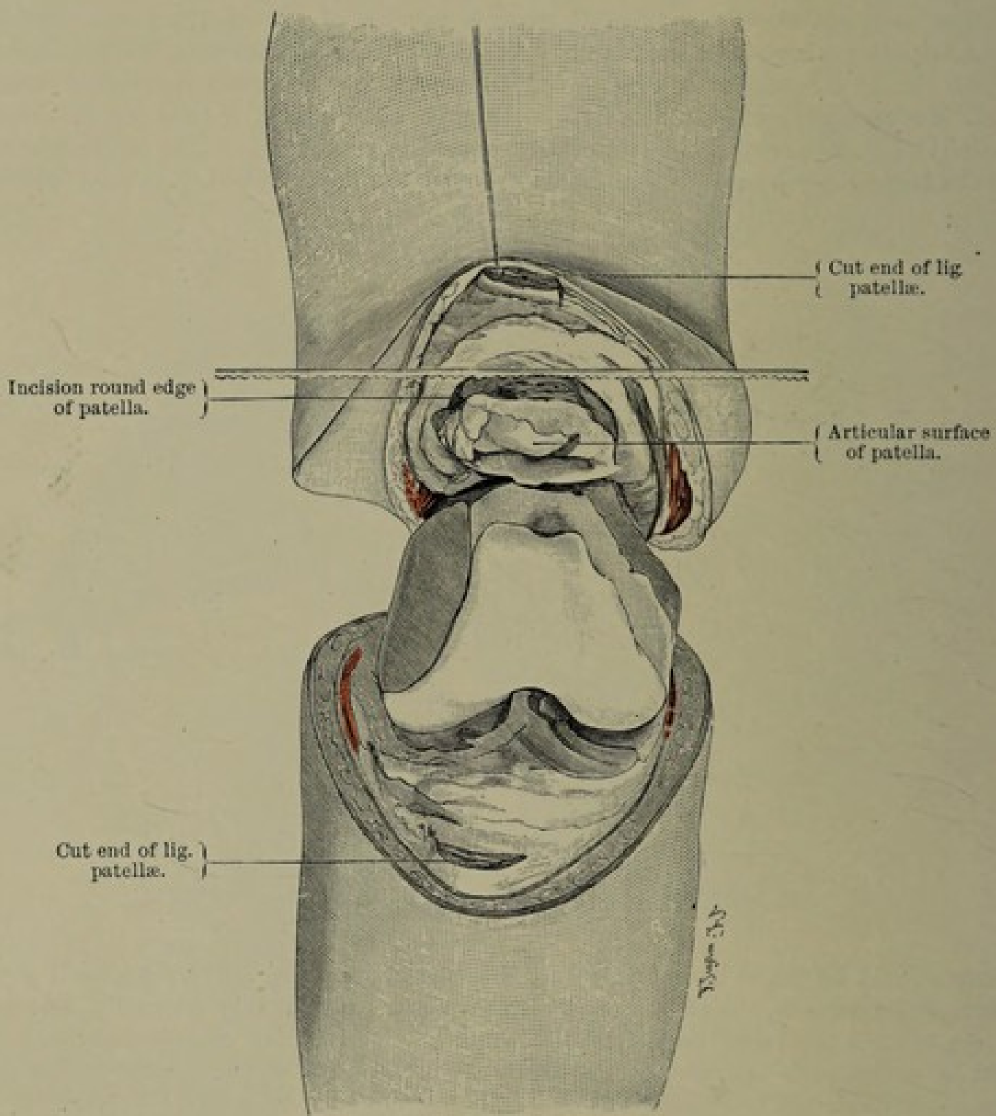


Fig. 236.—Supracondyloid osteoplastic amputation (Gritti) by an oval incision.

Balacescu[1] speaks in high terms of Gritti's operation, especially in regard to the shape of the stump obtained. In 111 reported cases he found the mortality from the operation was only 7·2 per cent.

Silbermark's modification[2] of Mosetig's operation, in which the stump of the ligamentum patellæ is merely stitched to the ends of the flexor tendons will be found described in former editions of this work.

54. Amputation through the Middle of the Thigh. The mass of muscle here affects the choice of method (*vide* Figs. 230 and 231). In the typical method a

[1] *Revista de chirurgie*, Bukarest, 1903, Nos. 11 and 12. [2] *Centralbl. f. Chir.* 1904.

long anterior (slightly internal) and a convex posterior flap are made (*vide* Fig. 230). If there is much muscle the skin and fascia only are dissected back, and the muscles are cut transversely. If the muscles are atrophied a flap consisting of skin, fascia, and muscle is taken from the quadriceps. The operation is performed according to the rules for aperiosteal amputation (*vide* General Introduction), *i.e.* the periosteum is divided 1 to 2 cm. above the level at which the bone is to be sawn across leaving the stump bare. The sharp edges of the sawn bone are rounded off with bone forceps.

Methods which result in the scar lying on the stump are only permissible when the question of weight-bearing has not to be considered, and then only if the condition of the wound is simplified or improved by it, *i.e.* if the operation can be performed more expeditiously and with smaller wound surfaces. In muscular limbs two short flaps are made, and after retracting them, a clean cut is carried transversely through the muscles (Lisfranc and Esmarch). A very clean wound can also be made by dividing the muscles by transfixion after the skin has been divided. This operation is equivalent to the lanceolate incision as illustrated in Fig. 231. In very muscular limbs the periosteum is separated upwards for several centimetres so that a sufficient covering of skin and soft parts may be obtained.

55. High Amputation of the Thigh. When a high amputation of the thigh is performed, the artificial limb must take its support from the pelvis (tuber ischii) and there is no necessity for trying to obtain a stump capable of bearing weight. The stump must, however, be freely movable, so that the artificial limb can be fully controlled.

The technique of high amputation and disarticulation is therefore very similar. The racket incision, which we mentioned in the introductory chapter as being specially suited for this purpose, should be adopted (*vide* Fig. 230).

With a racket incision the hæmorrhage is easily controlled, a consideration which is here of more importance than lower down in the thigh, where an Esmarch's elastic tourniquet can be readily applied. By placing the longitudinal incision on the outer side of the thigh along the posterior border of the vastus externus, one can cut boldly down to the bone. The periosteum is then raised and the bone divided at the proper level [two-fifths of the diameter of the limb above the level at which the soft parts are divided (Neudörffer)], the lower end of the femur being brought out at the wound.

An elastic tourniquet is now applied, and having previously indicated by a scratch on the skin the level at which the limb is to be amputated, we rapidly make a circular incision with two successive sweeps of the knife. It is often more advisable to incline the incision a little obliquely downwards and forwards. An assistant grasps the soft parts and controls the vessels with his fingers, or Lynn-Thomas's excellent forceps-tourniquet (Fig. 200) may be applied and the soft parts in front and behind securely clamped.

56. Disarticulation at the Hip (Figs. 237, 238, and 239). Considering the mass of muscle which surrounds the hip-joint and the great importance, after removing the entire bony apparatus of the limb, of obtaining a movable muscular stump, high amputation through the thigh with subperiosteal removal of the upper end of the femur should, in the absence of special indications to the contrary, be regarded as the normal procedure. We may refer the reader to what has been said in speaking of amputations in general. Experience has taught us that here, just as in the shoulder, a movable muscular stump is of the greatest service in enabling an artificial limb to be worn.

A very different procedure must be adopted when it is necessary to remove as much as possible of the deeper soft parts, as, for example, in malignant disease. According to the indications, therefore, different methods of amputation must be employed, and these may be classified into two main groups.

The method practised by Beck and Verneuil, and improved upon by Rose (extirpation method), is to be regarded as the type of methods in which the deep soft parts must also be removed. For all cases, on the other hand, where the

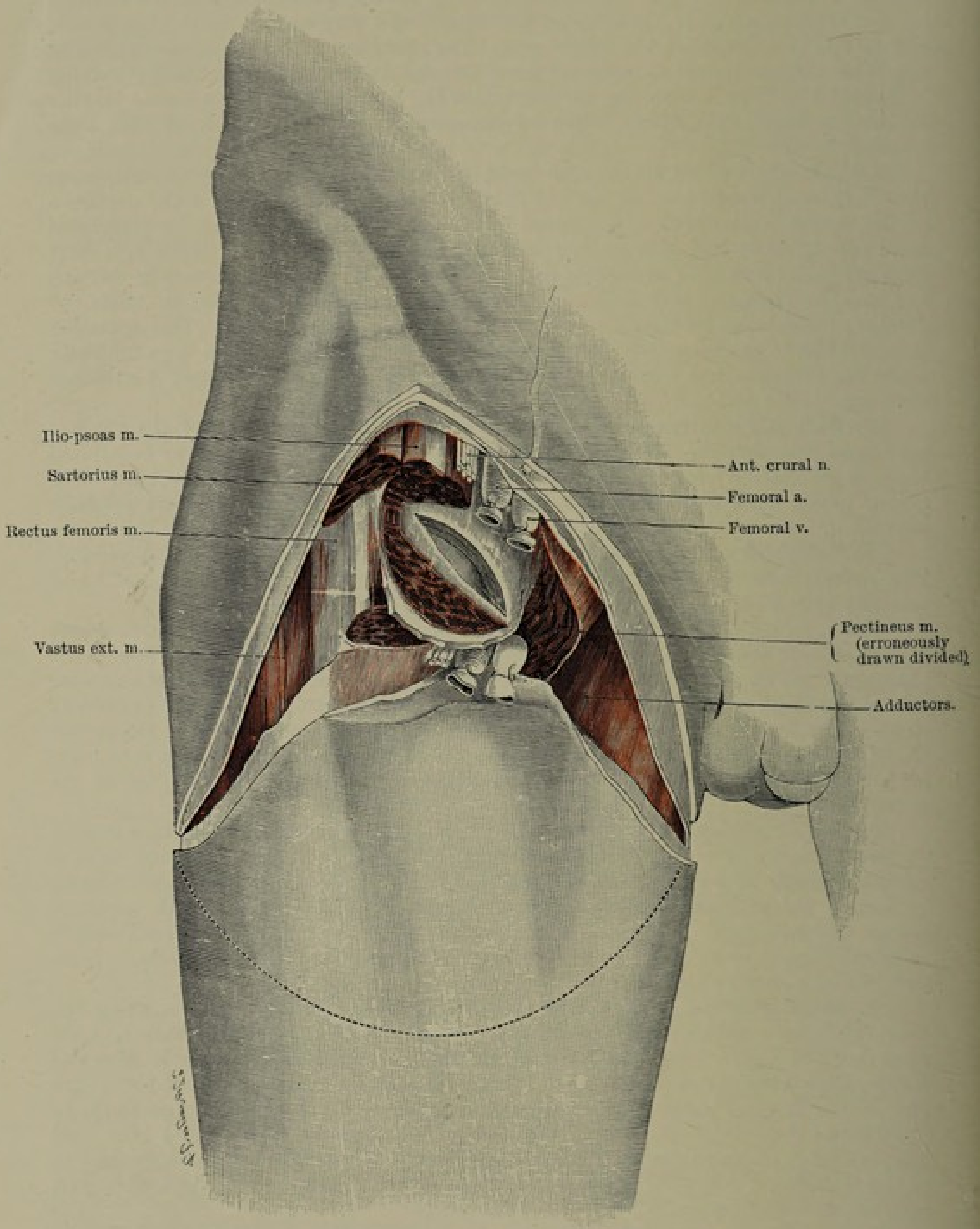


FIG. 237.—Disarticulation at the hip for disease affecting the soft parts in front. Extirpation method by the oval (or lanceolate) incision. The main vessels are first tied; the sartorius and ilio-psoas muscles are divided and the joint is opened anteriorly. The pectineus is erroneously represented as divided, whereas the anterior surface of the muscle should have been represented.

muscles can be retained, Roux's or Kocher's modification of the method of Ravaton (1743, Treves) and Kerr is indicated. An external racket or an external lanceolate incision is made, and a combined excision and amputation performed, as specially practised by us. The principle of this operation was carried out by Furneaux Jordan, who, by means of an external longitudinal incision, divided the insertions of the muscles into the trochanter and upper part of the femur, and amputated the limb as low down as possible by the circular method.

The excision-amputation method (a modification of Jordan's method) practised by us, diminishes the loss of blood, as it permits of the part of the operation which must be done without complete prophylactic control of hæmorrhage being performed with the minimum of injury. Lister has availed himself by this method of the advantage of first of all disarticulating the head of the femur, *which Esmarch leaves to the last.*

The remarkable danger and mortality which formerly attended the operation have been greatly reduced since Esmarch taught us how to effectually control the hæmorrhage. Rose's method is *meant* to be performed without Esmarch's prophylactic measure. Thanks, therefore, to the improvement in the technique, amputation at the hip can now be undertaken without hesitation even in comparatively feeble persons. We have had no experience of Wyeth's method, in which two large steel pins are pushed through the joint to keep the rubber tube from slipping. Wyeth has also employed this method for the shoulder since 1890, and has produced evidence to show that in nearly seventy cases the bleeding was controlled with absolute certainty. It may therefore be used with advantage in certain circumstances.

(*a*) *Extirpation Method* (Fig. 237) (Beck-Rose's operation). Rose, following the example of Beck (Lüning), removed the thigh like a tumour by dividing the larger vessels between two ligatures, and ligaturing the others immediately after dividing them. This *extirpation method* is the more suitable when the tumour extends high up in the region of the hip-joint. In such cases the soft parts can only be partially retained. For this reason no special description can be given of the operation to be performed, as this must necessarily vary in different cases. It is always desirable, however, to place the incision so that the main vessels (as in removing the upper extremity along with the shoulder girdle) can be ligatured at the outset, *i.e.* the angle of the incision is to be placed over the femoral vessels (Fig. 237). In this way all bleeding is prevented, with the exception of that from the obturator, gluteal, sciatic, and possibly the internal pudic arteries. If, however, forceps be at once applied to the bleeding vessels after dividing them, further hæmorrhage is reduced to a minimum.

The figure shows that the method described by us, from our experience of cases of sarcoma extending high up, depends on these principles, and can be considered as the *anterior* racket, in distinction to the *external* racket. According to Farabœuf and Treves, Larrey introduced this incision, which was practised in a modified form by Cooper, Verneuil, and Roser. Guthrie's and Lisfranc's methods are also very similar as regards the position of the incision, which was, however, partly made by transfixion. Of the earlier transfixion methods, which were regularly practised and taught, and were based on rapidity of execution with disregard of proper means of checking hæmorrhage, no more notice need be taken as they involve too severe bleeding.

(*b*) *Excision-Amputation Method* (Fig. 239). In all cases where the soft parts in the region of the hip can be retained, the bone should be shelled out from the soft parts quite bare, as the muscles of the stump are of great functional use for the attachment of an artificial limb. Especially if the operation be done subperiosteally, an actively movable stump is obtained just as in a high amputation through the femur. Like Shuter and others, we have seen such a solid and perfectly movable stump formed from the periosteum that it was scarcely possible to believe that disarticulation at the hip had really been performed. The method usually employed is that by the external racket incision.

Hæmorrhage is arrested by an elastic tourniquet, which, to prevent it slipping downwards, must always be applied in the form of a figure-of-eight round the thigh and pelvis. The complicated precautions of Trendelenburg, Senn, and Wyeth may

have advantages in individual cases, but as a rule they are unnecessary. Trendelenburg transfixes the limb with steel rods passed towards the inner side from the excision wound, and then winds a rubber tube round them in the form of figures-of-eight. Senn passes a double rubber tube through the limb from the wound for resecting the hip-joint, and ties the soft parts in two halves. Wyeth prevents the rubber tourniquet from slipping by transfixing the limb through its root with two large steel pins. Braun ligatures the external iliac vessels, and from this wound an assistant compresses the internal iliac, a plan which, he asserts, is attended with least hæmorrhage.

A circular incision is made through the skin at the level estimated in the usual way, the muscles are divided down to the bone at the level of the edge of the retracted skin, and, after dividing the periosteum, the bone is sawn across. The vessels are now carefully ligatured and the tourniquet removed.

Instead of the simple circular incision it is better to make an oval incision extending upwards on the outer side of the bone (Fig. 236): if necessary we may adopt Liston's plan of making short anterior

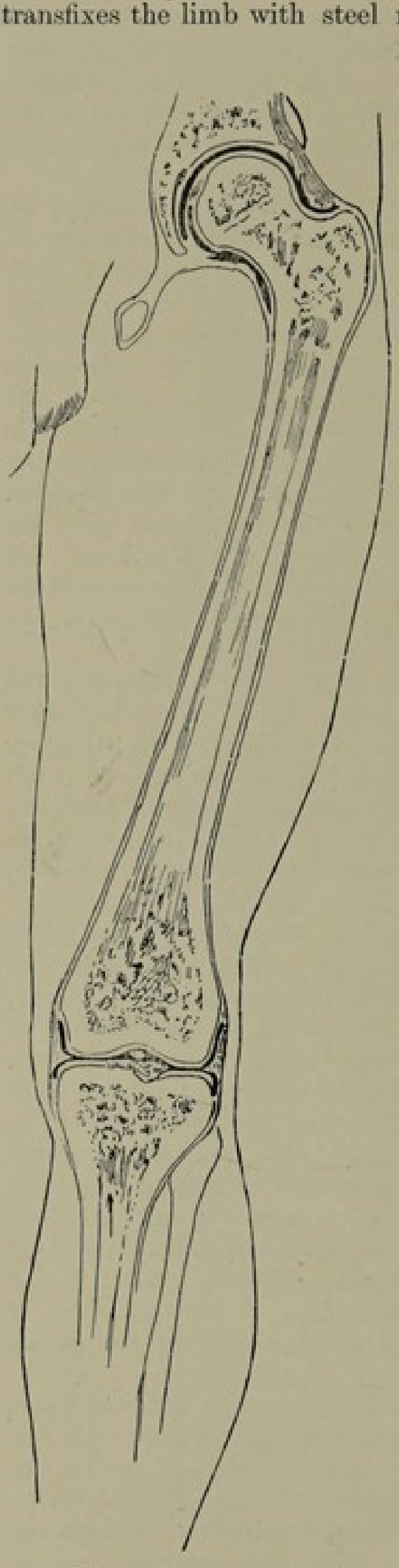


FIG. 238.—Coronal section of the hip- and knee-joints (after Henle).

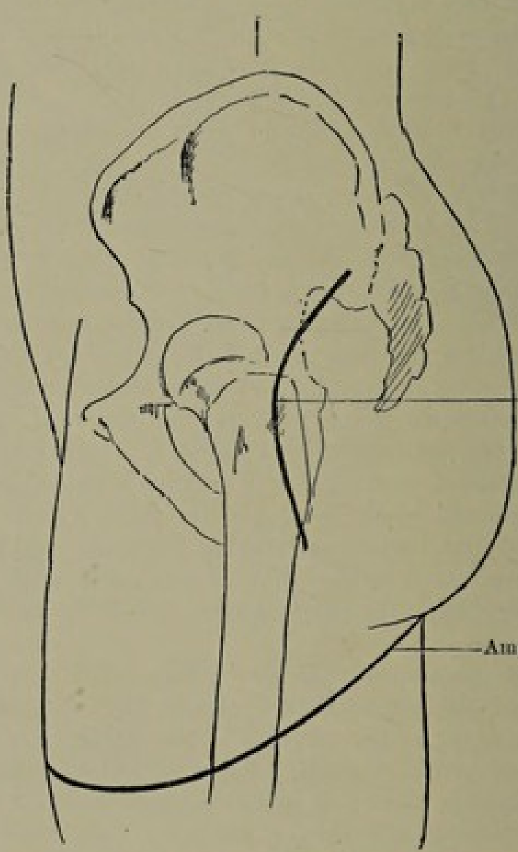


FIG. 239.—Disarticulation at the hip-joint.

and posterior skin flaps and dividing the muscles circularly.

Beck and Esmarch, after the circular amputation, divide the soft parts at the outer surface of the femur, and dissect out the bone subperiosteally by detaching

with a knife the attachment of the periosteum at the linea aspera, the insertions of the muscles (glutei, pyriformis, obturator externus, obturator internus and gemelli, and the quadratus femoris) into and below the great trochanter, the ilio-psoas into the lesser trochanter, and the attachments of the capsule in the region of the anterior and posterior intertrochanteric lines. The ligamentum teres is torn across by twisting round the femur.

Since 1876 we have had faultless results—nine cases, with no deaths (reported by Roux). Our method of operating (Fig. 239) is as follows:—The incision is the same as that described for excision of the hip, namely, in a curved direction over the great trochanter and through the fibres of the gluteus maximus, but is shorter than the ordinary one for excision. The fibres of the gluteus maximus are separated in the line of the incision and drawn apart. Branches of the gluteal and circumflex arteries are ligatured, the capsule of the joint is divided, and the insertions of the muscles (the glutei anteriorly, and the pyriformis, obturators, and quadratus posteriorly) are separated from their attachments close to the trochanter. The head of the femur is now dislocated, the ligamentum teres being divided or torn through. The soft parts are separated forwards and backwards from the great trochanter as far down as the lesser trochanter, where the strong insertion of the ilio-psoas is divided with a knife.

After completely arresting the bleeding, the limb is held up vertically, and an Esmarch's tourniquet applied in the form of a figure-of-eight around the highest part of the thigh and pelvis. The crossing of the figure-of-eight must be upon the posterior and outer aspect—that is to say, behind and above the great trochanter, so that sufficient pressure is exerted anteriorly.

The limb is now amputated below the trochanters. The skin incision is circular. The skin is then retracted, and the muscles are cut with a clean sweep down to the bone. The soft coverings must always be abundantly calculated for. The bone is then sawn across, and all visible vessels—first the femoral, then the profunda vessels, the internal saphenous vein, and the numerous small arteries—must be carefully ligatured, and the tourniquet removed.

The stump of the upper part of the femur is now surrounded with aseptic gauze and grasped while the remaining connections are freed from it subperiosteally, using the chisel for the linea aspera and insertions of the tendons, after which it is drawn out of the wound. Drains are introduced through special openings close to the resection and amputation wounds, both of which are closed by layers of sutures. In this way primary healing can be obtained in six to ten days.

Roux, in the paper already referred to, has drawn some comparisons between our operation and the methods employed by Volkmann, Guyon, and Reverdin.

57. Amputation of the Pelvis and Interilio-Abdominal Disarticulation. Our two cases of resection of the innominate bone, and those of Roux, show that this extensive operation can be performed with the best results. It is surprising, therefore, that the first cases of amputation of the hip along with the innominate, recorded by Gayet, should all have died.

Billroth first undertook the operation in 1889. Jaboulay performed it in 1894, and again in 1895, while the operation has also been done by Cacciopoli. These were cases of osteosarcoma of the pelvis, and in all death rapidly followed from shock, or sepsis. Girard of Bern was more fortunate, having performed the operation successfully in 1895, and again in 1897, in which cases, however, the osteosarcoma grew from the upper end of the femur, so that the operation was much easier than in cases where the tumour springs from the pelvis. Lastly, two cases were operated on for hip-joint disease with extensive involvement of the pelvis, one by Gerard in 1897 (which died from shock), and one by Bardenheuer which recovered. The ninth case was operated on successfully (Jaboulay's method) by Salistscheff in 1898: the case was a difficult one and necessitated ligature of the common iliac artery and separation of the symphysis. Finally, we performed the operation with a fatal result on a boy with an extensive pulsating sarcoma of the pelvis. The case will be published. Kadjan also operated unsuccessfully.

The latest collection of cases has been made by Keen and Da Costa,[1] who reported an unsuccessful case in 1903. According to their figures only 5 out of 19 cases have recovered. But this apparently large mortality, 73·7 per cent, is increased if the indications for operation in the successful cases are examined. Bardenheuer's case was one of tuberculosis, and it may fairly be asked whether such a formidable operation is really indicated in tuberculosis of the pelvis. Girard's unsuccessful case was also one of tuberculosis of the hip-joint. Even if the hip-joint is involved one can combine a resection of the pelvis with excision of the hip as Roux and the author have proved (*vide* Resection of half the Pelvis). The reader is also referred to Sprengel's method of resection for extensive disease of the pelvis.

Freeman's case is not an interilio-abdominal disarticulation, but an amputation of the pelvis. The fact that the operation was considered possible shows that the conditions were more favourable than in those cases in which disarticulation is indicated.

In both of Girard's two successful cases, the sarcoma was situated in the thigh and not in the pelvis, cases in which one may keep close to the bone—(partly subperiosteal) in dissecting the pelvis, thus making the operation incomparably more simple and bloodless. One of his cases died of mestastasis after six months, while the disease recurred in the second case after about the same period. The operation amounted rather to a resection of half the pelvis, as disarticulation at the hip had been performed on a previous occasion.

Salitscheff's case was one of sarcoma of the pelvis, which from the description had extended chiefly downwards round the femur. The further career of this patient is not reported. The tumour was partly cystic, and was limited by a thick capsule.

Since the previous edition was published we have operated on yet another case of sarcoma of the pelvis, the patient succumbing from collapse. The prospects offered by the operation are very gloomy, as Morestin observed in the description of his case, even when the operation is clearly indicated, and where nothing but interilio-abdominal disarticulation remains to be performed. We regard it, therefore, as the duty of the surgeon in every case to determine whether resection of one half of the pelvis, or, what is more advisable, partial resection of the pelvis with or without excision of the hip, will not answer the purpose, and also whether or not amputation of the pelvis (Freeman) with retention of the posterior part of the ilium is possible, for in the latter case the operation is less severe; finally, in the case of a rapidly-growing, soft, vascular sarcoma of the pelvis, whether it would be better to try the effect of treatment by the Röntgen ray's and Coley's fluid, as, if the size of the tumour undergoes any reduction, there is more prospect of the operation proving successful.

Keen has reviewed the various incisions that have been adopted, and there appears to be no doubt that the same incision cannot invariably be employed. But the direction of the incision is not after all a matter of prime importance. The control of the hæmorrhage is of greater moment, for hitherto in all the unsuccessful cases death has been due to hæmorrhage generally in the first few hours. Nanu's and Keen's cases died on the second and twentieth days respectively from gangrene.

Secondly, in determining the incision one must always have in mind whether a resection or at least amputation of the pelvis may be sufficient. Freeman's and Keen's cases are typical instances of this point, and we here reproduce the two figures from Keen's article showing the line of division of the bone.

By preserving the posterior part of the ilium as shown in Figs. 240 and 241, the difficulty connected with separation of the sacro-iliac joint (a process which generally occupies time) is surmounted. Retention of the descending ramus of the pubis and part of the ascending ramus of the ischium dispenses with the separation of the root of the penis, an operation accompanied by much bleeding (Keen).

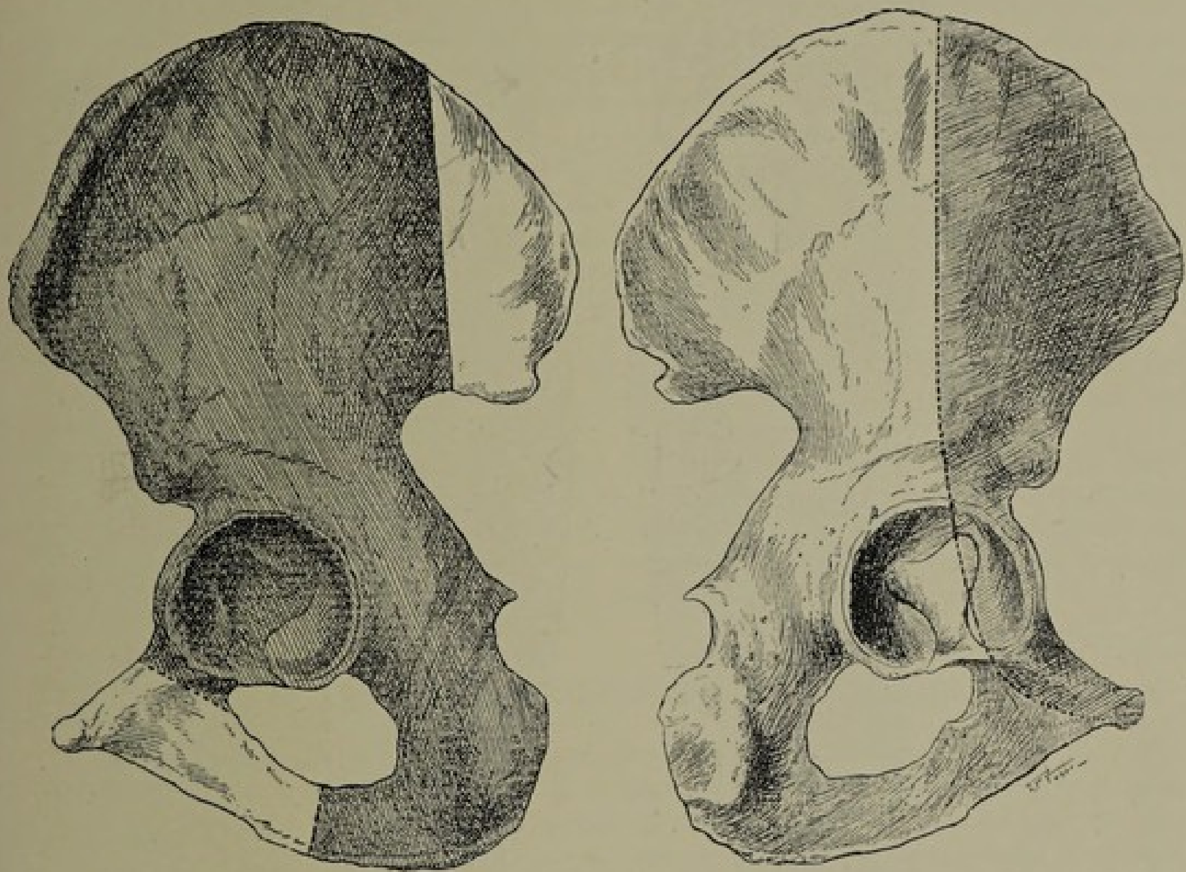
A still greater advantage of leaving these portions of bone, is that there is no necessity for the attachment of the muscles to the pelvis being divided, for no matter how rapidly this is effected, division of the muscles is always accompanied by excessive bleeding. As in Rose's method of disarticulation at the hip, large portions of muscle should be seized with crushing forceps, applied at some distance from their

[1] *Clinique internationale*, vol. iv.

attachments and divided between clamps. Lynn Thomas's forceps are excellently adapted for this purpose, as the tissues can be transfixed by the small blade.

On the basis of experiments and of our unfortunate experiences with two patients, we should proceed as follows in a case of sarcoma of the pelvis, in which condition alone an interilio-abdominal disarticulation is indicated. The median basilic vein is exposed and everything is prepared for intravenous injection. The patient is placed on a well-warmed operation table, and an enema of tea and brandy is administered.

An incision is made parallel to Poupart's ligament exactly similar to that used in ligature of the common iliac artery (1 in Fig. 242). (This might be effected under local anæsthesia.) The fascia is divided in the form of an angular flap, the muscles are separated in the direction of their fibres, the fascia is transversalis raised along with the peritoneum, and the internal iliac fossa and the common iliac artery



Figs. 240 and 241.—Lines of section of pelvis in Keen and Freeman's cases of amputation of pelvis.

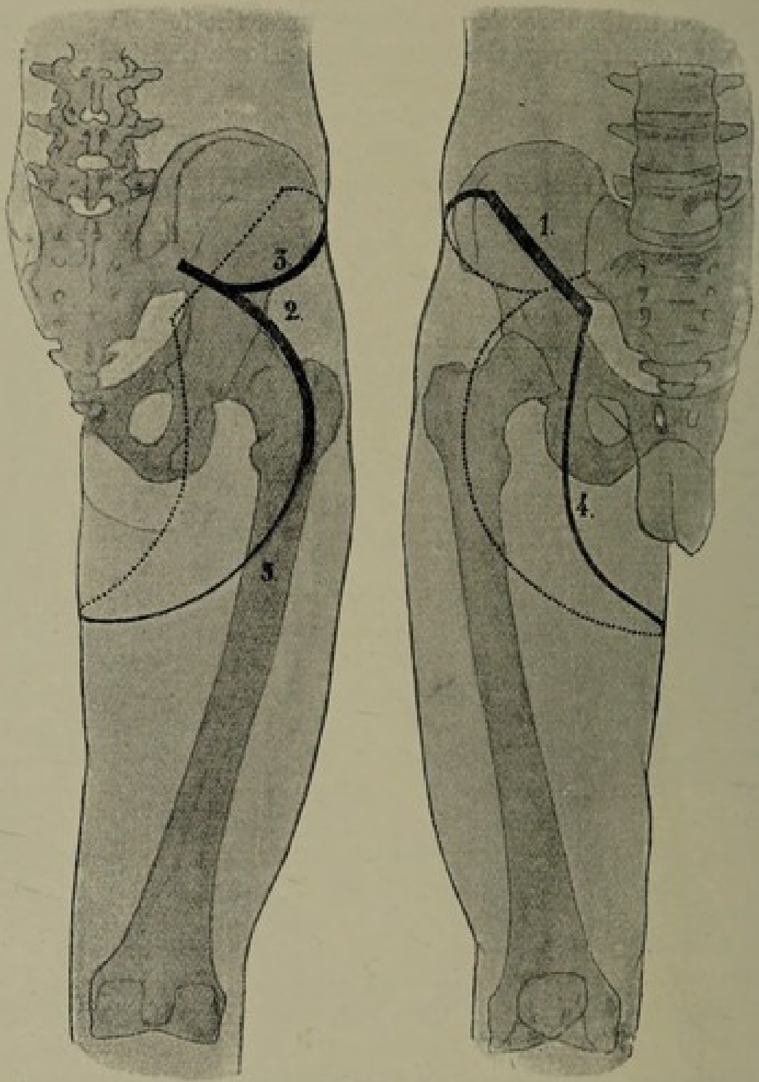
are exposed. The artery is temporarily controlled with a suitable compressor or clamp (Halsted), and after the vein has been emptied by elevating the limb, it is also clamped. We regard temporary closure of the vessels as a necessary precaution against collapse from acute anæmia. The inner surface of the pelvis is now carefully investigated, the limits of the tumour are defined, and the proposed lines of section of the pelvis determined.

The dorsal aspect of the innominate bone is then similarly examined. This is most satisfactorily effected through an incision in the same direction as that for ligature of the gluteal artery (2 in Fig. 242), only considerably longer and more like that we recommend for posterior excision of the hip at the upper border of the gluteus maximus. The great sacro-sciatic notch is thus exposed, and the line at which the bone is to be divided is defined.

After its fibres have been split the gluteus maximus can be drawn downwards with a hook without any appreciable bleeding and the bone is exposed at the upper

border of the great sacro-sciatic notch, where it is to be divided or, alternatively, the lower end of the sacro-iliac synchondrosis is exposed.

The tendon of the pyriformis is next cut across and the trunks of the great and small sciatic nerves are exposed and divided in the lower part of the great sacro-sciatic notch. The shock incurred by division of the great sciatic nerve may be avoided by an injection of novocain. With a hammer and chisel the base of the ischial spine is then cut through to the outer side of the internal pudic artery and nerve, and the inner aspect of the gemelli and the obturator internus followed down-



b. From behind. *a.* From in front.

Fig. 242.—Interilio-abdominal disarticulation. The graduated thickness of the black lines and the numbers indicate the course of the incisions.

wards to the sacro-sciatic ligament, the descending ramus of the ischium being then chiselled through into the foramen ovale above the attachment of the ligament to the ischium and tuberosity; in this way the tuber ischii is only held by the ligament and the muscles of the perineum.

The anterior and posterior incisions are now joined, as shown in Fig. 242 (No. 3), crushing forceps are pushed underneath the gluteus medius and minimus in the proposed line of section of the ilium, and the muscles are then divided between two

clamps, the application of the clamp being preferable to division of the muscles at their attachment to the bone.

A finger is now inserted into the anterior incision (Fig. 242, No. 1), two pairs of clamp forceps being introduced along it and the abdominal muscles are clamped just above the crest of the ilium. They are then divided between the forceps as far as the line of section of the crest posteriorly.

The ilio-psoas is next dealt with. The external iliac vessels, together with the ilio-inguinal and genito-crural nerves, are raised and retracted; but the nerves which descend at the side of the psoas and iliacus, namely, the anterior crural and the external cutaneous, are divided. The ilio-psoas is cut across between two forceps, and the bone is divided with a chisel, bone-forceps, or Gigli's saw, from the sacro-sciatic notch upwards along the selected line.

The anterior portion of the flap incision (No. 4, Fig. 242) is now carried vertically downwards on the anterior surface of the adductors, thus exposing the horizontal and descending ramus of the pubis, with the femoral vessels lying externally. The latter are ligatured above the origin of the profunda so that the internal circumflex vessels may be retained in the flap. The pubis is next divided with a chisel or bone-forceps as shown in Fig. 240 or Fig. 241 (Keen), separating the attachment of the internal and external obturator muscles from the foramen ovale. The obturator externus is then cut across. The innominate bone can now be drawn downwards and outwards, being only held by the levator ani. The pelvic fascia and periosteum are divided at the entrance to the true pelvis as far as the horizontal ramus of the pubis, preserving the obturator vessels and nerve, and the strip of fascia by which the levator ani and coccygeus are attached.

Finally, the skin incisions 4 and 5, Fig. 242, are completed, the adductors and the hamstrings are divided at their origin from the tuber ischii, and the vessels are tied seriatim.

The forceps, which still grasp the muscles, are now removed one at a time and the vessels are tied. After transfusion, the temporary clamp on the common iliac artery is removed and any branches of the obturator, circumflex, gluteal, and sciatic arteries which may still be bleeding are immediately secured. Our incision corresponds in the main with that of Savariand and Keen.

(k) Amputations of the Hand and Fingers

58. Amputation and Disarticulation of the Fingers (Figs. 243 and 244). The chief rule in the case of the fingers is to endeavour to retain a stump, no matter how short, provided the tendons remain connected with it, and that it can be covered with sound skin. A flap from the palmar aspect is preferable, as it avoids a palmar cicatrix, which is exposed to pressure. The oblique circular incision is most to be recommended, and is better than Farabœuf's lateral-palmar incision for the index and little finger. For a disarticulation the line of the joints is easily made out, because with the finger flexed they are always placed on the distal side of the dorsal bony prominences (Fig. 243). In disarticulations at the interphalangeal joints the knife is applied over the joint line, and directed obliquely downwards towards the palmar aspect. The attachment of the extensors at the base of the phalanx, then the dorsal part of the capsule, the lateral ligaments, the anterior part of the capsule, and lastly the flexor tendons, are divided, the latter being divided at the base of the phalanx, while the finger is held in the semi-flexed position. The ends of the extensor and flexor tendons are then carefully sutured to the remains of the capsule.

In amputations the palmar flap must be turned back in order that the rest of the incision may be carried round the bone. In dividing the tissues down to the bone the finger must be held midway between flexion and extension, so that both tendons are put slightly on the stretch and retain their function. The ends of the tendons are stitched to the corresponding tendon sheaths or to each other.

In disarticulating a finger at the metacarpo-phalangeal or at the carpo-metacarpal

joint the racket or *lanceolate incision* is used, the longitudinal portion of which is carried upwards over the back of the joint (Fig. 244). The tendons are divided in the middle position of the hand (so that the movements of the latter may not be interfered with) and are sutured to the remains of the capsule. The periosteum is divided and separated along with the capsule.

In metacarpo-phalangeal disarticulation of the thumb, the index finger, and the little finger, the dorsal part of the incision is placed towards the middle line of the hand instead of over the middle of the bone or joint.

In disarticulating a finger, with or without its metacarpal bone, the transverse incision follows exactly the line of the web of the fingers (Fig. 246): incisions must not be made higher up in the palm.

In disarticulation of the thumb at the metacarpo-phalangeal joint, it is important that the long tendons should be properly stitched, because the metacarpal of the thumb is movable, and the long extensors (with the abductor pollicis) are the only muscles which oppose the action of the short flexors in the thenar eminence.

Disarticulation of the Thumb (or Little Finger) along with its Metacarpal. In disarticulation of the first and fifth digits at the carpo-metacarpal joint, the strong muscles which form the thenar (and hypothenar) eminence must be preserved intact. As was pointed out

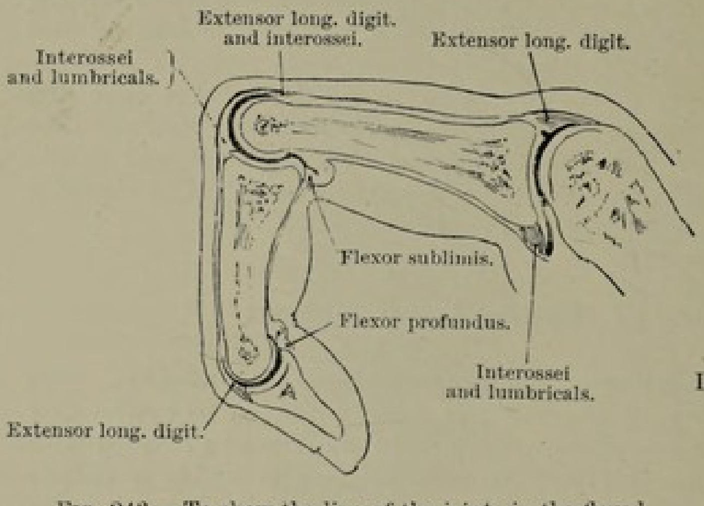


FIG. 243.—To show the line of the joints in the flexed position of the finger.

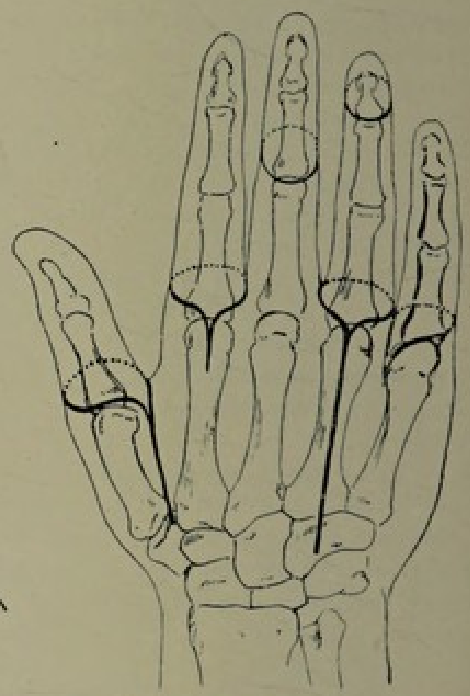


FIG. 244.
Disarticulation of little finger.
,, index finger.
,, ring finger along with its metacarpal bone.
,, thumb along with its metacarpal bone.
(Dorsal aspect of hand.)

in the general consideration of amputations, a racket or lanceolate incision with a long handle (*vide* Fig. 244) is to be preferred. Further, the handle of the racket should not be made quite on the dorsum, but should be placed more internal, towards the margin of the interosseus space. It is carried right down to the periosteum and bone and the latter is shelled out subperiosteally, and disarticulated at the proximal end by means of a transverse or oblique incision round the finger.

The long tendons should not be divided in the longitudinal portion of the incision, but should be cut across in the transverse part, the metacarpal bone occupying a position midway between extension and flexion. They should be stitched to the remains of the capsule which has been left attached to the periosteum. The long extensor tendons in particular (viz. extensor longus, extensor brevis, and abductor pollicis) must be carefully stitched, as in action they are antagonistic to the short powerful flexors as well as to the abductor. In conclusion, it must not be forgotten that the metacarpal may reform after a subperiosteal removal.

59. Disarticulation at the Wrist-Joint (Fig. 245). Very different methods are admissible for this operation, as for amputation through the forearm, the object being to obtain as long a stump as possible. In contrast to the main rule for the foot, an amputation must not be performed transversely through the wrist as long as a movable finger or portion of the hand can be retained.

An oblique circular incision is made, the upper end of which is placed at the level of the wrist-joint behind, while its lower end extends down on to the palm, the width of the flap corresponding to the diameter of the wrist. With the hand fully flexed towards the palm the extensor tendons and the posterior ligament are divided, whilst, below the projecting styloid processes, the lateral ligaments and tendons (extensor carpi ulnaris and the three extensors of the thumb) are cut across and the joint is opened. The bundle of flexor tendons is separated from the carpus and divided along with the skin at the extremity of the palmar flap. The palmar flap has the advantage of being very well nourished, of possessing fine tactile sensibility, and, in certain circumstances, of forming a movable muscular stump, while it further avoids leaving a scar on the palm, which would be exposed to undue pressure. The latter advantage is shared by Dubreuil's method, recommended by Treves, in which a flap is taken

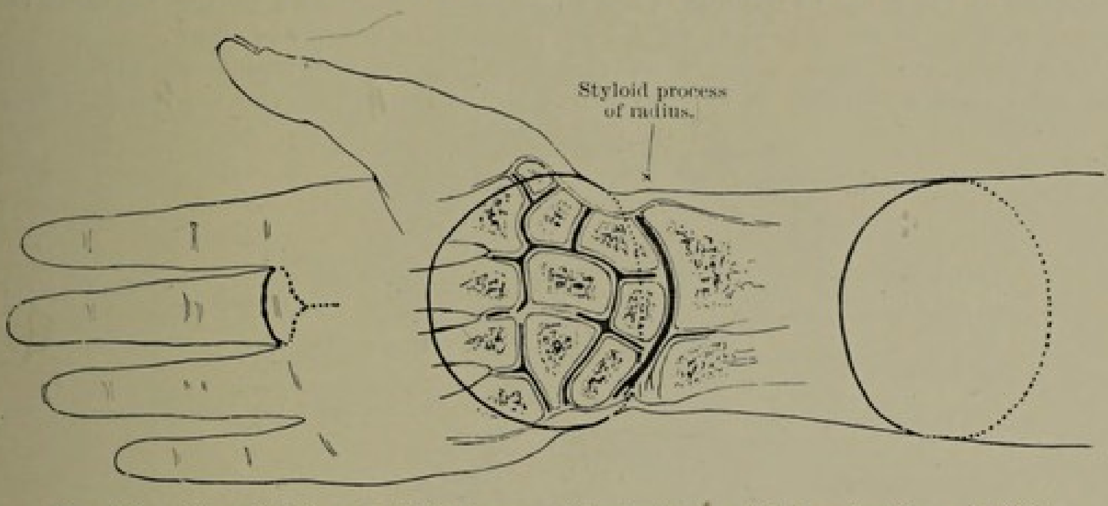


FIG. 245.—Disarticulation of middle finger. Disarticulation of the hand at the wrist-joint. Amputation through the forearm.

from the radial side and the muscles of the thumb are preserved. But care must be taken not to have the cicatrix over the end of the radius, where it is exposed to the greatest pressure. As the stump is not directly exposed to any pressure, an oblique incision (dorsal flap) or a circular incision extending half the diameter of the limb below the joint, may also be adopted. The flexor and extensor tendons should be sutured over the end of the stump to ensure that their function will not be impaired.

(l) Amputation of the Arm

60. Amputation of the Forearm (Figs. 245 and 246). As there is no necessity to provide a stump capable of bearing pressure, either a circular or oblique incision may be made, the flap in the latter case being taken from either aspect of the arm. Treves rightly states that in the muscular part of the forearm flap operations are preferable to either of the above methods on account of the difficulty of reflecting the skin and fascia.

Further, in the upper half of the forearm, where there is a considerable thickness of muscle, the racket incision should be adopted, the bones being shelled out subperiosteally, and the divided muscles carefully sutured over the end of the stump.

61. Disarticulation at the Elbow (Figs. 247, 248, 249). As in amputation in the region of the knee-joint, so also at the elbow, disarticulation at the joint itself is

to be preferred to amputation through the forearm high up, provided the joint itself is healthy and the muscle insertions at the ends of the bones of the forearm can be retained.

If, while the joint is healthy, the bones of the forearm must be removed, it is here also a great advantage if a muscular stump can be obtained with its nerve-supply uninjured. The simple racket incision described under the general principles of amputations, in which the soft parts of the forearm are divided circularly down to the bones, and the latter shelled out subperiosteally as far as the joints, is the most simple procedure and gives the best functional results (Fig. 247).

The most satisfactory incision for shelling out the bones of the forearm is the external J-incision we employ for resection of the elbow, as it entails least harm, the operation being subcapsulo-subperiosteal.

If the muscles cannot be preserved the oblique incision will be found to give a good stump. Further, the circular incision assumes the form of the oblique incision if the amputation is performed with the forearm held in the fully-extended position (Miller).

In the operative course the error is repeatedly made of regarding the tip of the olecranon as the guide to the line of the elbow-joint. The head of the radius is the proper guide. It can always be felt at the posterior aspect of the elbow.

An oblique incision is made on the dorsal aspect, beginning at the line of the joint, and extending a hand's-breadth below the tip of the olecranon. With

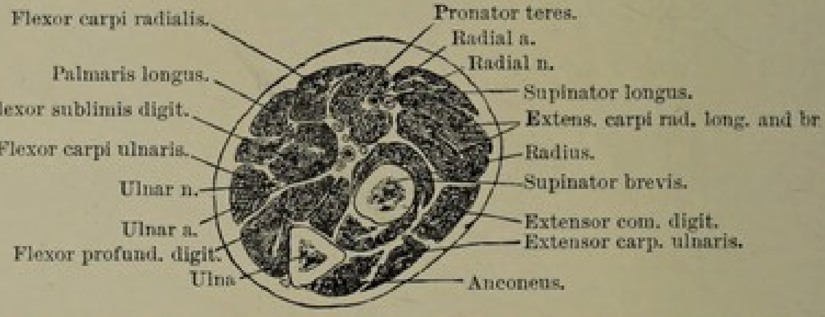


FIG. 246.—Transverse section through the upper third of the forearm (from a photograph).

the elbow bent to an angle of 135° the incision is parallel to the prolonged axis of the upper arm. The posterior flap, together with the periosteum, the anconeus, and the insertion of the triceps, is dissected up beyond the tip of the olecranon as far as the posterior surface of the humerus. In front, the soft parts and capsule of the joint are divided transversely. The flap being held aside, the radio-humeral joint is opened from without inwards.

Farabœuf, on the contrary, makes the oblique incision in the reverse way, commencing at the tip of the olecranon and extending downwards across the front of the forearm as far as a hand's-breadth below the elbow-joint.

62. Amputation through the Upper Arm (Fig. 250). In order that a broad covering may be obtained for the stump, it must be borne in mind that the upper arm is markedly flattened from side to side. Flaps are to be taken from the broad aspect. Accordingly, when oblique incisions are made, the upper end should fall over the internal bicipital sulcus. The biceps retracts to a great extent. A simple circular incision answers admirably if the soft parts are sufficiently pushed back subperiosteally.

The surgical neck of the humerus limits the height up to which a useful stump can be got in amputating through the upper arm, because the capsule extends down to this level internally. The other factors determining the future usefulness of the stump are the insertions of the deltoid, pectoralis major, and latissimus dorsi muscles, these being the chief adductors and abductors of the stump.

In amputating near the shoulder it is very essential that the function of the muscles should be retained, the best incisions to use here being either the racket or lanceolate

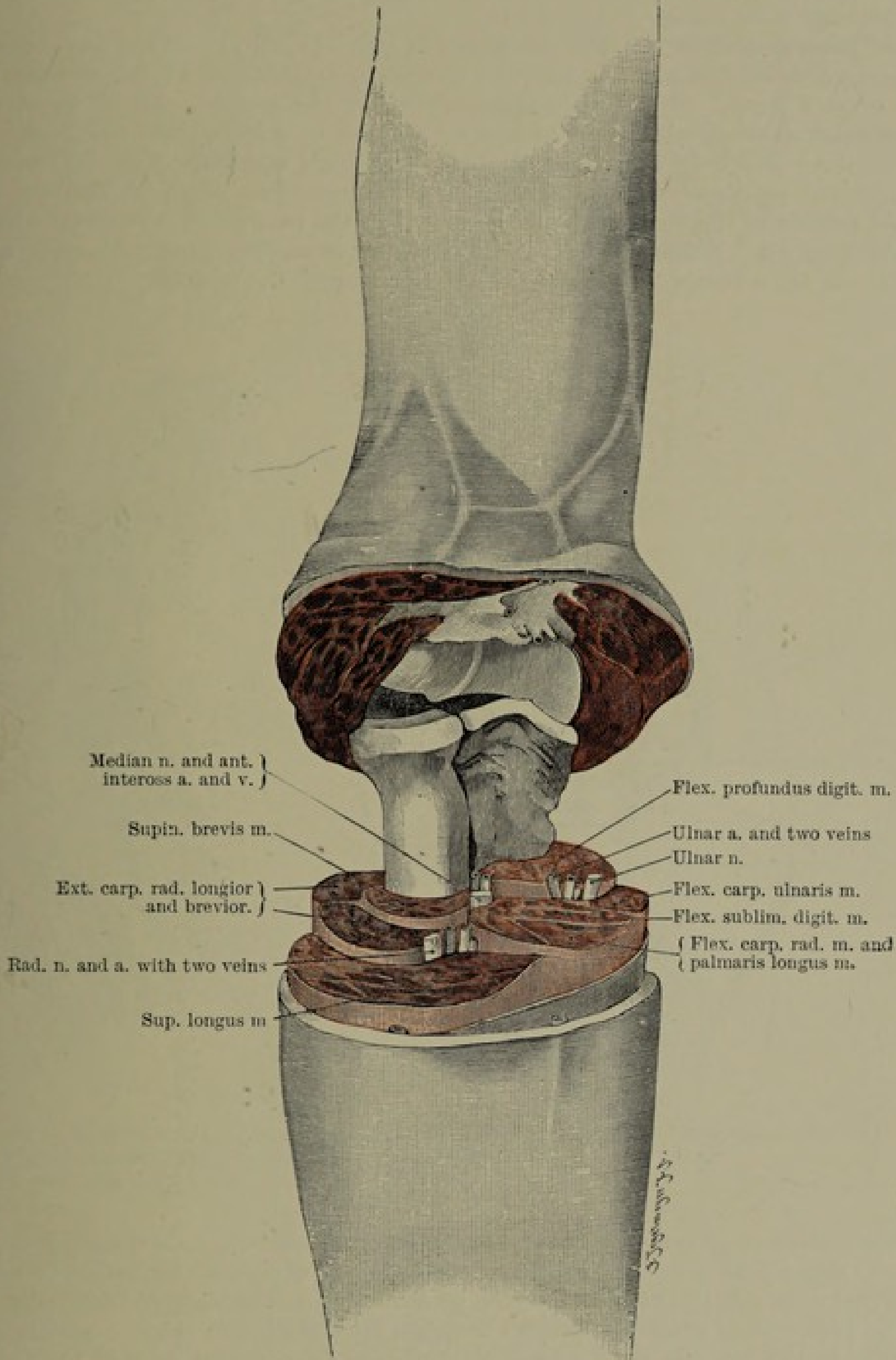


FIG. 247.—Disarticulation at the elbow-joint by a circular incision. The incision has been made down to the bone, and a "muscle-stump" provided by subperiosteal removal of the bones of the forearm. The soft parts are retracted upwards, and the joint is opened from in front.

variety. The longitudinal portion of the incision is made in the interval between the muscular groups supplied by different nerves, *i.e.* it should be made down to the bone at the anterior border of the deltoid between the internal and external rotators of the

humerus. The transverse portion encircles the limb about three-fifths of its diameter below the level at which the bone is divided, after the periosteum has been detached and the bone sawn across.

63. Disarticulation at the Shoulder (Figs. 251, 252). What has been said regarding disarticulation at the hip-joint applies to amputation at the shoulder with even greater force. If the soft parts, especially the muscles, can be preserved, a musculo-periosteal stump should always be ensured by shelling out the bone. This can be done either by combining excision with high amputation, or by the racket or lanceolate incisions. Just as in the thigh, the important point is, that the longitudinal portion of the incision should be placed in the interval between two muscular groups, supplied by different nerves. For this reason we give preference to the adoption of the anterior racket and the anterior lanceolate incisions.

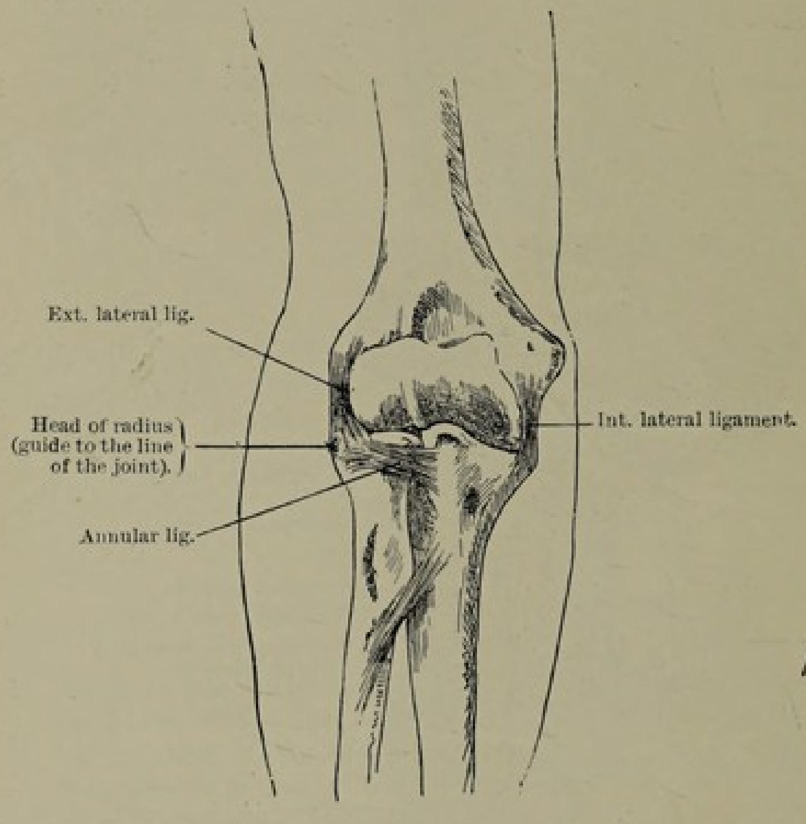


Fig. 248.—Ligaments of the elbow-joint.

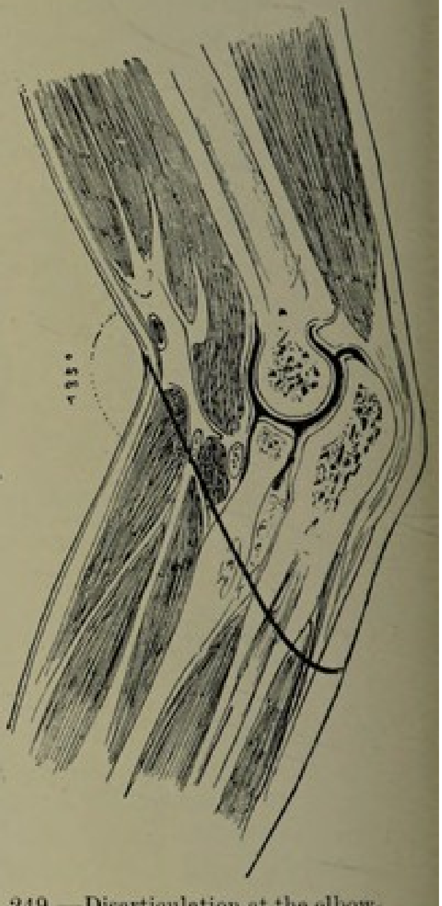


Fig. 249.—Disarticulation at the elbow-joint. (Longitudinal section through the elbow-joint, after Braune.)

When there is considerable laceration of the soft parts, *e.g.* after an injury, or if they are invaded by a new growth, the incision must of course be varied to suit the individual case. If the muscles have to be removed, a lanceolate incision (Fig. 252) is to be preferred as it affords the best covering for the stump. It is a matter of no difficulty to ligature the main vessels through the longitudinal part of the incision. The principle of the method is, therefore, the same as that employed by Rose for the hip, the main vessels being ligatured through the first incision, the remaining bleeding points being at once secured as the tissues are divided.

Just as at the hip, the typical disarticulation at the shoulder (racket incision) is carried out by performing a circular amputation at the level of the fold of the axilla, and then shelling out the humerus by an anterior longitudinal incision similar to that employed for excision of the joint.

Especially in the ordinary cases requiring disarticulation, viz. crushes of the arm,

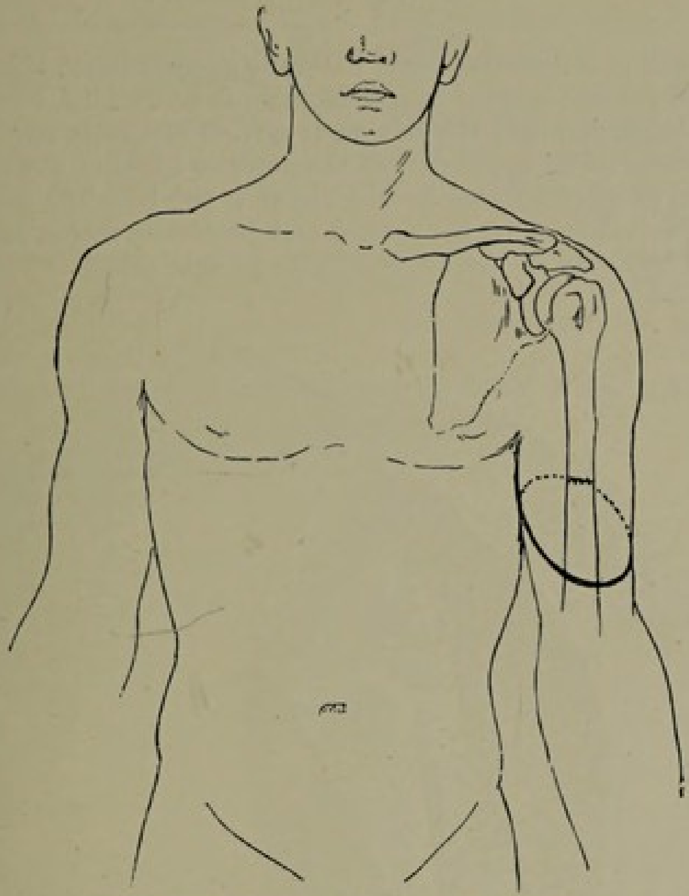


FIG. 250.—Amputation through the upper arm.

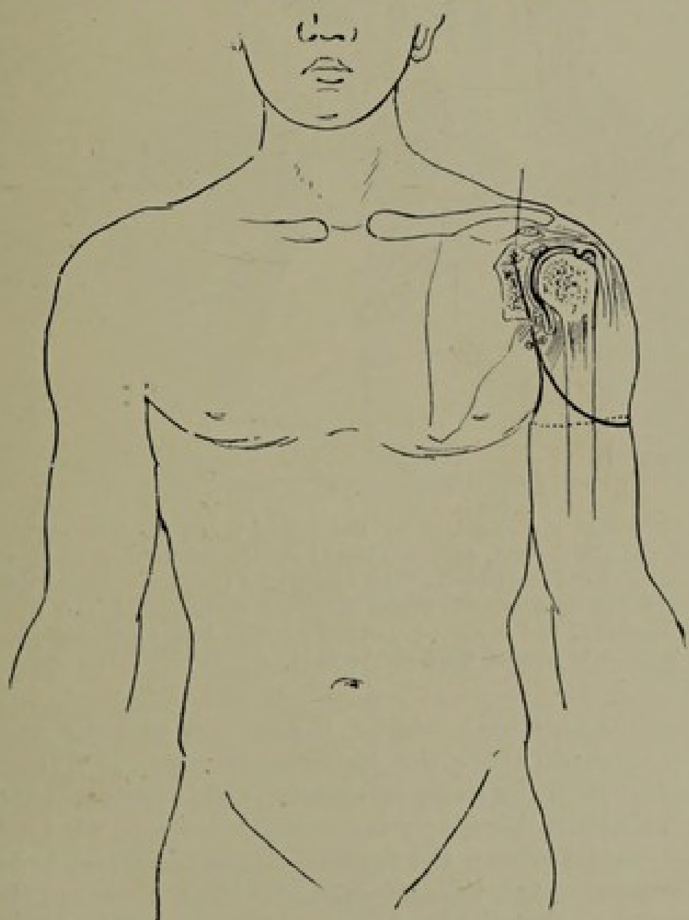


FIG. 251.—Disarticulation at the shoulder-joint.

the method we will now describe would naturally suggest itself. As severe shock and anæmia are often present, serious hæmorrhage must be avoided.

An incision beginning over the clavicle is carried vertically downwards external to the coracoid process. The upper part of the anterior fibres of the deltoid are divided, and forceps are at once applied to the bleeding points. The cephalic vein, which ascends in the interval between the deltoid and pectoralis major, is ligatured, as also are the acromial branches of the acromio-thoracic axis artery. The bone is reached

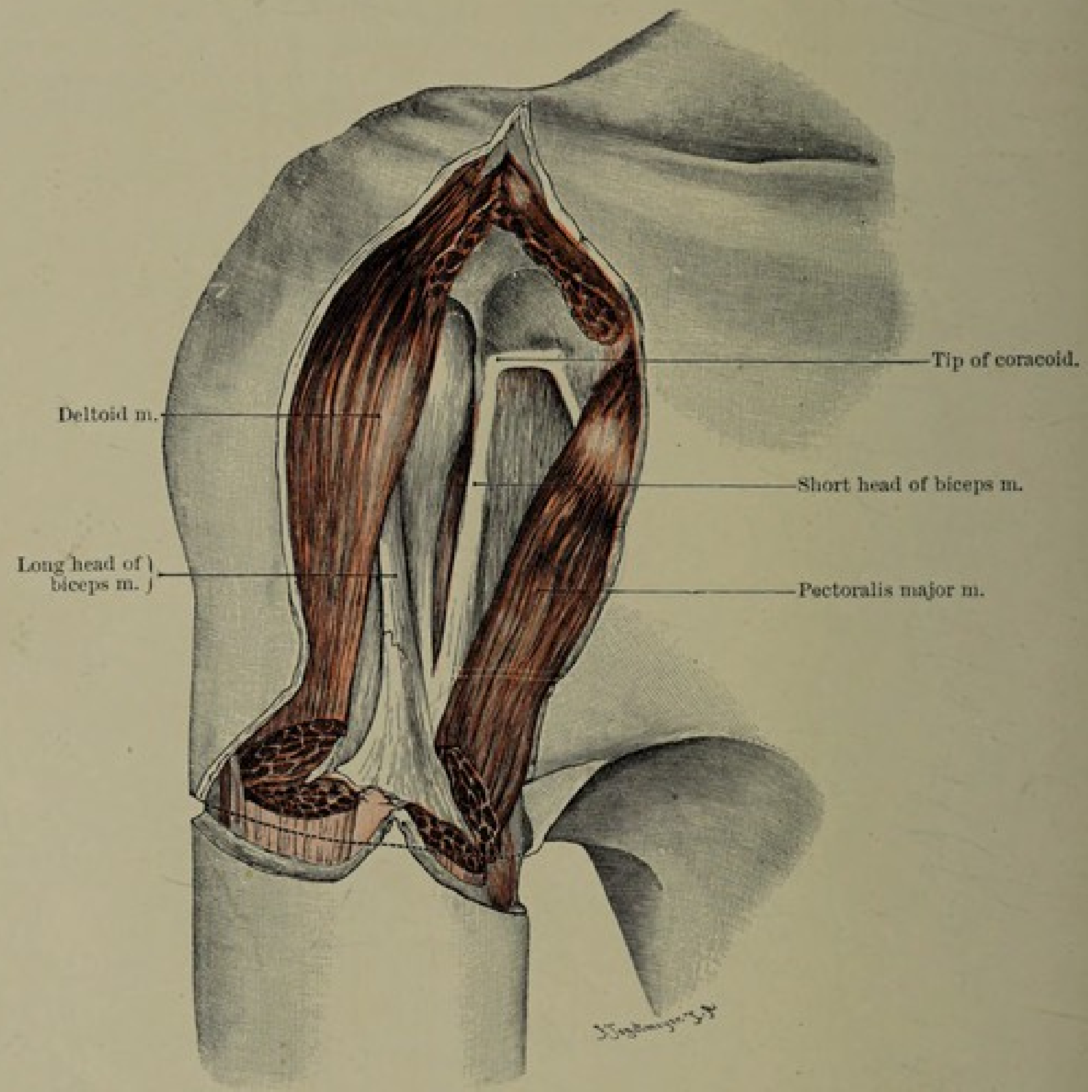


FIG. 252.—Disarticulation at the shoulder by the racket incision. The incision is made along the anterior edge of the deltoid, commencing above the coracoid process, which is exposed along with the origins of the short head of the biceps and the coraco-brachialis. The anterior border of the deltoid has been divided where it covers the coracoid, and the pectoralis major and deltoid are separated and divided lower down. The long head of the biceps is exposed, along which the incision is carried down to the bone.

by passing between the anterior border of the deltoid and the pectoralis major, and the capsule is slit upwards along the bicipital groove. The insertion of the subscapularis is detached from the lesser tuberosity, and lower down the insertions of the pectoralis major, latissimus dorsi, and teres major are separated subperiosteally from the region of the bicipital groove, the anterior circumflex artery being ligatured. The insertions of the supraspinatus, infraspinatus, and teres minor are then separated from the greater tuberosity, so that the head of the humerus may be protruded upwards and forwards out of the wound.

The racket incision is now completed by dividing the skin circularly at the level of the axillary folds. The vessels and nerves are then easily isolated, the former being ligatured and the latter divided. The subscapular artery and nerves can be grasped and dealt with. The circumflex nerve, which courses over the teres major and behind the bone to supply the deltoid, is to be carefully avoided, as the deltoid is the chief muscle of the future stump.

The method above described resembles very closely the racket method of Spence.[1] Larrey's racket method, recommended by Farabœuf, in which the longitudinal incision is placed externally, is not to be preferred, as it does not avoid the circumflex nerve, and therefore causes paralysis of the deltoid.

64. Interscapulo - Thoracic Amputation (Figs. 253, 254). In this operation,

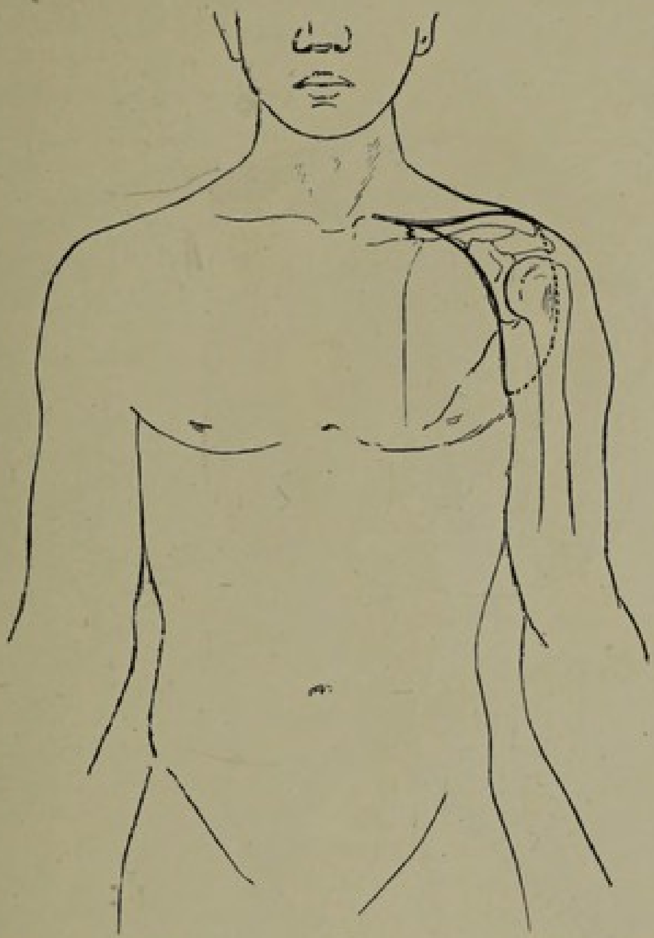


FIG. 253.—Removal of the upper extremity together with the shoulder girdle.

which is not a disarticulation, as no joint has to be opened in removing the shoulder girdle, the clavicle is sawn through, and only the muscular attachments to the scapula are divided. Hence the name we have selected.

Berger's operation is most commonly performed for injuries and tumours of the head of the humerus and the scapula (but exceptionally also for gangrene and spreading cellulitis), which have implicated the shoulder-joint and the scapula, frequently together with the axillary glands, the vessels, and muscles. Cases are also met with in which it is necessary to remove along with the arm merely a portion of the scapula (acromion and glenoid). If carried out in an exact manner, the operation is no more dangerous than disarticulation at the shoulder, and gives far better permanent results, in contrast to the conditions associated with interilio-abdominal disarticulation. The operation is

[1] Spence's *Lectures on Surgery*, vol. ii.

dependent for success on the mobility of the shoulder girdle, more especially of the scapula.

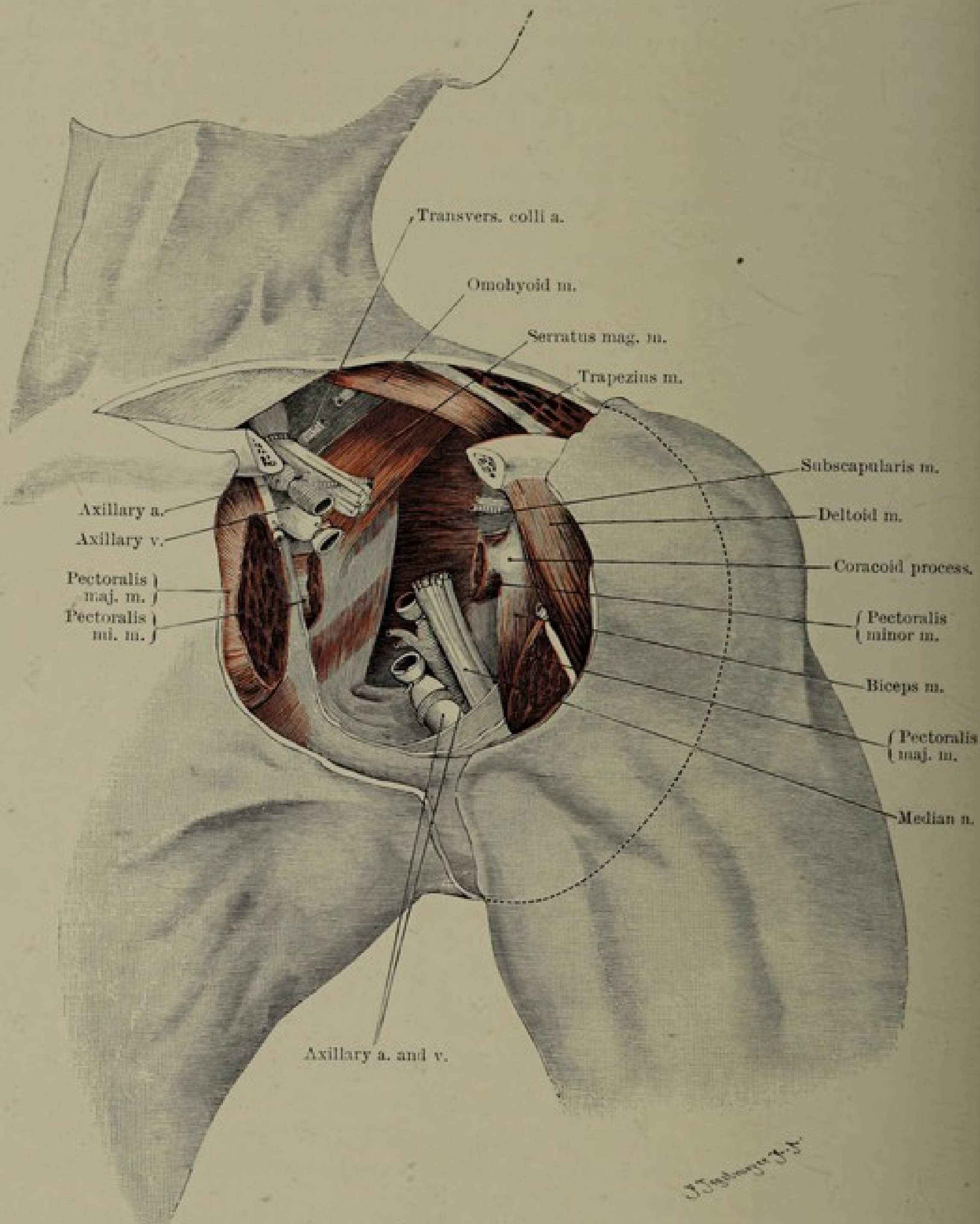


FIG. 254.—Disarticulation of arm and shoulder girdle, anterior incision, followed by division of clavicle pectorals, main vessels, and brachial plexus. The chest wall is seen on the left; the anterior aspect of the scapula covered by the subscapularis occupies the floor of the wound.

In 1898 Berger found that out of 46 cases there were only two deaths directly due to the operation, while ten were alive and well one year after the operation.

Buchanan has compiled an exhaustive list of the cases up till 1900 which were

operated on by Berger's method. In 1737 a patient, whose arm and scapula were completely torn off as a result of a machine accident, was successfully treated in St. Thomas's Hospital, and in 1808 Cunning performed the first successful operation for a gunshot wound, and in 1886 Crosty one for tumour. In 1887 Berger wrote an exhaustive monograph containing a clear description of the details of the operation. Buchanan gives a list of 181 cases (131 for tumour) with 16 per cent of deaths. To these may be added 31 cases in which, after disarticulation at the shoulder, the scapula was subsequently excised with 6·6 per cent of deaths. Since the introduction of antiseptics the mortality has been reduced to 8 per cent.

Jeaubran and Riche have collected 188 cases with a mortality of 11·1 per cent. They draw special attention to the fact that before 1887 the mortality was 29 per cent, but that now it is only 7·8 per cent. To Lister, therefore, as well as Berger, much credit must be given. They mention 8 cases of sarcoma in which a radical cure was obtained, although in Küster's case there was a recurrence after ten years' interval.

We would here allude to the necessity of making a thorough examination of the humerus in all new growths affecting it, in case excision or disarticulation at the shoulder-joint might not still be possible, and especially in cases of tumour of the scapula whether resection might not be sufficient, possibly combined with excision of the shoulder-joint.

The operation is performed through a racket or lanceolate incision, such as we always employ for amputations near the trunk, and is carried out as follows:—

Prophylactic control of hæmorrhage is obtained by ligaturing the large vessels, while the extent of the incision has often to be greatly modified as it depends on the amount of skin involved in the disease.

Operation. An incision down to the bone is made along the clavicle, and after separation of the periosteum with a raspatory, the clavicle is sawn through in its inner third, and pulled outwards with a sharp hook. The posterior layer of the periosteum and the underlying subclavius muscle are then carefully divided, the trunks of the brachial plexus exposed, and the individual cords isolated and divided after injection with novocain.

The axillary vein occupies an anterior position immediately behind the subclavius muscle, while the artery lies close below the nerves of the plexus. Both artery and vein are ligatured and divided.

If it be desired to restrict the hæmorrhage to a minimum, it is necessary to secure the branches of the subclavian which pass outwards in front of the scaleni. These are the ascending cervical passing vertically upwards, the superficial cervical passing upwards and outwards, the suprascapular passing horizontally beneath the clavicle, and, lastly, and most important, the transversalis colli artery, which passes outwards and backwards over or through the brachial plexus to supply the levator anguli scapulæ and supraspinatus muscles, and is continued downwards as the posterior scapular artery along the vertical border of the scapula, between the rhomboids and the serratus posticus superior. No important hæmorrhage need then be anticipated.

The operation is now proceeded with according to the method originally proposed by Rose for disarticulation at the hip—that is to say, as if the arm and scapula constituted a tumour which one had to excise. An incision is carried round the arm as is indicated in Fig. 254, and the skin, fascia, and the two pectoral muscles are divided. When the axilla contains infected glands the muscles are divided close to the thorax. In the absence of infected glands the muscles are divided close to their insertions into the humerus and coracoid process respectively. The cephalic vein, which runs in the groove in front of the deltoid, is avoided.

The dissection is continued along the outer wall of the thorax, *i.e.* the serratus magnus through the loose cellular tissue towards the ventral surface of the scapula, infected glands, should they exist, being at the same time raised from the thorax. When the posterior fold of the axilla is reached, the latissimus dorsi is divided close to its insertion, or nearer the thorax if the glands are involved.

The trapezius is now detached from the upper border of the clavicle and the

acromion process (if necessary the Lynn Thomas forceps being used to control the bleeding), after which the arm and shoulder are rotated outwards so as to completely expose the ventral aspect of the scapula and its muscles. At the upper angle the thick insertion of the levator anguli scapulæ is divided, and branches of the posterior scapular artery secured. The thick serratus magnus and the thinner rhomboids are then divided in succession along the vertebral border of the scapula. The arm and the scapula being now drawn away from the trunk, the trapezius is separated from the spine, and the omo-hyoid from the upper border of the scapula, and the arm and shoulder girdle are removed without appreciable loss of blood.

We performed this operation in 1902 on a boy for a diffuse sarcoma of the scapula, which involved the shoulder-joint and the upper portion of the humerus. Only two teaspoonfuls of blood were lost, and in five days the wound was simply covered with a strip of collodion, a single glass drainage tube having been inserted through a special opening in the posterior fold of the axilla.

Our description thus corresponds essentially to the interscapulo-thoracic disarticulation of Berger, who, along with Farabœuf, Adelmann and Chavasse, has gained distinction for the development of the best procedure. Bergmann also, according to Nasse, performs the operation in the same way as above described. Esmarch has added to the method the sawing of the clavicle and preliminary ligature of the subclavian vessels. If the tumour has invaded the skin extensively, Keen's plan of utilising the skin from the whole length of the upper arm may be employed.

SECTION V

SURGERY OF THE HEAD AND TRUNK

A. SURGERY OF THE HEAD

1. Soft Parts of the Scalp

THE scalp is characterised by its rich vascular supply, the vessels, however, being easily accessible to ligature, because they run in the skin and subcutaneous tissue, which is firmly united to the occipito-frontalis. The arteries lie loose in the scalp, the veins not to the same extent; therefore the latter do not retract like the arteries. In hæmorrhage from the arteries, press upon the skin close to the edge of the wound and seize the vessels with artery forceps; if our toothed artery forceps do not succeed, then a ligature must be passed around the vessel by means of a curved needle. Hæmorrhage may be temporarily arrested after the manner employed by Doyen in extensive craniectomies, *i.e.* by winding an elastic tourniquet around the greatest circumference of the head.

The vessels which supply the scalp come from the frontal, temporal, and occipital regions. If, therefore, it is desirable in severe hæmorrhage from the scalp to apply a proximal ligature to the main vessels we must turn to these three regions.

Operations on the cranium have already been fully considered under the surgery of the nervous system, and need not be further referred to in this section.

Plastic operations play an important part in the surgery of the face, and are performed for congenital deformities and disfigurements due to traumatic and pathological causes. As, however, they form a class of their own, we can do no more than merely refer to a few of the more important operations. The extent to which plastic surgery of the face can be carried has been demonstrated by Senn of Chicago, who actually reconstructed a face out of a flap turned down from the scalp.

2. The Face, including the Nose, Mouth, and Fauces

The skin of the face is less dense than that of the scalp, but, like it, is extremely vascular. We must be prepared, therefore, for spurting vessels even in skin incisions. Most of the vessels lie under the cutis. As regards the *direction of incisions* (Fig. 255, 256), the general rules which have been laid down are to be applied. Above all, the facial nerve has to be avoided when operating upon the face, and incisions must be chosen which run parallel to its branches, as any injury to the nerve results in disfigurement. It is much less serious to cut through a branch of an artery than to injure a nerve, no matter how small. Accordingly the incisions should radiate from a centre which corresponds to the entrance of the nerve into the parotid. By this means lesions which interfere with expression are guarded against. Some of the vessels, however, will be divided transversely, but Stenson's duct, which runs parallel to the normal

incisions, is avoided. The muscles must be partly divided. Muscular incisions, are, as a rule, avoided ; one keeps rather to the septa between them, because infected muscular wounds heal badly. Since the introduction of asepsis, however, the latter consideration no longer comes into question. Rapid union of muscle along with complete restoration of its function can now be obtained, provided the nerves of supply have not been injured. We have constantly to refer to this point in our text-book : it is preferable to cut through a powerful muscle (as, for example, the rectus abdominis) and bring about a tendinous intersection than cause its paralysis and atrophy by injuring the nerve which supplies it.

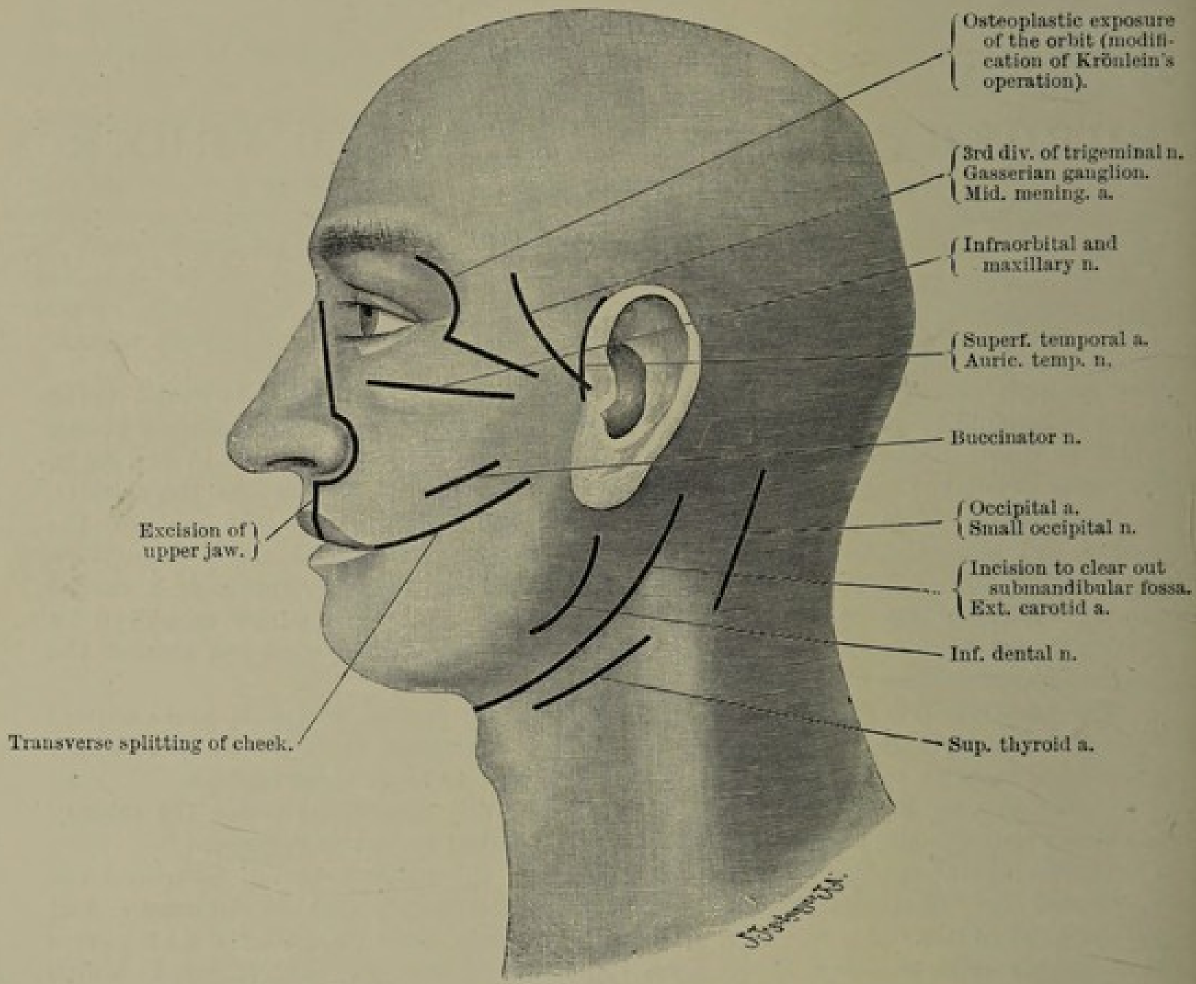


FIG. 255.—Some normal incisions for the head and neck (Kocher).

(a) Surgery of the Eye and Orbit

In the chapter on the surgery of the optic nerve we described appropriate methods by which the orbit may be exposed with preservation of the eyeball.

When the eyeball has to be sacrificed, *e.g.* in malignant disease, an extensive preliminary osteoplastic resection is unnecessary, all that is required being division of the outer angle of the eyelids.

(b) Surgery of the Nose and Associated Cavities

In all operations in the region of the nose, the mouth, and the pharynx, and especially in operations on the jaws, two indications which above all others influence

the result must receive attention, viz. the prevention of excessive hæmorrhage, and the avoidance of aspiration of blood and mucus into the bronchi and lungs.

In the removal of tumours of the nose from the base of the skull, and in resection of the upper jaw, the danger of an excessive loss of blood is great. Steps must therefore be taken to prevent the bleeding. Many authors have devoted their attention to the methods of prophylactic arrest of hæmorrhage in the above operations. We

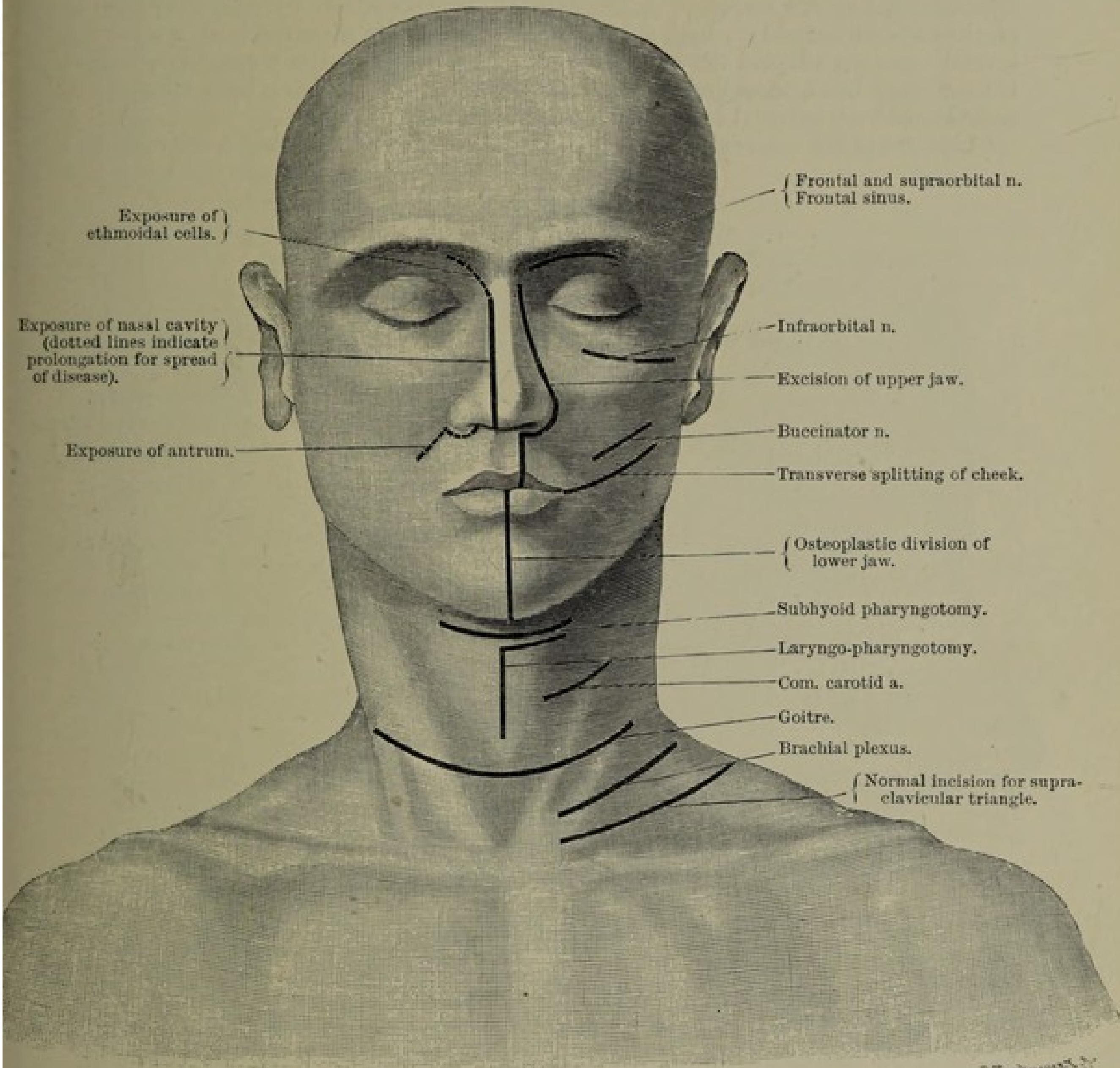


FIG. 256.—Some "normal" incisions for the head and neck (Kocher).

may refer to the work of Schlatter, who summarises the views regarding ligature of the external carotid as a preliminary operation to resections of the upper jaw. In the early editions of this work we have expressed a very different opinion from that which we now hold regarding preliminary arrest of hæmorrhage by ligature of the carotid, and, as we entirely agree with some of the conclusions which Schlatter draws from the literature of the subject, and from his own observations, we should like to express our views more decidedly.

Whatever one may say, ligature of the common carotid in an old man with arterial

sclerosis is equivalent to a death sentence. One cannot definitely enough distinguish between youth with sound vessels and age with degenerated ones. If it can be possibly avoided, the common carotid is never to be ligatured in an old man merely for the prophylactic arrest of hæmorrhage. The choice lies solely between ligature of the external carotid and temporary compression of the common carotid, the latter being the practice especially followed by Schönborn.

In advanced epithelioma of the upper jaw when the condition of the arteries is satisfactory, Fowler[1] controls the hæmorrhage very effectively by temporary ligature of the common carotid on both sides. No evil effects are observed, and we have on several occasions adopted the same procedure in excision of the Gasserian ganglion. On the other hand, according to Dawbarn, excellent results have been obtained by resection of both external carotids and their branches.

Ligature of the external carotid is, as Lipps has shown, not a dangerous operation,

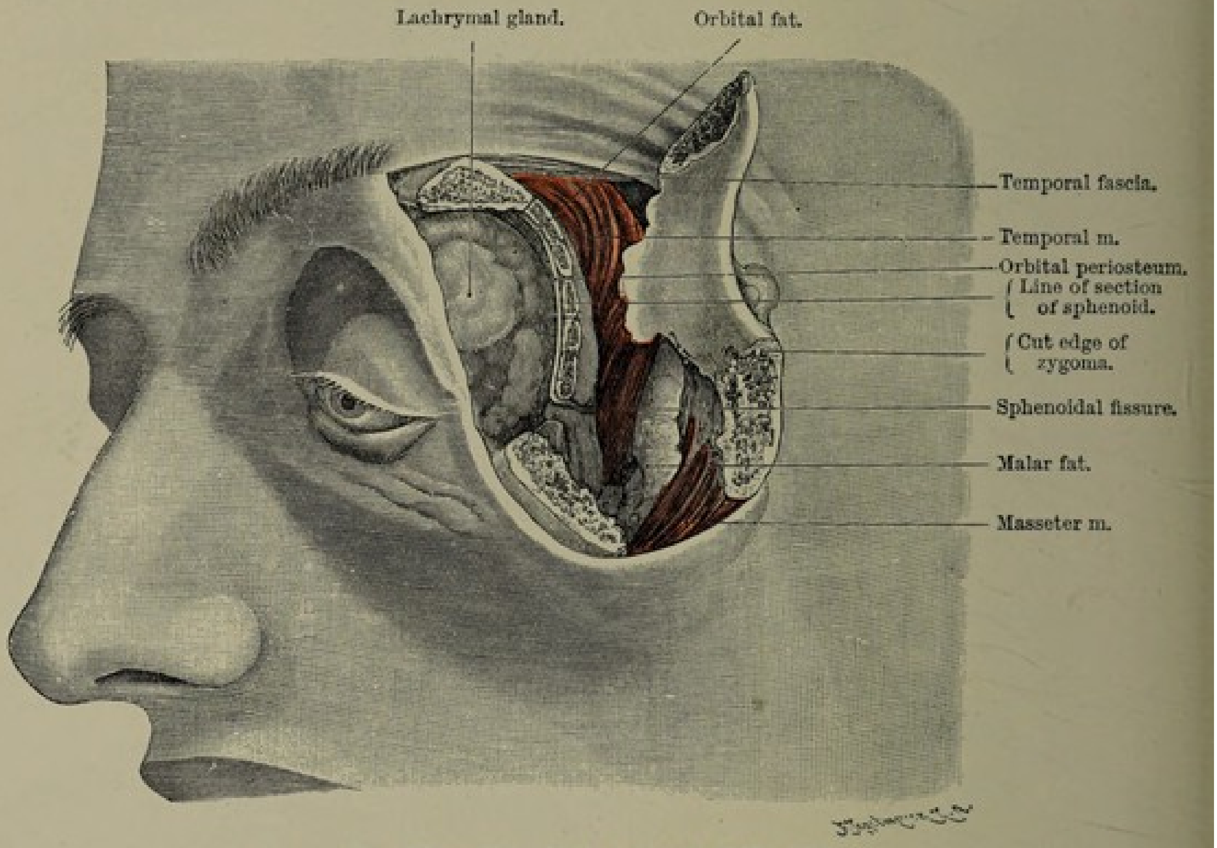


FIG. 257.—Osteoplastic exposure of the orbit.

and our own experience, along with that of others (Friedrich quite recently confirmed this view), shows that it very materially diminishes the loss of blood in dangerous resections of the upper jaw.

How far temporary compression of the common carotid is advisable when the vessels are sclerosed is as yet undecided. In one case at the end of 1898, in which we were obliged to ligature the common carotid in an old man on whom we had performed a pharyngoglossotomy, the patient was quite well after the operation, but hemiplegia, unconsciousness, and fever gradually set in, and a fatal issue followed. The subsequent cerebral softening, therefore, had caused these disturbances. Would these have been avoided if the circulation had remained free ?

In young individuals with healthy arteries the common carotid may, without fear, be provisionally compressed or ligatured, as the effect on the brain, which takes the form of a unilateral diminution in the amount of blood it contains, is quite transitory.

[1] *Buffalo Med. Journ.*, June 1903.

The second indication in all operations in the upper digestive and respiratory tract, viz. the prevention of aspiration of blood and mucus, can be much more simply and securely fulfilled by the correct posturing of the patient than by a prophylactic tracheotomy and plugging of the larynx, or by performing the operation under partial anæsthesia. It is well to repeat once more (although the subject has already been considered) that the proper method is to place the patient on his back with the head and thorax sloping downwards (but not with the head alone hanging downwards), not only during the operation, but also subsequently. In this way aspiration of blood at the operation, and of the wound secretion at a later date, is most readily avoided.

Since we have carried out this procedure as a principle in all operations in connection with the mouth, nose, larynx, pharynx, and trachea, we have been able to dispense with all other precautionary measures, and have had such success with it that we cannot too strongly recommend the general adoption of this simple precaution. The head can be steadied in a perfectly convenient position upon a cushion.

The following remarks must be added regarding the after-treatment :—Those cases in which the swallowing mechanism is affected and the reflex excitability of the larynx injured, are to be clearly distinguished from these in which those functions have suffered no damage. If a patient can swallow, even with difficulty, and if he is reflexly stimulated to cough as soon as any secretion reaches the larynx, he should be allowed to sit up even on the day following the operation. One has only to see how well the patient looks and says he feels when he is allowed to sit and walk in order to be convinced of the great advantage of this plan. The patient expectorates much more freely, and aspiration pneumonia does not occur.

During the night, on the other hand, many of these patients must be placed in an inclined position with the neck lowest, and those who are unable to swallow, for example those who, in consequence of paralysis of the superior laryngeal nerve, have lost the reflex excitability of the larnyx, must keep this position for eight to fourteen days, or even longer.

1. Exposure of the Nasal Cavity and Sinuses.—Although an ulcer or new growth of the nasal mucous membrane can readily be detected with the nasal speculum, it is often difficult to estimate the extent of the disease, and especially to determine its origin and depth. It is unfortunate that so many specialists make light to their patients of the removal of "polypi" even when it is obvious that they are not dealing with an ordinary mucous polypus or a pedunculated simple fibroma.

In these cases, nothing short of a thorough exposure of the nose and affected accessory cavities can effect a cure. But at the same time one must be able to assure the patient that any resulting disfigurement will not be of a serious nature. We must therefore be able to thoroughly expose the cavities by incisions which are neither unsightly nor injurious.

It is important that one should know how to enlarge the nares for the purpose of securing a better view or of palpating the parts with the finger. The simplest way of effecting this is by *splitting the nasal septum*, a method which we recommend. The blades of a strong pair of scissors are introduced, one into each nostril, as far back as possible, and the cartilaginous septum is divided. Blood spurts from the small arteries of the septum. The finger can then be introduced into the nose, the walls of which can be manipulated. In ozæna this procedure suffices to clear up the cause, and especially to discover and remove circumscribed areas of diseased bone. The introduction of a couple of sutures enables us to bring about union so exact that practically no visible result of the interference is left.

In deviations of the nasal septum the narrowed nostril must be exposed and an incision made on to the projecting cartilage (or bone), off which the mucous membrane is stripped and the projecting portion of the cartilage resected with forceps.

In all operations undertaken for malignant new growths, very thorough access must be obtained so that one can get a good view of the nasal cavity in order to define the extent of the disease, and especially so that one may be able to remove all the disease and at the same time control the hæmorrhage. In such cases it is

desirable to employ a definite incision which, when prolonged, will enable us to reach the accessory sinuses (maxillary, ethmoidal, frontal, and sphenoidal).

Methods of Access from the Front (Naso-maxillary Route)

2. Radical Operation for Pansinusitis Nasalis (Moure).—The normal operation, which fulfils the above requirements and causes a minimum of disfigurement, consists in splitting the nose close to the middle line, a method also recommended by Dieffenbach and König (Fig. 258). The incision is not made exactly in the middle line, on account of the furrow which runs along the anterior edge of the septal

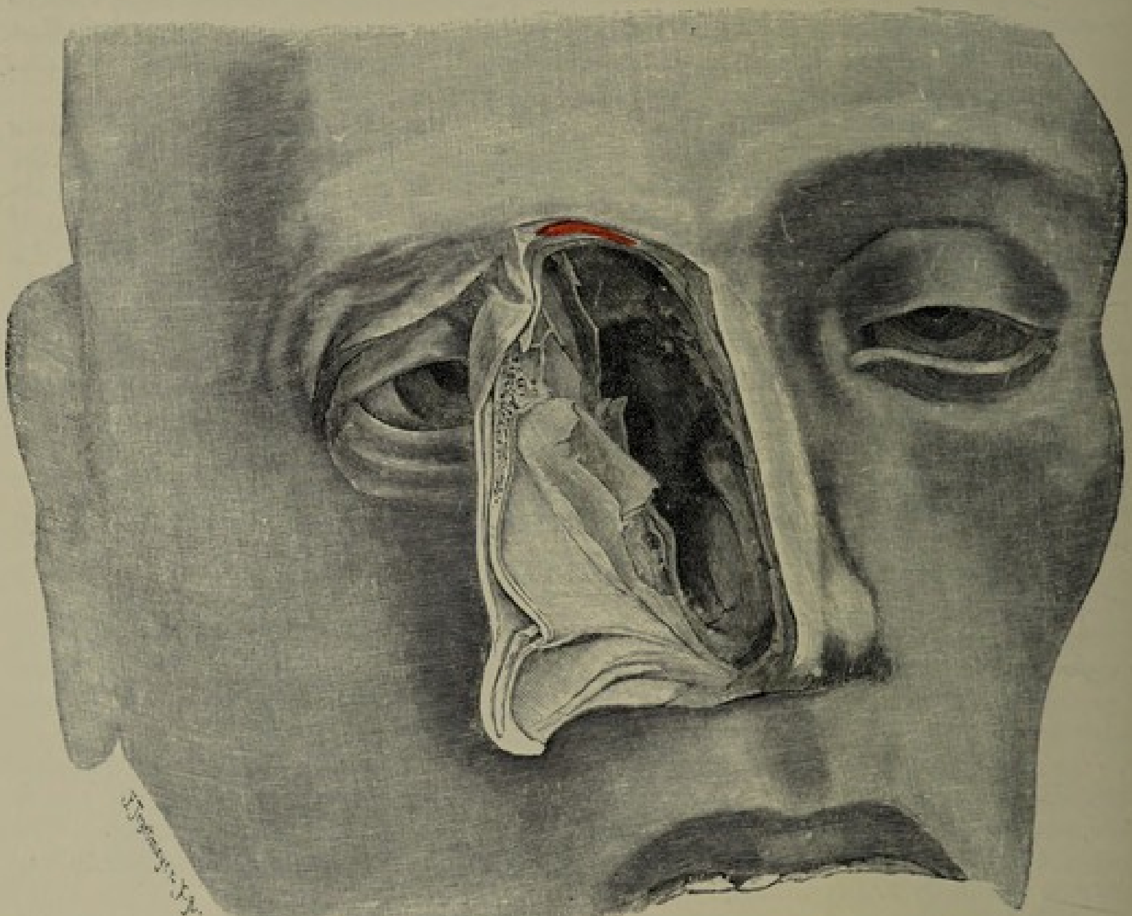


Fig. 258.—Paramedian incision for radical operation on the nasal cavity. The nasal bone and frontal process of the superior maxilla on one side have been divided and the lateral wall of the nose has been turned outwards. The ethmoid and its os planum are removed, exposing the sharp edge of bone between the orbital and nasal cavities. The frontal sinus has been opened up by removing its floor. The nasal septum is exposed lower down.

cartilage of the nose. A cicatrix along this furrow would, by contraction, render it visible, and so produce distinct disfigurement. By division of the lateral nasal cartilage and the nasal bone a little to one side of the middle line, a cicatrix is obtained which is scarcely visible. This incision has the advantage that, if necessary, it can be easily enlarged without disfigurement, *i.e.* a so-called radical operation can be performed,[1] and several or all of the sinuses can be opened up (polysinusitis). By prolonging the incision on to the eyebrow[2] access is obtained to either the

[1] *Vide* Cheval, *Bull. Soc. Roy. Brux.*, 1905, No. 9.

[2] The transverse incision below the lower lid (Terrier, Athané) is to be discarded on account of the ascending branches of the facial nerve to the orbicularis palpebrarum.

ethmoidal cells or the frontal sinus. It can further be extended in the naso-labial fold, thus allowing the ala nasi to be freed, and can then be carried outwards in the oblique fold between the cheek and the lip. Lastly, it may be carried downwards through the upper lip near the middle line when a further separation of the soft parts is desired.

The bridge of the nose is split in the middle line, but the level at which the transverse incision through the bone is made varies (higher or lower) according to the seat of the disease.

The base of the nasal bone on the diseased side is divided with bone-forceps, the root of the frontal process of the superior maxilla detached with the chisel from below upwards towards the orbit, and the lateral wall of the nose turned outwards as a flap.

As is the rule in new growths if one wishes to expose the antrum of Highmore at the same time, the inner wall of the antrum is detached from the horizontal plate of the palate bone with the chisel and is removed as far as necessary, the inferior turbinate being also excised if required. In this way the nasal cavity and the antrum of Highmore can be easily converted into one large cavity.

If the ethmoid is much involved, the incision is carried along the eyebrow, dividing the periosteum alongside the nasal bone and stripping it back over the lachrymal bone and the os planum of the ethmoid (the lacrymal sac being preserved) so that the bone may be removed if necessary from the cribriform plate above, to the anterior margin of the sphenoidal sinus behind.

The frontal sinus may be opened through the same incision by removing the bone forming its floor, a process which also entails the removal of the nasal spine and the floor of the sinus.

By this means one continuous cavity is obtained from the frontal sinus above to the antrum of Highmore and the floor of the nose.[1] Posteriorly the thin anterior wall of the sphenoidal sinus is easily opened at a depth of about 6 cm. If the disease is situated upon the outer wall of the nose and extends to the upper jaw, then it is better to *split the nose laterally*. An incision is made along the groove around the ala nasi and extending upwards, either as far only as the summit of the osseous anterior nares, the detached side of the nose being thrown upwards and inwards, or the division may be extended upwards along the nasal process of the upper jaw, and transversely through the root of the nasal bone. In this way very good access is got to the anterior part of the nose, so that tubercular ulcerations can be readily exposed to thorough local treatment. The method, however, has the disadvantage of throwing out of action some of the muscular fibres, namely, the pyramidalis nasi and the levator alæ nasi. As, however, the muscular incisions generally heal by first intention, and the nerve-supply remains partly intact, no noteworthy interference with the play of the features results. The nasal branches of the facial artery are divided, but its angular termination is avoided at the upper part of the wound. By careful suturing the scar ultimately becomes almost invisible.

The method of Chassaignac and Bruns, in which the nose is turned aside laterally, has been occasionally practised; according to Czerny's experience (Naab), it is a good method for naso-pharyngeal fibromata which occupy the anterior part of the nose, as it may bring about a radical cure. In this procedure the whole nose is turned over to one side by dividing the septum by means of two incisions which meet at an oblique angle, the one from above, the other from below. The junction of the nasal bone with the nasal process of the superior maxilla of the opposite side is broken across.

If it be necessary to see farther back into the nose than is possible by the above methods, then a partial osteoplastic resection of the upper jaw may be made whereby the inner, the anterior, and a portion of the upper wall of the antrum are turned outwards, and a view far back into the posterior nares is obtained.

In contrast to the access obtained from in front which may be called the naso-maxillary route, which we have described as the "normal" operation because it is suitable

[1] *Vide* also Grünwald, *Rhinochir. Mitteilungen*, *Centralbl. f. Chir.* Bd. 3, 1906.

even for diffuse disease extending from the frontal sinus down through the ethmoidal bone to the floor of the nasal cavity and into the antrum of Highmore, there are other methods which should be used according to the localisation of the tumour, *i.e.* the bucco-nasal route (below) or the naso-orbital route (above).

3. The Bucco-Nasal Route. Denker[1] employs the buccal route, originally introduced by Rouge for the treatment of ozæna even for malignant tumours of the nose. In the former edition of this work we described Rouge's method of opening the nasal cavity by an incision through the sub-labial mucous membrane, with separation of the cartilaginous portion of the nose from the osseous nares and septum, followed by turning up of the nose and cheeks. Rouge divides the mucous membrane below the nares in the fold between the gum and the upper lip as far as the wisdom tooth, and raises the soft parts with a raspatory as far up as the infraorbital margin, at the same time elevating the mucous membrane in the inferior and middle meatus for a distance of 5 cm. He then opens into the antrum from the front and removes its nasal wall. It is thus seen that the first stage of the operation corresponds with the ordinary method of opening the antrum from the canine fossa, with, however, a freer removal of the anterior and nasal walls. It causes no disfigurement; but in the case of a new growth situated high up, the access is not so satisfactory as that provided by the naso-maxillary route, while the bleeding is less easily controlled, and the results are more uncertain.

4. Opening the Maxillary Sinus (Antrum of Highmore). The simplest and therefore the best method of obtaining free and dependent drainage in suppurative conditions (especially acute) of the antrum, is to open the antrum through the canine fossa in the mouth, where the bone between the strong buttresses on either side formed by the nasal process and the ridge of the malar bone is thin.

The mucous membrane is incised down to the bone, obliquely from before backwards immediately below the line of reflection of the lip, the incision being made rather lower posteriorly, but invariably made so that there remains a fold of mucous membrane in the lower side to hold stitches. The periosteum is detached upwards, exposing an area of bone the size of the terminal phalanx of the finger, the bone being afterwards chiselled out with a gouge 1 cm. broad. A finger is then introduced into the cavity and any necrosed bone, stumps of teeth or tumour are felt for. The bleeding in acute cases may be very active if the antral mucous membrane is hyperæmic and swollen, and may have to be controlled by rapidly packing the antrum with strips of iodoform gauze.

When the bleeding is slight, as occurs in chronic cases, a communication may be made with the inferior meatus of the nose by pushing a curved trocar through the thinnest part of the inner wall below the middle of the inferior turbinate bone, after which the gauze packing may be passed through to the nose, and the opening in the mouth closed with a few catgut sutures.

A suitable method for obtaining simple drainage of the antrum when exploration is not required, is to bore upwards with a perforator through the socket of the second bicuspid or of the first or second molar tooth, the first molar, according to v. Stein, giving most room. This method is only suitable, however, in cases where prolonged drainage of the purulent contents is desired. A small self-retaining silver tube can be readily introduced, by which means excellent drainage is provided.

A third method of opening into the antrum without making a skin incision is to break through its *inner wall* below the middle of the inferior turbinated bone, using a bent, sharp-pointed perforator (Mikulicz). The advantage of this method is that the pus flows, not into the mouth, but into the nose, its disadvantage, however, being that it does not, like the operation from the mouth, open the lowest part of the antrum. Neither of the two latter methods allows of direct inspection of the antrum, or of the introduction of the finger into it.

Friedrich of Greifswald has introduced a modification of the Luc-Caldwell operation (Hajek) for the radical cure of antral empyema. The method provides a permanent communication between the nose and the antrum and thus prevents

[1] *München med. Wochenschrift*, 1906, No. 20.

stagnation of the antral secretion. The inner wall down to the floor of the antrum is freely removed.

When it is important to avoid an external scar, the anterior surface of the superior maxilla may be exposed by making an incision in the fold between the gum and upper lip as was originally adopted by Rouge for the treatment of ozæna. The bony margin of the nares is then chiselled away and the antrum brought into communication with the inferior meatus by removing the anterior part of the nasal wall.

Friedrich's operation is rendered more easy if an incision is made in the fold of the ala nasi, and a second oblique one in the fold between the lip and cheek down to the bone. An area of bone, 1 cm. square, is then removed with a hammer and chisel and Luer's forceps from the osseous margin of the nares, after which the nasal wall of the antrum is cut away above the floor of the antrum for a distance 1 cm. high extending 3 cm. backwards, part of the inferior turbinate bone being removed as well.

The antrum is then explored with the finger, thoroughly scraped out, and plugged from the nose. When the incisions are stitched up no noticeable scar is left.

After opening the nasal cavity, access is got to the *nasal duct* under the anterior end of the inferior turbinate bone $1\frac{1}{2}$ cm. ($\frac{5}{8}$ in.) behind the edge of the osseous anterior nares. The *antrum of Highmore* is reached by passing outwards under the middle turbinal $2\frac{1}{2}$ cm. (1 in.) behind the above bony edge, while higher up, under the same turbinated bone, a probe may be passed into the duct of the *frontal sinus*. The direction of the canal, as well as that of the nasal duct, is about parallel to the lateral wall of the osseous anterior nares.

Fronto-Nasal Methods

5. To open the Frontal Sinus.—Simple exploratory puncture of the frontal sinus may be performed according to the method devised by us and described by A Kocher, in which a drill is pushed through the skin over the inner third of the eyebrow (no incision being made) and then bored through the bone. The presence of purulent contents in the sinus can be determined with an exploring syringe.

In cases of empyema the sinus is drained by the following method :—

(*a*) *Opening the Sinus.* After shaving off the eyebrow, an incision is carried down to the bone along the supraorbital margin as far as the middle line. The upper edge of the wound, along with the separated periosteum, is drawn well upwards. The supratrochlear and supraorbital nerves, and the accompanying arteries, are divided, but the branches of the facial nerve to the occipito-frontalis, corrugator, and orbicularis muscles, which are of greater importance, are avoided. It is seldom necessary to make a second incision passing obliquely upwards towards the middle line. After raising up the skin and periosteum with a raspatory, the sinus is opened with a chisel, or rotating burr, at the inner end of the superciliary eminence. The anterior wall contains diplöe, and is richly supplied with blood, so that one must be prepared for bleeding. The posterior wall consists only of the vitrea. Beneath the anterior wall is the mucous membrane, which is smooth and bluish when healthy but bluish-red, friable, and markedly thickened when suppurating. After dividing the mucous membrane, a probe may be passed downwards and backwards from the sinus into the nose under the anterior end of the middle turbinal, and, after forcibly dilating the canal, drainage is established by the introduction of a tube.

It is well for this purpose to make use of a very light silver drainage tube, having two or three flanges towards the sinus, so that it may be firmly retained in position, but at the same time be sufficiently yielding, so that with a firm pull from below the flanges may come together, and may not prevent the withdrawal of the tube towards the nose. The tube must be worn until the suppuration ceases. As a rule it is better, without further separation of the periosteum, to cut through the bone with a straight chisel from the initial opening, first in an outward, and then in

an upward direction, the extent of the sinus in both these directions being first ascertained by a probe.

By means of an elevator the triangular portion of bone which has thus been formed, along with its periosteum, can be broken across and folded upwards and outwards. The entire mucous lining may be completely removed with a small sharp spoon. In this way a complete cure is obtained by establishing free drainage into the nose. An iodoform gauze tampon is introduced and the wound partially sutured, secondary sutures being introduced two days later.

The above method suffices for acute and recent cases in which there is merely a purulent catarrh of the sinus, for example, in those cases which occur as a complication of acute rhinitis, or in infectious diseases without visible continuous infection from below (*e.g.* influenza). In cases of longer duration, on the other hand, the mucous membrane does not recover, the surface of the bone becomes diseased, the ethmoid cells become involved from the pus flowing over them, and thus permanent healing is prevented. These cases must be relieved by a radical operation.

(*b*) *The Radical Operation on the Frontal Sinus.* Three radical methods may be mentioned. The first, generally referred to as Kuhnt's method, but performed by us much earlier, consists in the obliteration of the sinus by the removal of the whole of the anterior wall of the sinus. In this method the above-described angular incision must be employed. The sinus is opened as described, the soft parts along with the periosteum are separated, the anterior wall of the sinus is then removed with cutting bone forceps, and the diseased mucous membrane scraped out; no drainage is employed, and the soft parts are applied to the posterior wall of the sinus.

The disadvantage of this operation is that considerable deformity results, even although the cicatrix itself is scarcely visible. The forehead appears to be irregularly sunken in. This method is, therefore, to be limited to the most obstinate cases, and to those where danger of intracranial complications is feared. The deformity might be avoided if the anterior wall were folded back by the osteoplastic method, and the posterior wall removed; but the fear of an intracranial retention of pus forbids this procedure, which could only be considered if subdural suppuration already existed. Jansen's method of removing merely the orbital wall of the sinus and packing is not to be compared in its results to the removal of the whole wall.

To prevent the deformity an osteoplastic method has been introduced. In an earlier edition of this work we stated that, as a rule, it was better, instead of proceeding from a small opening into the sinus, to divide the anterior wall at both extremities with bone forceps without separating the periosteum, and then to break across the bony flap at its base. In this way a free view is obtained of the whole cavity, thus allowing of complete removal of the disease. Küster, Gussenbauer, and Czerny have methodically carried out the osteoplastic trephining. Czerny's incision produces much more deformity than that employed by us and accepted by Golovine. Golovine, by means of a variable incision, forms a flap of bone with its base at the supraorbital margin. Killian has attempted to minimise the disfigurement by resecting the anterior and inferior walls of the sinus, leaving, however, a supraorbital bridge of bone (Fig. 259).

The osteoplastic method, as compared with that of making a small trephine opening, allows not only of a thorough removal of the diseased mucous membrane and bone, but it also enables the drainage opening to be placed at the deepest part of the cavity, this, as Küster has rightly insisted, being essential when dealing with cavities with rigid walls. Drainage may also be carried out conveniently by passing a tube from the nose and out through the skin, so that the cavity may be thoroughly washed out.

A third method is especially adapted to meet the last indication, which is so important if a radical cure is to be obtained; it attacks the opening of the fronto-nasal duct and the ethmoidal cells to a varying extent, so as to permanently prevent any pocketing of pus, or any hindrance to perfectly free drainage into the nasal cavity. Winkler splits the nose in the middle line. Killian performs a temporary resection of the nasal bone and of the nasal process of the superior maxilla. Barth, by means

of a longitudinal incision, turns aside a still more limited flap of bone, consisting merely of the nasal bone and the nasal process of the frontal bone.

In Barth's operation, after the bone has been folded back, the diseased mucous membrane of the frontal sinus is seen to project from above forwards into the wound, and can be freely incised and the frontal sinus plugged; then the upper part of the nasal cavity may be laid freely open by means of the spoon, chisel, and scissors, so that a permanent free communication between the frontal sinus and the cavity of the nose is obtained. This method of placing the opening of the sinus towards the nose is

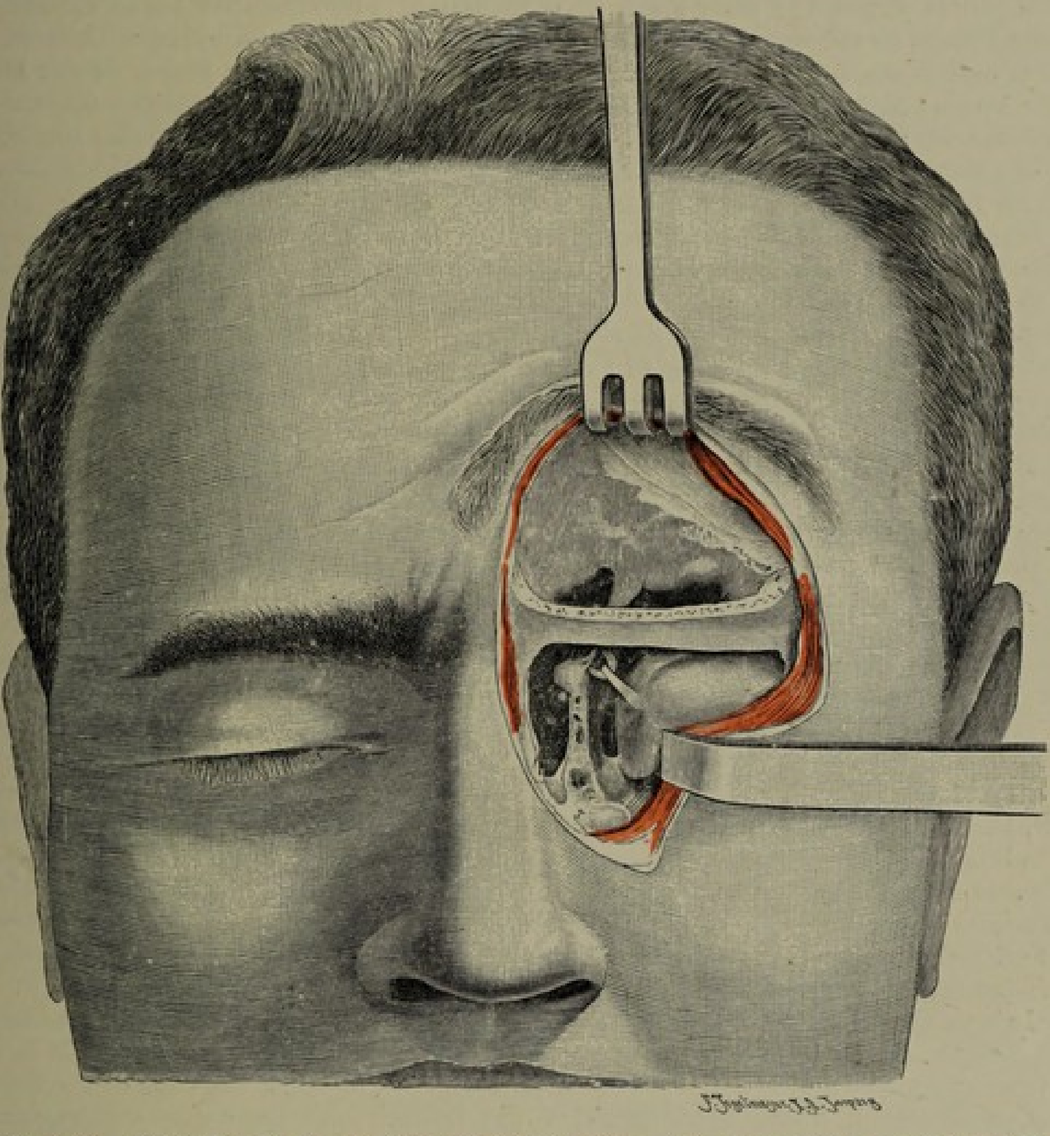


Fig. 259.—Killian's radical operation on the frontal sinus. The supraorbital margin has been retained in the form of a bridge (from a dissection by Tramond).

specially indicated in all cases where disease of the nose, especially of the ethmoidal cells, is combined with inflammation of the sinus, whether primary or secondary. The operation has been methodically developed by Killian, with whose name it is commonly associated. The main feature of the operation is that, by providing sufficient room in front, and removing the floor of the sinus, the anterior ethmoidal cells are entirely cleared out, and a free communication between the nose and frontal sinus is permanently procured. The after-treatment consists merely in frequent douching of the nose, provided an intense affection of the sinus does not render it desirable to stuff the cavity for several days with iodoform or xeroform gauze.

6. Opening the Ethmoidal Sinuses (Treatment of Ethmoiditis). The ethmoidal

sinus has already been alluded to in describing the incision for exposing the nasal together with the accessory cavities. The exposure of the roof of the naso-pharynx is considered in the section dealing with excision of the upper jaw, which is a necessary preliminary.

(c) Surgery of the Jaws

7. **Resection of the Upper Jaw** (Figs. 260, 261, 262). In order to have the courage to carry out a partial or total resection of the upper jaw with the necessary thoroughness during the early stage of a malignant tumour—that is, to expose the diseased parts so thoroughly that all suspicious tissues may be removed with certainty—it is indispensable to be acquainted with methods of operation which do not result in too serious disfigurement. The play of the features, more especially, must not be unnecessarily interfered with. It is not, therefore, a question of obtaining fine scars, but of preserving intact the branches of the facial nerve. To this end the following incision is recommended.

It is almost always desirable, in the first place, to remove the glands at the angle of the jaw and at the anterior border of the sterno-mastoid by the "normal incision for the submaxillary triangle." The opportunity should at the same time be taken to ligature the external carotid, as this preliminary procedure greatly diminishes the bleeding and allows the operator to see exactly what he is doing.

Temporary occlusion of the common carotid proves even more satisfactory. This is effected by passing a stout four-ply ligature round the artery and bringing the loop out of the wound, while the edges of the wound are protected by means of aseptic gauze fixed to the skin. The loop may be pulled taut by an assistant, by which means the bleeding is completely kept in check.

Having thus taken steps to make the operation bloodless, we make an incision through the upper lip along the naso-labial ridge into the nasal orifice, from thence close around the ala of the nose, and obliquely upwards and inwards along the osseous anterior nares to the junction of the frontal bone with the nasal process of the upper jaw. In this way the levator alæ nasi muscle alone is divided, which will scarcely affect the expression of the features. Fig. 260 shows how slight the deformity is. It is limited, in fact, to a slight falling in of the cheek and sinking down of the lower eyelid.

Should the above incision, which Esmarch ascribes to Nélation, give an insufficient view, there are two ways of obtaining a more free access: in the case of tumours which extend far back, by the addition of an independent incision extending transversely outwards from the angle of the mouth, as has been more fully described for obtaining free access to the buccal cavity. The operation thus becomes similar to that performed by Fergusson. This is a very suitable incision to employ when the new growth has extended far backwards along the alveolar margin and roof of the mouth.

As a rule an incision at a higher level is necessary in order to get sufficient access to the region of the orbit and the malar bone. It is made in such a way that it falls between the upper and lower areas of the facial nerve, at the lower edge of the orbicularis palpebrarum, above the origins of the levator labii superioris and zygomatic muscles (our normal upper jaw incision below the infraorbital margin). This incision is similar to that described by O. Weber, except that it is directed obliquely downwards to avoid the branches of the facial nerve. Still better access is obtained if the incision divides the inner canthus of the eye, and is continued outwards and slightly downwards from the outer canthus. The mucous membrane is divided along the lower lid. This is practically Dieffenbach's incision, but he splits the nose in the middle line.

The flap, including the whole of the healthy soft parts and the nerves, is reflected outwards, and the bone (or tumour) exposed by dividing the reflection of the mucous membrane of the cheek. Hæmorrhage is temporarily arrested by grasping firmly the base of the flap, which allows of the vessels (angular, labial, infraorbital, and transverse facial) being secured and ligatured. Immediate and thorough arrest of the hæmorrhage is a very important step in the operation.

Next comes the separation of the upper jaw from its connections. When the disease is extensive the nasal process of the upper jaw, together with the nasal bone, is divided with the chisel and bone pliers from the highest part of the osseous anterior nares, and the division is continued backwards through the lachrymal and ethmoid bones as far as the hinder end of the spheno-maxillary fissure, no injuries of importance being inflicted. As regards the connection of the upper jaw with the malar bone, the line of division will depend upon the extent of the disease, being made either at the maxillo-malar junction, or in such a way as to remove the malar bone as well, by dividing its zygomatic and frontal processes with a chisel. For this a small separate incision must be made, the edges of which must be drawn firmly apart with sharp hooks.

There remains now the third connection, namely, with the upper jaw of the

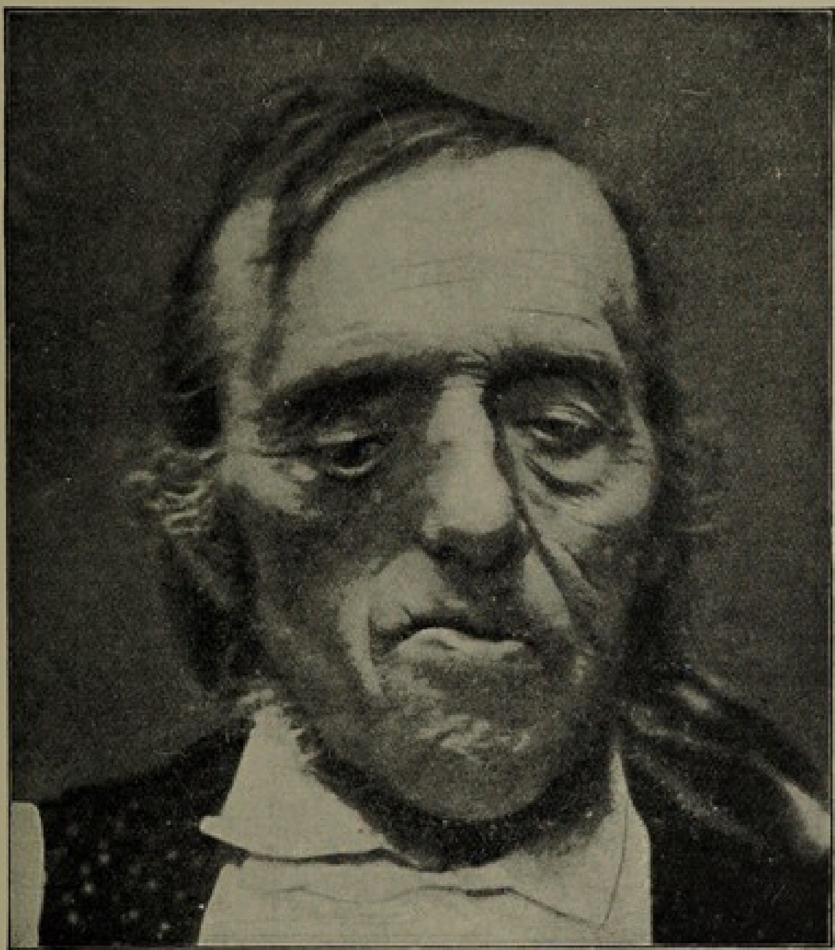


FIG. 260 shows the result after complete excision of the upper jaw (for a malignant tumour) by the angular incision.

opposite side. The mucous membrane and periosteum of the palate having been divided down to the bone beyond the disease, and the soft palate having been separated from the hard palate with the knife, or better with the thermo-cautery, a chisel is placed between the median incisors, and the hard palate is cut through in its entire length. If the latter procedure is difficult, cutting forceps may be used.

Lastly, the connection with the pterygoid process is to be considered. By drawing the flap forcibly backwards, the soft parts (mucous membrane, buccinator, and the two pterygoid muscles) can be separated from without as far back as the pterygoid process, and the hæmorrhage having been properly arrested, the process is chiselled through from the exterior. When the pterygoid is not to be removed the upper jaw is separated from it by forcibly wrenching it downwards, a process which should be carried out rapidly in order that the arrest of hæmorrhage may at once be proceeded

with, as the large terminal branches of the internal maxillary artery (spheno-palatine, descending palatine, and infraorbital) have been torn through.

As regards after-treatment there are two methods: if the bleeding has quite ceased, the wound should be irrigated half-hourly with very warm normal salt solution; if the bleeding continues, the cavity should be packed with xeroform gauze, and not changed until it becomes loose.

The main point to be observed in the after-treatment is the prevention of aspiration pneumonia by raising the foot of the bed when the patient is recumbent. We allow our patients up as early as the second day.

For quite localised tumours, as well as for the removal of sequestra, an incision

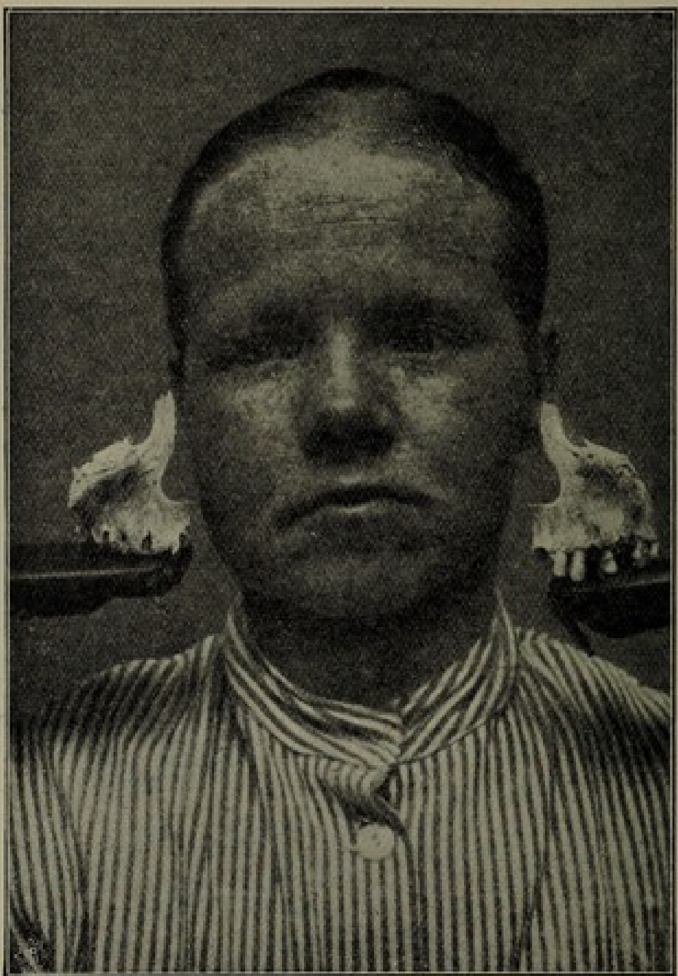


Fig. 261.—Excision of both upper jaws for phosphorus necrosis, without an external incision. Photograph taken four weeks after operation. The patient wears no artificial mould.

through the upper lip into the nose will suffice. We have recently performed a complete resection of both jaws for phosphorus necrosis without making any external skin incision. In such cases, owing to the periosteum being left, the disfigurement is so slight that it is hardly possible to realise that so serious an operation has been performed.

The after result is very different in cases of malignant tumours, which involve the entire upper jaw, and especially those which have developed from the *antrum of Highmore*. Here recurrence is the rule, because by our present methods we cannot be sure of removing all the disease. The fault lies partly in the disregard of prophylactic means to prevent hæmorrhage, and partly in incorrect posturing of the patient.

In all those cases where we cannot with certainty determine the boundaries of the new growth we must make up our mind from the beginning to extend our incisions, on the one hand, well beyond the region of the upper jaw, and, on the other, we must not shrink from removing the skin covering the tumour as far as it is adherent. The excision of a large portion of the cheek and eyelid will, of course, have to determine the form of the incision.

Where it is not necessary to remove the skin, we recommend, where the disease is extensive, the employment of a modified Dieffenbach's incision, *i.e.* perpendicularly through the upper lip along the naso-labial groove, and vertically upwards through the nose just external to the middle line. At the root of the nose the incision is carried outwards along the palpebral fissure, and from the outer canthus outwards and downwards, as far as the posterior part of the zygomatic arch. The large flap is then reflected backwards as far as the masseter, and the bleeding arrested. The

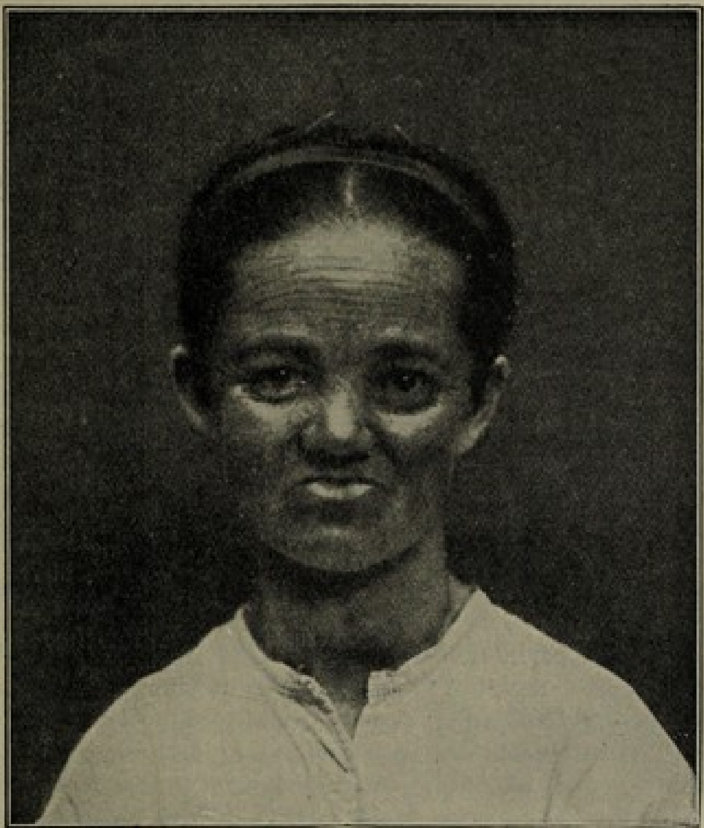


FIG. 262.—Photograph of patient, 10 years after resection of both upper jaws for phosphorus necrosis.

eyeball should be removed under all circumstances, in order that a fair opportunity may be provided for the removal of the diseased tissues in the region of the ethmoid and of the spheno-maxillary fissure down to the base of the skull, as it is here that recurrence is specially apt to occur. The next step in the operation is the division of the base of the external angular process of the frontal and then of the posterior part of zygomatic arch, after which it is determined how far the tumour has implicated the region of the ethmoid, the nasal bones, and the orbit, so that one may keep wide of its limits in these regions. The nasal bone, along with the nasal process of the upper jaw and the orbital plate of the ethmoid, is then severed from the frontal. The base of the pterygoid process must be chiselled through from the outside, and removed along with the internal and external pterygoid muscles. Great disfigurement after resection of the upper jaw is caused by the falling down of the eyeball and lower eyelid when the long-standing œdema has disappeared. König has introduced an excellent plastic operation to prevent this deformity. He takes a strip of muscle, two

fingers'-breadth, from the insertion of the temporal muscle, together with a piece of the anterior border of the coronoid process, which he chisels through down to its base, and having placed it transversely below the eyeball, fixes it to the remains of the nasal process of the upper jaw. In this way a support is provided for the eyeball.

8. Osteoplastic Resection of the Upper Jaw. Osteoplastic resection of the upper jaw is mainly performed as a preliminary step in the removal of tumours of the nasal cavity, which reach as high as, or originate from, the roof of the nose and naso-pharynx, and especially if they have invaded the orbital cavity. We referred to this point in considering the surgery of the nasal cavity, at the same time describing the partial resection of the jaw by which the nose and accessory cavities are reached.

A complete osteoplastic resection of the jaw may be regarded as an extended form of the naso-maxillary method, and is carried out on precisely the same lines as those recommended in the next paragraph, with this difference, however, that after the skin incision has been made, the soft parts are not dissected up, but remain in contact with the bone when the latter is reflected outwards. The subsequent disfigurement is therefore less, very fine cicatrices being obtained.

9. Osteoplastic Resection of the Upper Jaw to expose the Base of the Skull—*e.g.* for naso-pharyngeal tumours, malignant tumours of the ethmoid and sphenoid, and for diseases of the sphenoidal sinus and the pituitary body.

The exposure of the ethmoidal sinus for the removal of a malignant tumour which has involved the orbit, must be combined with resection of the upper jaw, the operation thus forming a combination of the naso-orbital and naso-maxillary routes. The latter is carried out in the manner described under *b*, page 384, but one may resect only a part of the upper jaw, leaving the horizontal plate of the palatal bone. The incision resembles that for resection of the upper jaw, but the lip is not split and the horizontal limb is made shorter. In other respects the procedure is as follows :—

The posterior nares are first plugged in the usual way with a Bellocq's sound, in order to prevent the passage of blood downwards into the air passages during any part of the operation. This may also be effected by placing the patient on his side. The nose is split close to the middle line from the affected nostril upwards between the nasal bones as far as the glabella, and firm pressure is applied with gauze pads to stop the bleeding. An incision is then made at the outer angle of the orbit down to the frontal process of the malar, which is exposed subperiosteally with a raspatory and then chiselled through, little hæmorrhage resulting. The anterior end of the zygomatic arch is dealt with in the same way. The upper jaw is chiselled through (at the level of the inferior meatus) from the floor of the nose horizontally outwards through the *antrum of Highmore*, the mucous membrane of the mouth being nowhere injured. The soft parts are then divided and the base of the nasal bone is snipped across with forceps, which are carried laterally also through the lachrymal and ethmoid bones to the floor of the orbit. In this way, without excessive bleeding, a flap consisting of the cheek and nose, together with the bone (the anterior wall of antrum, nasal process of the upper jaw, and the nasal and frontal bones), is turned outwards and downwards and the tumour exposed, which in our case filled the nasal cavity and antrum, and had, by destroying the ethmoid, penetrated the orbit.

The method above described somewhat resembles Jordan's modification of Langenbeck's osteoplastic resection of the upper jaw with temporary resection of the nose. By it Czerny (Naab) has successfully removed naso-pharyngeal fibromata.

Jordan has operated in various ways. His plan of wrenching the upper jaw and nose over to the opposite side has, like Langenbeck's, the disadvantage of a disfiguring incision, which also injures branches of the facial nerve. His first plan, which more resembles that practised by O. Weber and the author, avoids this disadvantage.

Polypi can be readily cleared out as far as the base of the skull, and when the eyeball can also be removed one can sometimes easily reach from the inner and back part of the orbit into the sphenoidal sinus, which may be investigated with the finger, and if necessary cleared out. The parts as far as the sphenoidal sinus are so readily accessible that careful cauterisation can be done up to the base of the skull,

which is exposed from the cribriform plate of the ethmoid as far back as the sella turcica.

When it is necessary to obtain access to both sphenoidal sinuses, the posterior and upper part of the nasal septum must be removed, if it be not already destroyed.

By trephining the roof of the sphenoidal sinus in a backward and upward direction it does not seem to be impossible to remove a tumour of the pituitary body (in acromegaly) after the above-described preliminary operation has been performed.

The sphenoidal sinus is exposed in exactly the same way as the ethmoidal sinus. Siebenmann does not hesitate to puncture the sphenoidal sinus above the choanæ by inserting a needle below the middle turbinate bone; and if pus is found he removes the greater portion of the anterior wall of the sinus with a sharp spoon. As the wall is thin it can be readily penetrated.

The position of the sphenoidal sinus and the manner in which it can be reached from the middle meatus is best understood by a reference to a sagittal section of the skull. The point at which the sphenoidal sinus should be penetrated lies between the posterior extremity of the middle turbinate bone and the attachment of the ala of the vomer at the upper part of the posterior opening of the nares. The puncture opening is then enlarged with a sharp spoon.

Lastly, the palatine route must be clearly distinguished from the naso-maxillary and buccal routes for exposing the nasal cavities.

The transpalatine route for exposing the roof of the nasal cavity has been described by Nélaton and Gussenbauer. It causes comparatively little injury, gives, however, rather limited access, and is only suitable for pedunculated tumours, *e.g.* polypoid fibromata and fibrosarcomata.

Gussenbauer splits the hard and soft palate in the middle line, separates the muco-periosteum on both sides and chisels off the horizontal plate of the palate as well as the vomer, by this method exposing the posterior part of the roof of the nose and naso-pharynx.

Lastly, the freest access to the whole of the nasal cavity and to the roof of the nose and naso-pharynx is provided by a method we have introduced, namely, by temporary reflection of both upper jaws.

The technique is fairly simple: The upper lip is split into the nostril near the philtrum, the mucous membrane in the fold between the jaw and the lip (and cheek) is divided sufficiently to allow of a chisel being applied above the alveolar margin so as to cut through the anterior wall at the floor of the antrum, the chisel being provided with a short projecting guard on one side. There is no resulting injury to the mucous membrane of the posterior wall, while the vessels and nerves running forwards to the horizontal plate of the palate remain undivided.

The alveolar margin and palate are divided with a broad, thin chisel exactly in the middle line in the interval between the incisor teeth. The soft palate is also divided and the edges are forcibly pulled apart with strong hooks. The mucous membrane of the nose is divided, the vomer pushed aside (or cut across) and the turbinate bones are excised if they hamper the operator.

The access obtained to the base of the skull by this method is better than is provided by any other operation, and although less room often suffices in cases of pedunculated fibromata, we consider this method necessary in dealing with tumours that have a broad attachment and especially with vascular sarcomata or carcinomata. The operation provides excellent access, with the great advantage that the resulting deformity is nil, only a very slight scar being left, and at the most the incisor teeth next the saw-cut may be slightly loosened. The two halves of the palate are then carefully approximated and its coverings, as well as the soft palate, are united with sutures. The raw surface at the base of the skull must be well packed and the end of the packing brought out through the nostril.

Up to the present, the operation has been performed six times, by Depage (twice), Larise, Bornhaupt (Falkenberg), Nicoladoni (Hertle), Payr and Enderlen. Our case has been published by Lanz.

Surgeons are agreed that the operation gives a freer access than is provided by

any other method, and that there is least subsequent injury and no disfigurement, because the palatal processes and the soft palate reunite very readily. Payr has observed very good results in two cases. The severe bleeding which often occurs is not to be attributed to the operation so much as to the condition by which it is occasioned—*i.e.* the vascularity of a broad-based tumour.

We have endeavoured to diminish the bleeding by ligaturing both external carotid arteries, a precaution which Depage and Enderlen have found of service, although less importance is attached to it by others. Fowler's temporary ligature of both common carotid arteries might prove more effective, with the addition of the loop, which we suggested and which can be pulled on if required.

The hanging position of the head is to be avoided, but the oblique position of the trunk is necessary to prevent aspiration. The anæsthetic is administered with Arnd's ether-apparatus. Depage, Larise, and Hertle perform tracheotomy. Kuhn has called attention to the special advantages of administering the anæsthetic by peroral intubation, which allows the entrance to the larynx and oesophagus to be plugged, while Payr has attempted to induce local anæsthesia by inserting the needle of a syringe below the external palpebral ligament and injecting cocain along the floor of the orbit towards the spheno-maxillary fissure.

Partsch has modified our operation inasmuch as he does not divide the palate in the middle line but merely turns back the flaps after cutting through the bone above the alveolar margin. This does not provide such good access to non-pedunculated malignant tumours, which are generally very vascular, and for which our operation is intended.

10. Removal of the Pituitary Body. Hertle has rightly observed that the diagnosis of a tumour of the pituitary body can be made with relative certainty from the presence of bitemporal hemianopia, as well as evidences of acromegaly, and that the question of excision should be considered when medical treatment has failed. The temporary reflexion of both upper jaws and the removal of the lower wall of the sphenoidal sinus would lead one down to the point where the pituitary body could be removed from the sella turcica.[1]

Hertle calls attention to his experiments on the cadaver in which he successfully excised the pituitary body without injury to the adjacent structures. Maas and Friedemann[2] have performed the operation successfully in cats, while Schloffer has made experiments on the cadaver. The orbito-naso-maxillary route, described for radical operations for polysinusitis, may also be employed to expose the sella turcica.

11. Exposure of the Retro-maxillary Fossa. Access to retro-maxillary tumours must be obtained behind the upper jaw, the successful exposure of this region depending on the removal of the zygoma and malar bone, so that we have to refer the operator to our method of osteoplastic resection of the zygoma for neurectomy of the third division of the trigeminal, and also to the osteoplastic removal of the malar bone for neurectomy of the second division of the trigeminal nerve at the base of the skull.

12. Resection of the Lower Jaw. This is a simple operation; but here again we must not produce unnecessary deformity about the mouth by injuring the supra-mandibular branches of the facial nerve.

On account of the simplicity and comparatively little mark it leaves, we employ a mesial incision, which divides the under lip and extends downwards as far as the centre of the hyoid. By this incision we can get sufficient access to disease in the neighbourhood of the symphysis and the greater part of the horizontal ramus of the lower jaw. One should not be tempted, unless it is absolutely necessary, to add a lateral incision, as it is apt to have an injurious effect on the mechanism of swallowing by injuring the muscles and nerves, and therefore to give rise to danger from aspiration pneumonia. Wyeth, in fact, used no other incision for the removal of one-half of the lower jaw for sarcoma; moreover, the mesial splitting of the lip gives rise to no noteworthy disfigurement.

When the disease involves the region of the angle and ascending ramus, and when

[1] Hertle, "Temporäre Aufklappung beider Oberkiefer nach Kocher," *Arch. für klin. Chir.* Bd. 73.

[2] Maas and Friedemann, *Berl. klin. Wochenschr.*, 1900, No. 52, and 1902, No. 19.

it is necessary to expose and clear out the submaxillary fossa for a malignant tumour, a lateral incision is added. On account of the facial nerve it must be placed below and not over the margin of the jaw; indeed it should pass upwards and backwards from the hyoid bone along the submaxillo-cervical crease to a finger's-breadth behind and below the angle of the jaw, and from thence up to the apex of the mastoid process (compare our *normal incision* for the superior triangle of the neck). The flap thus made is dissected up and fixed by a stitch or two to the skin of the face. In doing this, keep as near as possible to the bone by including the muscular structures in the flap (anteriorly, the levator menti, depressor labii inferioris, and depressor anguli oris, posteriorly, the buccinator and masseter). From the inner surface of the jaw are detached, anteriorly, the digastric, mylo-hyoid, genio-hyoid, and genio-hyo-glossus; posteriorly, the internal pterygoid. When the glands below the body of the jaw are diseased, the anterior and posterior bellies of the digastric are first exposed, and the entire bunch of the lymphatic glands, including the salivary glands, is then dissected up over the edge of the jaw.

It is important to saw through the anterior part of the jaw immediately after the incision through the lip has been made, and before detaching the muscles, in order that by drawing it well forward the soft parts may be put on the stretch. After dividing the muscles and the mucous membrane the jaw is drawn downwards so as to expose the coronoid process, which, along with the insertion of the temporal muscle, is snipped off with bone pliers. In disarticulating the condyle sharp instruments are to be avoided, so as not to wound the internal maxillary artery. The capsule of the joint and the insertion of the external pterygoid are torn through by torsion after all the other structures have been divided. The facial artery has already been divided and ligatured in dissecting up the soft parts. When the horizontal portion of the jaw is sawn across, the inferior dental artery is divided as it lies in the inferior dental canal, and may be plugged with a pellet of wax; when the entire half of the jaw is removed this artery is ligatured in the posterior and upper angle of the wound, either before or after the jaw is drawn downwards, or in dissecting up the internal pterygoid muscle, when the inferior dental nerve will be either cut or torn across. Just as in some cases of resection of the upper jaw, so here also it may be necessary, in order to avoid loss of blood, to ligature the external carotid above the superior thyroid, or, it may be, above the origin of the lingual. If the muscles connecting the tongue to the lower jaw have been necessarily divided, their stumps must be stitched forwards, as otherwise the tongue will fall back and obstruct the entrance to the larynx.

When the disease involves the ascending ramus, either primarily or secondarily to carcinoma of the pharynx, the jaw should be divided in front of the ramus (Langenbeck). We prefer, however, to use the same incision as that recommended for resection of the lower jaw in general rather than Langenbeck's incision, which descends vertically from the angle of the mouth (Esmarch), *i.e.* we employ an incision which is placed along a line extending from the mastoid process towards the hyoid bone, and modify its length according to circumstances. After ligature of the facial artery the lower border of the jaw is exposed immediately in front of the masseter, the periosteum is separated in front and behind, and the elevator is pushed through the mucous membrane, after which the lower jaw is divided with a keyhole-saw behind the molar teeth.

The ascending ramus is now drawn upwards with a hook, while the anterior part of the jaw is drawn forwards, the further steps of the operation being similar to those for resection of half the jaw.

When the entire half or the whole of the jaw has been removed, especially if the operation has been done subperiosteally, and the periosteum preserved, a mould (Claude-Martin) is to be made, over which the periosteum is stitched so that the newly-forming jaw may be properly shaped. Subperiosteal resection of the lower jaw, *e.g.* in phosphorus necrosis, is a simple operation. After the teeth, which are generally loose, have been removed, the gum and the periosteum are divided, and the latter is pushed back with a periosteum elevator to expose the diseased bone. This is then divided and removed.

Fig. 263 *a*.

Fig. 263 *b*.

Necrosis of the entire lower jaw. Photograph taken five months after operation.

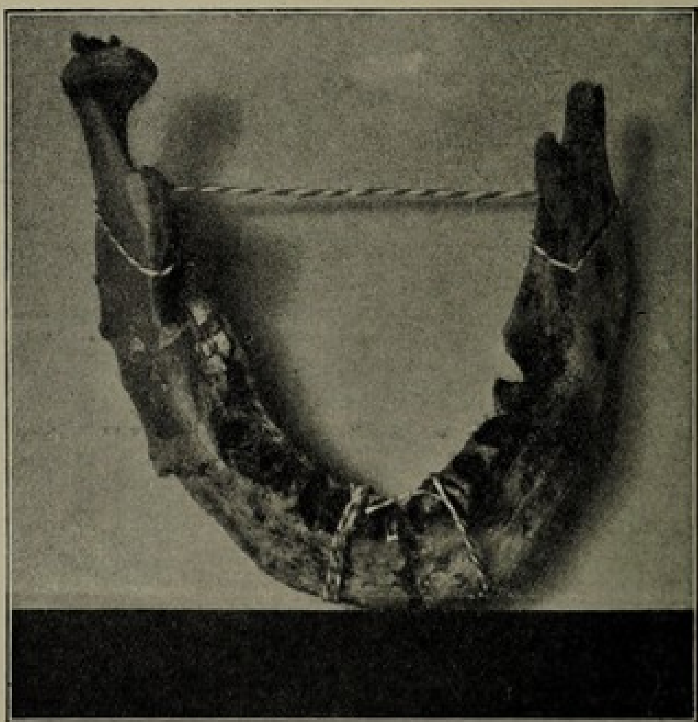


Fig. 264.—Photograph of lower jaw from same case.

Fig. 263 (*a* and *b*) shows the appearance of a patient five months after a total resection of the lower jaw where no artificial mould had been used. Fig. 264 represents the necrosed lower jaw after removal.

13. Osteoplastic Division of the Lower Jaw. In regard to the immediate insertion of an artificial mould of the jaw, Vallas and Martin assert that the skin incision must not be placed over the border of the jaw, as otherwise the mould presses on the line of suture. They advocate the use of the incision we have described, which is placed at a considerably lower level.

The wound should be completely closed without drainage, and if possible the mucous membrane of the cheek and the floor of the mouth should be united with stitches. The masseter and internal pterygoid muscles should be carefully dissected off the bone and should be subsequently united under the mould, so that the best functional results may be procured. Finally it is more advantageous to remove, rather than leave, the ascending ramus.

In former editions of this work we advocated division of the lower jaw in front of the ascending ramus for disease in the region of the isthmus of the fauces and the posterior pharyngeal wall. We are convinced, however, that ample room can be obtained even in these cases, and with the least injury, by dividing the jaw through a mesial incision (*vide* Excision of the Tongue and of the Pharynx).

We therefore regard the mesial operation as the normal method for an osteoplastic resection. The soft parts as well as the lower lip must, of course, be divided down to the hyoid bone, a method which presents no difficulty, as the dissection is carried out in the middle line in the interval between the muscles passing from the tongue to the hyoid and lower jaw. To obtain a separation of the two halves of the jaw it is necessary to divide the mucous membrane of the floor of the mouth on the affected side between the tongue and the jaw.

No disturbance of function results from splitting of the jaw, and if two drill holes are made on either side before the bone is sawn, the two halves can be so firmly united that the patient is able to open and shut his mouth without discomfort immediately after the operation has been performed (*vide* Excision of the Tongue).

14. Resection of the Temporo-maxillary Joint (Fig. 265). Resection of the temporo-maxillary articulation is performed for suppurative inflammation (often metastatic), tubercular and rheumatoid arthritis, habitual and old-standing dislocation, and for ankylosis. The chief danger in the operation lies in injury to the facial nerve, especially to the orbital twigs. A short curved incision beginning just in front of the tragus is carried vertically upwards over the zygoma, so that the skin and fascia are divided, avoiding the superficial temporal artery and vein which lie farther back, or ligaturing them—especially the vein—if they are in the way. The fascia is carefully stripped off the zygoma subperiosteally. In the course of this removal the capsule is separated below from the condyle and the joint is opened into. An elevator is then introduced and the condyle of the mandible levered out. The meniscus is now exposed and excised if necessary; the condyle is cut through with bone forceps, and the glenoid fossa scraped with a sharp spoon.

After unilateral excision mobility returns in a very short time, and even after both sides have been excised the result is satisfactory, provided that active movements are begun as early as possible, *i.e.* in two or three days if the wound is aseptic. To ensure mobility, Helferich interposes part of the temporal muscle, while Kusnakow places a piece of the masseter between the glenoid fossa and the mandible. It would be still easier to place a flap of the temporal fascia over the head of the bone. If the cartilage is retained and the muscles of mastication are not atrophied, this modification is unnecessary.

The auriculo-temporal nerve runs up behind the condyle, while the internal maxillary artery crosses below it. By the above method we once cut down and reduced a dislocation of the jaw of four months' duration, obtaining an excellent result, also in a similar case of more than a year's duration.

Difficulty in opening the jaw, due not to stiffness of the joint, but to shortening and adhesions of the soft structures, can be treated in two ways: either by separating

the soft parts from the lower jaw, or by making a false joint in front of the adhesions, by resecting as large a piece of bone as may be required (Esmarch). The operation must be varied to suit different cases.

We have obtained an excellent result in a patient in whom it was impossible to overcome spasm of the muscles of mastication by extensive subperiosteal separation of the muscles from the jaw, an operation which has also been performed by Le Dentu.

(d) Surgery of the Auditory Organ

15. Exposure of the Middle Ear (Figs. 266-268). In the great majority of cases inflammations of the middle ear (which are caused by infection from the naso-pharynx along the Eustachian tube) may result in healing, by the process of suppuration, with

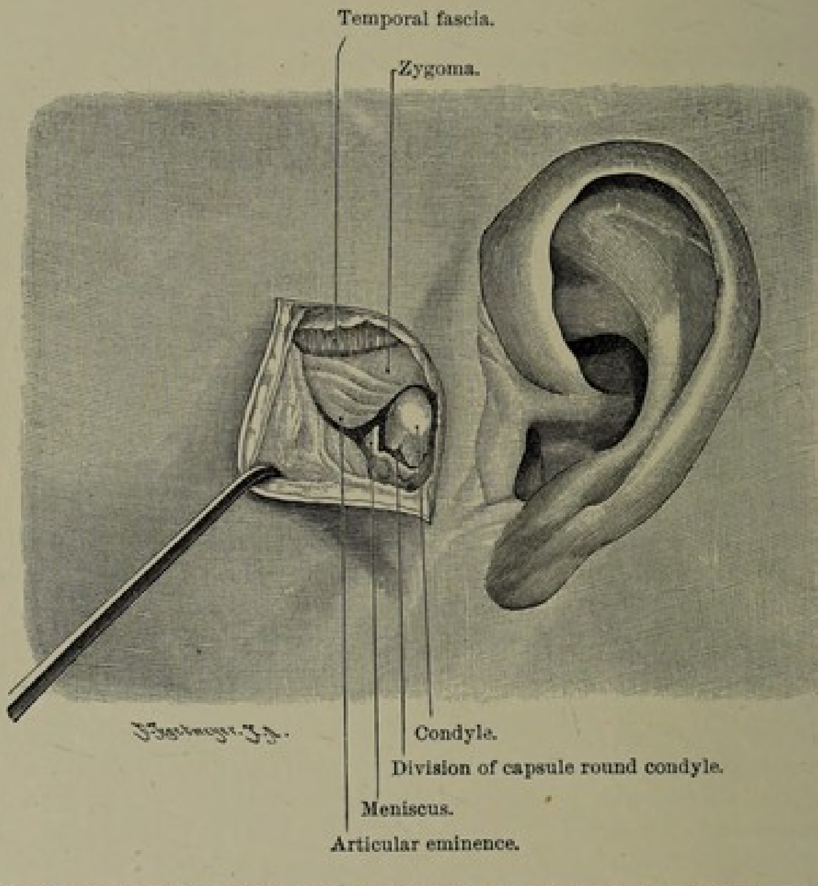


FIG. 265.—Resection of temporo-maxillary joint through an angular incision. The condyle of the jaw has been exposed and the capsule divided.

early perforation of the tympanic membrane, or when the pus is completely evacuated by incising the tympanic membrane at its lower part.

If the purulent discharge from the ear does not dry up in a short time we may conclude that the suppuration is not limited to the tympanic cavity. The floor of the cavity is flat, and therefore the flow from it is not unfavourable. The conditions are quite different when the suppuration has extended from the attic to the mastoid antrum and the mastoid cells. In this condition a free escape of pus can only take place after opening up the mastoid process, as the pus gravitates backwards and downwards, or it may be conducted from the antrum into the meatus, by removing the posterior wall of the latter.

The infective materials (most frequently diplococci and streptococci, also staphylococci), having reached the mastoid process and become stagnant, find a suitable nidus for their development, invade the thin walls, and reach the external and

internal periosteum. Perforation may take place at various points, most commonly occurring in the mastoid fossa and producing a phlegmonous swelling behind the auricle. The pus may also find its way upwards through the squamoso-mastoid suture, in which case the abscess forms above the attachment of the auricle. Lastly, perforation may take place lower down at the side of the apex of the mastoid process, the suppuration proceeding from the lower mastoid cells and causing a phlegmonous swelling under the sterno-mastoid (Bezold).

The internal periosteum of the mastoid process is the dura mater, and a periostitis in this situation is identical with pachymeningitis. Secondary to this is the development of a brain abscess in the temporo-sphenoidal lobe or cerebellum, or of basal meningitis or phlebitis of the lateral sinus, according to the site at which the transition from otitis to mastoiditis has taken place.

When the tympanic cavity is filled with stagnant pus, the result of disease in the neighbouring cavities, the infection may extend from it towards the cranial cavity, and it is especially the thin tegmen tympani through which the infected material most frequently penetrates.

If, therefore, an infective inflammation has once reached the middle ear, and if it has not subsided shortly after the escape of the exudation, the tympanic cavity, along with all its recesses and neighbouring spaces, must be freely exposed, and ready escape provided. It is interesting to observe how the fulfilment of this specially pressing indication has gradually been developed and completed in the last thirty years, until it has taken the form which we now describe as the "radical operation."

Certainly the conditions are very different when one has to deal with a recent and acute case, in which the changes are still superficial and essentially catarrhal in nature, and when the suppuration has penetrated deeply into the tissues. No doubt the radical operation, which to a large extent sacrifices the power of hearing, may often be avoided if, in acute inflammation, a complete removal of the exudation is effected at a sufficiently early period. For this purpose it suffices to open the antrum and mastoid cells, an operation [1] in the execution and exact development of which Schwartze (1873) has rendered valuable service.

16. Trephining the Mastoid Process (Schwartze's Operation). Exposure of the mastoid cells and antrum is indicated in every case where an acute inflammation of the middle ear does not at once subside after removing the cause, or after the withdrawal of the pus by paracentesis of the tympanic membrane. It is then almost certain that the exudate has extended beyond the tympanic cavity, in the first place, from the tympanic attic through the patent aditus into the antrum, and then into the mastoid cells, which in their turn are in open communication with the antrum. To open one of these cavities without opening the other is absurd. We do not speak, therefore, as in the text-books of the specialist, of "opening the antrum," but of trephining the mastoid process and its cavities.

The incision which we recommend is our auricular incision, which serves for all cases, even when a radical operation may have to be subsequently undertaken. It is very readily determined by applying the auricle against the skull, and carrying an incision down to the bone from the apex of the mastoid process alongside the posterior border of the auricle as far as its upper end. Should it be found necessary to enlarge the incision, all that is required is to carry it farther along the upper border of the auricle in order to give sufficient access from above as well as from behind. The only argument that can be urged against the incision is that the scar is not so well hidden behind the auricle as when the incision is made immediately behind the auricle. One or two spurting vessels are secured and the periosteum is separated forwards, as far as the meatus, with a sharp raspatory. At the junction of the upper and posterior walls of the osseus meatus will be found the more or less well-developed bony projection known as the supra-meatal spine of Bezold, but almost without exception the posterior end of the linea temporalis can be seen and felt distinctly. By applying a small gouge in this position and removing the bone directly inwards parallel to the osseus auditory canal, the cavity of the antrum will

[1] Originally carried out by Petit and Sassen, according to Heine.

be reached with certainty at a depth of 1·5 cm. Before the chisel is made to penetrate too deeply, it is desirable to chip away the superficial cortical layer from below in a backward direction from the above-mentioned area, so as to open the mastoid cells, at the same time retaining the cortex of the process in front.

When the cells (which lie for the most part quite superficially) have been reached, it should be noted if the suppuration has actually involved them, as in this event one has the assurance that the route for any further procedure has been opened up. The vertical portion of the lateral sinus may reach very far forwards, and although an indication of this condition is to be found in the oblique (sloping forward) instead of the vertical direction of the "*planum mastoideum*" (at the base of the mastoid process), it is nevertheless better to satisfy oneself as to the existence of this unfortunate complication by direct exposure.

After opening the cells which contain pus, it is easy, with a small Lüer's gouge-forceps, to remove the cortical coverings of all the cavities, to clear out the septa with a sharp spoon, and, by following up the deeper and upper cells, to open up the antrum until it is rendered perfectly patent. Care must be taken in using the sharp spoon that the approach to the attic is thoroughly exposed, so that free drainage from the attic is provided. In the lower part of the aditus the projection formed by the aqueduct of Fallopius and above it the external semicircular canal must not be injured.

When the operation is undertaken merely for acute cases there is no question of suture, still less of a plastic operation. After the cavity is thoroughly washed with sterilised salt solution it is swabbed with 10 per cent carbolic-alcohol solution and stuffed with iodoform gauze. Provisional sutures are passed through the edges of the wound, but are not tied until between the sixth and eighth day (secondary suturing), a drainage tube being introduced for a few days.

But it is quite another matter when the favourable opportunity has passed, for when caries and necrosis have appeared there is no longer a prospect of rapid healing. For the chronic cases of middle ear suppuration the radical operation is to be performed.

17. Radical Operation on the Middle Ear. The term "radical operation" as originally introduced by Siebenmann, was applied to cases where the antrum is so thoroughly opened that no special measures are required to keep the cavity open and clean (even in cases of cholesteatoma). It was at a later period that clearing out the tympanic cavity was included in the term.

By the radical operation (for the development of which, in its present form, we are indebted to Zaufal and Stacke) we understand the exposure not only of the mastoid cells and antrum, but of the entire tympanic cavity, including the attic (*recessus epitympanicus*) by the additional removal of the posterior and part of the superior wall of the osseous meatus. It is interesting to follow from Rheinhardt's minute description how this operation has developed step by step to the attainment of a surgically-correct procedure for the removal of infectious exudate and necrotic material. What is effected in the radical operation is nothing more than what surgeons have long done for every chronic suppurative bone affection.

After it became evident that Schwartze's operation, while reliable in acute middle-ear suppuration, was often unsuccessful in chronic cases, an endeavour was made to find a means of thoroughly exposing the tympanic cavity along with the antrum. Wolf had followed the plan of removing part of the posterior wall of the osseous meatus. Hartmann and Küster removed the whole of the posterior wall, while Bergmann added the removal of the upper wall in order to enable the tympanic cavity and the ossicles to be thoroughly cleaned out, Zaufal making the further addition of resecting the *pars epitympanica* between the antrum and the meatus. Lastly, Stacke opened the tympanic cavity directly by separating forward the cutaneous portion of the auditory canal and forming a flap from it to cover the raw bony cavity with epidermis, so as to provide a widened, instead of a too narrow, auditory canal, leading directly into the antrum and the middle ear.

Stacke's operation modified by Schwartze, Körner, and Liebermann is as follows :—

Bearing in mind the plastic character of the operation, we make the incision vertically downwards immediately behind the attachment of the auricle, dividing and ligaturing the posterior auricular artery. The periosteum is stripped forwards to the bony meatus, and backwards over the mastoid fossa, while the cutaneous portion of

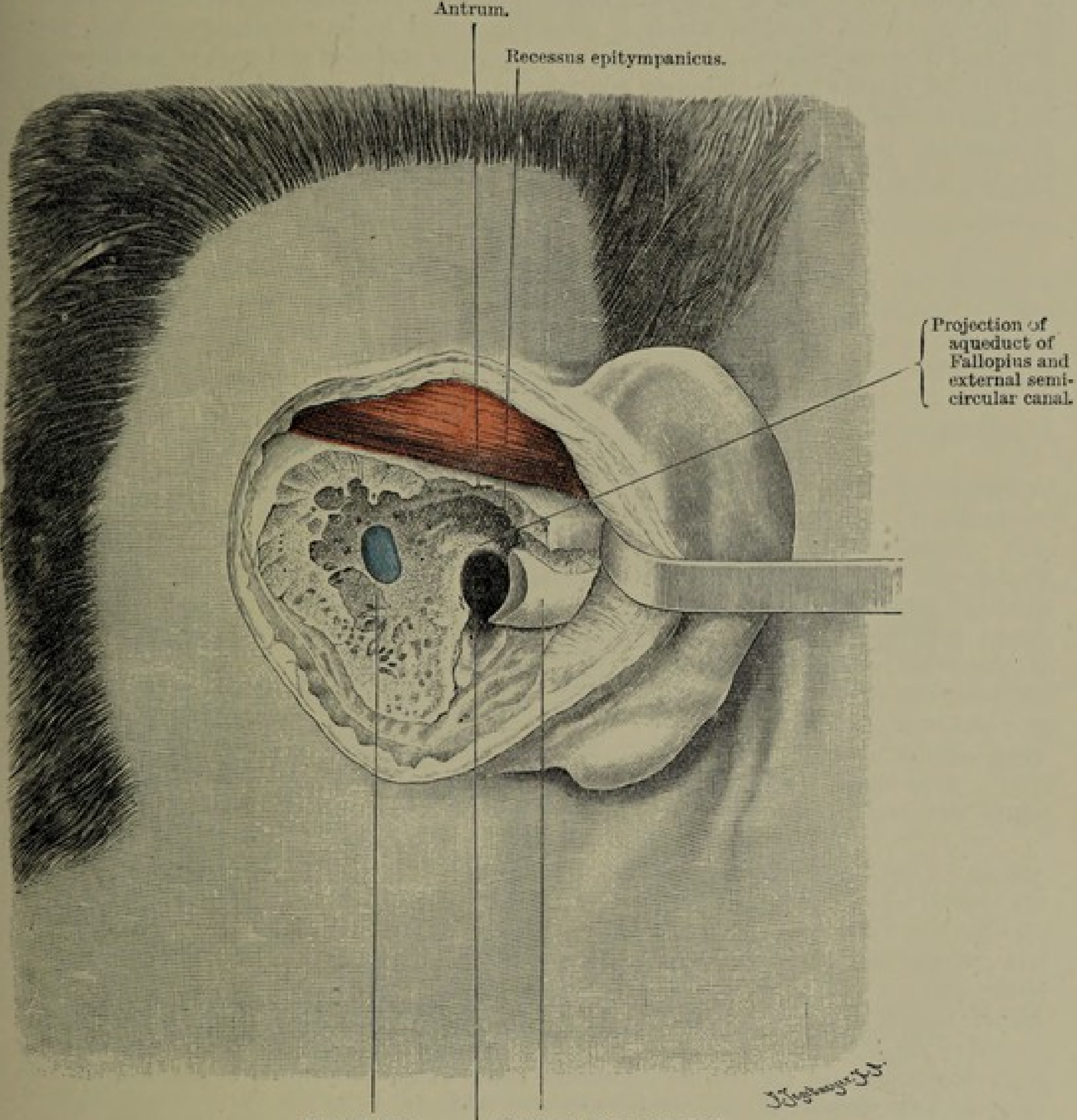


FIG. 266.—Radical operation on middle ear. The cartilage of the auricle has been divided and retracted forwards, and the mastoid process freely opened up, exposing the antrum with the tympanic attic. Immediately below the latter is seen the pale projection formed by the aqueduct of Fallopius and the external semicircular canal. The middle ear is freely exposed, the lateral sinus being seen posteriorly.

the meatus is detached with an elevator and retracted forwards with a blunt hook. Stacke divides the cutaneous part of the meatus down to the tympanum.

The mastoid cells and antrum are then exposed by applying the gouge immediately behind the external auditory meatus and below the supramastoid crest as already described.

The tympanic attic must now be thoroughly exposed and made continuous with

the middle ear and the cavity of the antrum through a wide opening bevelled downwards and outwards.

This is effected by chiselling away the posterior wall of the bony meatus, and to avoid injuring the deeply-placed external semicircular canal and the aqueduct of Fallopius immediately below it, which are recognised as two pale-coloured elevations in the lower part of the epitympanic recess, a probe is inserted into the space occupied by the membrana flaccida, which is generally found to be already perforated, and is passed from the meatus into the open antrum, the posterior and part of the superior wall of the meatus being obliquely gouged away. By this method the tympanic attic and the antrum, both of which are covered by the tegmen tympani, are exposed, and if necessary the incus and malleus may be extracted with a hook or forceps as recommended by Schwartze if they are necrosed, the stapes being left untouched.

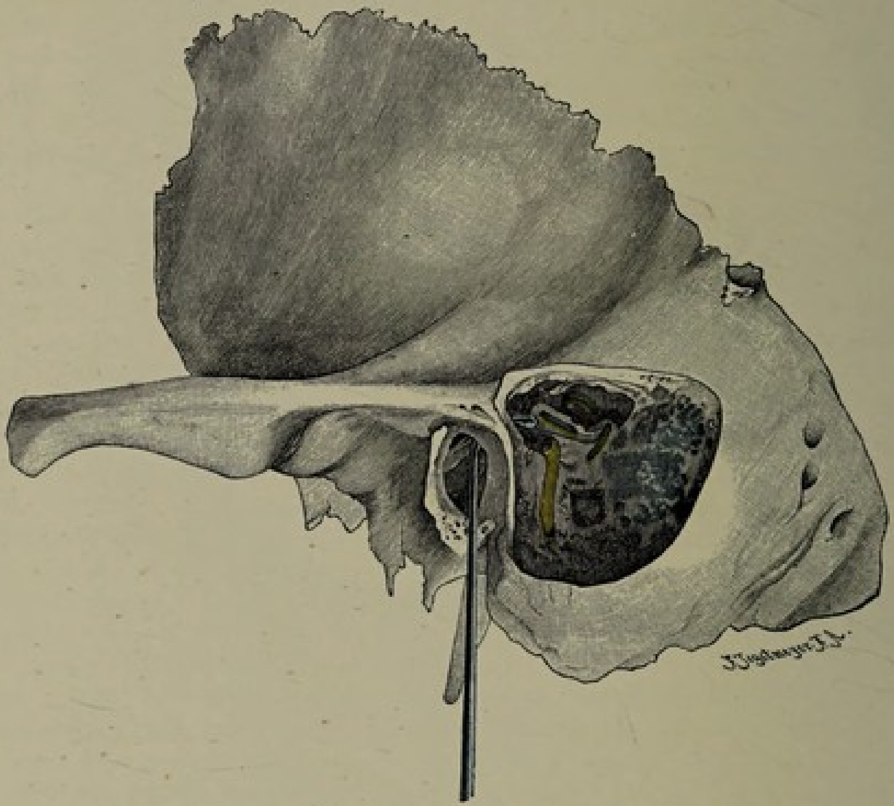


FIG. 267.—Exposure of the middle ear. The posterior bony wall of the auditory canal has not yet been removed; a probe has been passed from the external meatus through the aditus ad antrum, so that the bone above and below may be chiselled away without injury to the aqueduct of Fallopius and the external semicircular canal, which, for purposes of clearness, are here shown opened. (From a dissection by Tramond.)

When the operation has been properly performed the wound should widen out towards the surface in a funnel-shaped manner: there should be no overhanging bony edges, and one should be able to see freely into the tympanic cavity. Rheinhardt recommends that, in addition, the upper wall of the osseous canal should always be chiselled away because it contains bony cells. A grooved director is inserted beneath the cartilaginous portion of the canal, which is divided longitudinally as high up as possible. Externally the incision is carried vertically downwards along the margin of the concha so as to produce a large flap, which is turned down, fixed by a suture, and pressed backward against the raw bony surface by means of iodoform or xeroform tampons introduced from the auditory meatus. The edges of the incision are fixed with a couple of sutures, and, after a few days, if the wound runs a favourable course, they should be definitely closed by secondary suturing.

Siebenmann splits the cutaneous layer of the meatus in its long axis and carries the end of the incision upwards and downwards in form of a Y, afterwards dissecting the cartilage out of the flap and fixing the flap against the posterior wall of the bony meatus by means of one or two deep catgut stitches. By this method he obtains a wide external meatus, which leads directly down to the cavity in the bone. The wound behind may be entirely closed by means of secondary sutures. A Thiersch graft, the raw surface of which is directed outwards, may then be introduced through the auditory meatus, so that the latter may become covered over with epidermis. If a cholesteatoma is present, Siebenmann does not scrape the epithelium away but uses it as a superficial epithelial covering.

Notwithstanding the removal of the tympanum and the tympanic ossicles, the power of hearing is preserved.[1] Indeed a marked improvement in hearing often results after removal of the diseased ossicles, as the remains of the tympanum become adherent to the stapes.

18. Suppuration of the Labyrinth. In suppurative conditions of the labyrinth, characterised by nerve-deafness, giddiness, nausea and nystagmus, Milligan[2] advises that a search should invariably be made for a fistulous track leading from the middle ear, while at the same time he advocates the opening of the vestibule through the foot-plate of the stapes. A cerebellar abscess following suppuration in the labyrinth may be reached through the inner wall of the open antrum on the posterior surface of the petrous temporal.

19. The Operation in Intracranial Complications. Körner and Macewen deserve the credit of having demonstrated the method by which extensions of suppuration towards the cranial cavity are to be reached with the greatest certainty. The radical operation, or the opening of the mastoid cells, or antrum, not infrequently leads, in acute cases, down to the dura and the wall of the lateral sinus. Heimann has proposed, especially in the suppurative forms of otitis associated with severe general symptoms, or cerebral complications of any kind, that in the operation to expose the middle ear the posterior, and eventually also the middle, fossa of the skull should be opened. Much can be said for this, and one never regrets having been too thorough. When signs of intracranial disease or of sinus thrombosis exist, the skull and the lateral sinus must be opened at the site of the diseased bone. It is always the best plan to begin the operation in the manner described above, viz. by the thorough exposure of the middle ear and its accessory cavities.

By adopting this plan one follows the route which the suppuration has taken, viz. towards the middle fossa of the skull, through the tegmen tympani, and towards the posterior fossa, through the bony wall of the lateral sinus.

In this way subdural abscesses and thrombosis of the sinus are best exposed, and with the least possible damage. Free drainage must be provided for the whole extent of the abscess. In thrombosis of the sinus its vertical portion must be exposed by chiselling away the middle third of the mastoid process in its whole length as far as its apex, any bleeding from the emissary mastoid vein being arrested by a plug of wax. If the lumen of the sinus be opened, the vessel should, as recommended by E. Meyer and Withling (Trautmann), be plugged by a xeroform gauze tampon inserted between the wall of the sinus and the bone, as far down as the jugular bulb, and upwards as far as the genu of the sinus. Infectious thrombi can then be scooped out from the sinus, which should be plugged by pressure from without, or, when it is more extensively opened, should be packed with xeroform gauze.

If the thrombosis extends beyond the genu of the sinus, bleeding may take place from the superior petrosal sinus, which must then be plugged, but the thrombus must be followed into the horizontal limb. Should the thrombus extend downwards below the bulb, its lower limit must be ascertained by palpating the neck. The internal jugular vein is then thoroughly exposed and ligatured below the thrombus, the vein being slit up and the thrombus scraped out, with the object of preventing or curing the secondary bacteræmia.

20. Trephining for Cerebral Abscesses. Abscesses of the temporo-sphenoidal

[1] *Vide* Heath, *Lancet*, Dec. 1904. [2] *Lancet*, Feb. 1904.

lobe and cerebellum which cannot be directly reached from the middle ear on account of the absence of a continuous macroscopic track of suppuration, or on account of their depth, must be dealt with by direct trephining of the skull.

Trephining for temporo-sphenoidal abscesses is performed by prolonging the auricular incision (Fig. 268) parallel to the upper margin of the auricle as far as its anterior attachment. By separating the periosteum as far as the osseous auditory canal we expose the area of the squamous portion of the temporal bone above and

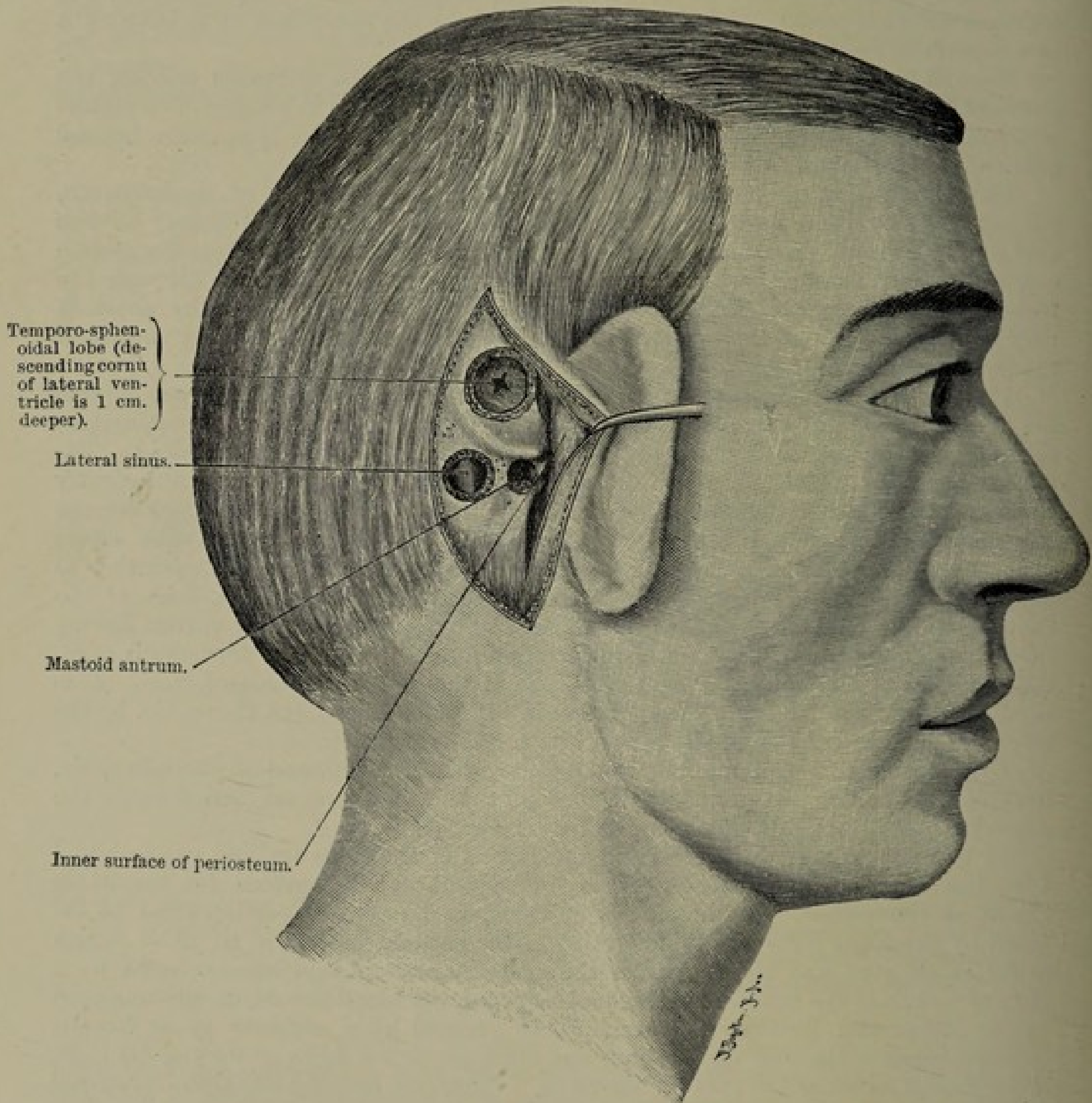


FIG. 268.—Opening the mastoid antrum and the lateral sinus. Exposure of the temporo-sphenoidal lobe and puncture of the descending horn of the lateral ventricle.

behind the ear, this area leading most certainly to the floor of the middle fossa, and by separating and lifting up the periosteum we can ascertain if an abscess exists between it and the bone. The trephine-opening lies above the posterior extremity of the temporal line, which turns horizontally forwards to form a definite ridge becoming continuous with the root of the zygoma. After division of the dura, the position of the abscess can be ascertained by palpation or puncture, should the changes in the membranes not be sufficient to indicate it. After drawing aside or ligaturing

the vessels of the pia the abscess is opened with a knife, and the opening dilated with forceps, the opening being made large enough to allow the cavity to be cautiously and thoroughly washed out. The cavity must be kept open for a few days and dusted with boracic acid and iodoform, or dressed with a xeroform tampon, the trephine-opening being stuffed with a xeroform tampon as a permanent dressing.

Trephining for an abscess of the cerebellum is performed after a previous opening of the groove for the lateral sinus, as it frequently happens that its disease forms the intermediate link in the chain of extension of suppuration. A horizontal incision is carried along the superior curved line of the occipital bone, the periosteum being separated backwards and downwards so as to expose the posterior fossa, which is opened below the lateral sinus.

(e) Surgery of the Salivary Glands

The method by which the sublingual gland is to be excised in cases of chronic inflammation, or tumour, is indicated by the position of the swelling.

21. Submaxillary Salivary Gland. In connection with the submaxillary gland it is to be observed that the incision may readily injure the cervical branch of the facial nerve to the platysma, wherefore it should not be made too high up, *i.e.* close to the border of the jaw, while, further, the platysma should be stitched separately, as we have already indicated in our introduction.

22. Excision of the Parotid. Extreme care has to be exercised in incising the parotid in cases of phlegmonous parotitis (especially the metastatic forms), because the deep incisions that are necessary may readily lead to injury of the facial nerve or to the formation of a salivary fistula. The incisions should therefore be made with careful dissection, and if possible should be in the direction of the branches of the pes anserinus. No general anæsthetic should be administered.

In the extirpation of a benign tumour of the parotid, *e.g.* lymphoma, fibroma, chondroma, myxoma, sarcoma, and the various mixed tumours, everything depends on defining the boundary between the tumour and the parotid tissue in which it is embedded, while every piece of tissue which resembles a nerve fibre should be mechanically stimulated before it is cut across, to ascertain if contraction of the facial muscles occurs. One has often to dissect out the pes anserinus entirely before the tumour can be separated.

A long vertical incision is required in dealing with malignant tumours of the parotid (sarcoma or carcinoma), beginning on the temple two fingers'-breadth above the zygoma and running vertically downwards in front of the tragus as far as a point on the anterior border of the sterno-mastoid two fingers'-breadth below the angle of the jaw. The skin is dissected up both in front and behind, and the lower border of the tumour defined as quickly as possible by incising the deep cervical fascia and exposing the anterior border of the sterno-mastoid, the external jugular vein being divided between two ligatures. If the tumour is adherent to the muscle, a portion of the upper end of the sterno-mastoid must be removed with it up to the mastoid process, where the soft parts behind the tumour are divided down to the bone. In freeing the lower border of the tumour the great vessels of the neck are exposed, the internal jugular vein being carefully isolated and any small venous branches tied.

A finger can now be passed under the tumour and the latter lifted up off the posterior belly of the digastric, which must be divided if adherent to the growth. The external carotid which is seen running upwards beneath the digastric and sterno-mastoid is readily exposed and divided between two ligatures. By this method both the styloid process with the muscles arising from it, and the anterior aspect of the mastoid process are now free. The parotid fascia in front is divided down to the masseter, and the tumour is separated from the angle of the jaw upwards, removing any adherent portions of the muscle. Not infrequently numerous veins are encountered in the cut surface of the muscle, which must be tied. At the anterior

border of the tumour below the zygoma the transverse facial artery and Stenson's duct are divided. The temporal fascia is next divided above the tumour, cutting across the superficial temporal artery and vein between two ligatures. The tumour is now freed from the zygoma above and from its anterior connections as far back as the posterior border of the ascending ramus of the jaw. If it is adherent to the joint capsule, the latter must be removed as well. No real harm results from opening into the joint. Immediately behind the joint, the external carotid divides into the superficial temporal and internal maxillary arteries, which are caught with forceps and divided.

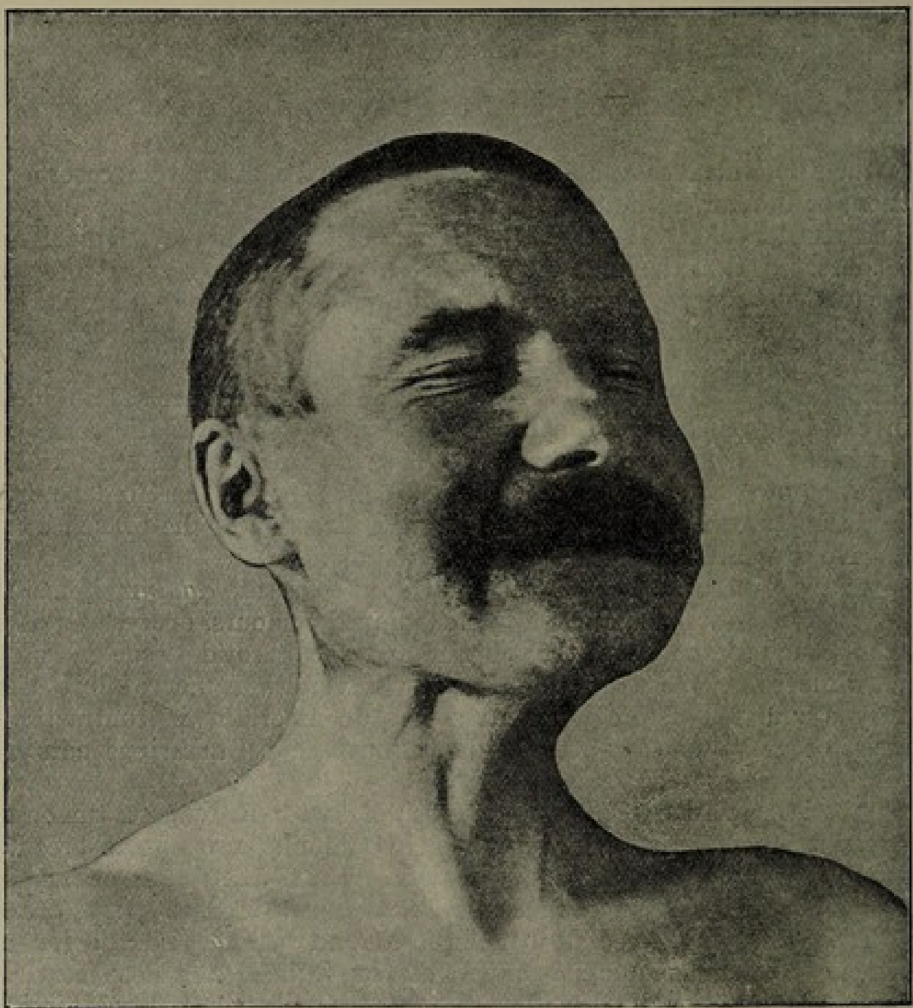


Fig. 269 shows the action of the facial muscles after the wound for splitting the cheek transversely has healed.

One has still to detach the tumour from the cartilage of the external auditory meatus, part of which may have to be removed. Any enlarged lymphatic glands along the lower border of the parotid should also be excised. If the tumour is adherent to the periosteum, a superficial layer of the mastoid process must be detached with the chisel. In this way a malignant tumour of the parotid may be successfully excised, without much loss of blood, the only serious damage being that entailed on the facial nerve, which is, of course, unavoidable.

When there are diseased glands in the neck, the incision should be prolonged down the anterior border of the sterno-mastoid as far as the omohyoid (*e.g.* in malignant disease of the tongue), and a second incision carried forwards in the fold between the floor of the mouth and the neck (*vide* our normal incision for the superior triangle of

the neck), with a thorough dissection of the glands below the jaw and beneath the sterno-mastoid.[1]

(f) Surgery of the Mouth and Pharynx

The structures in the mouth and pharynx can also be rendered accessible without osteoplastic resection of the lower jaw. An excellent method is by a *transverse*

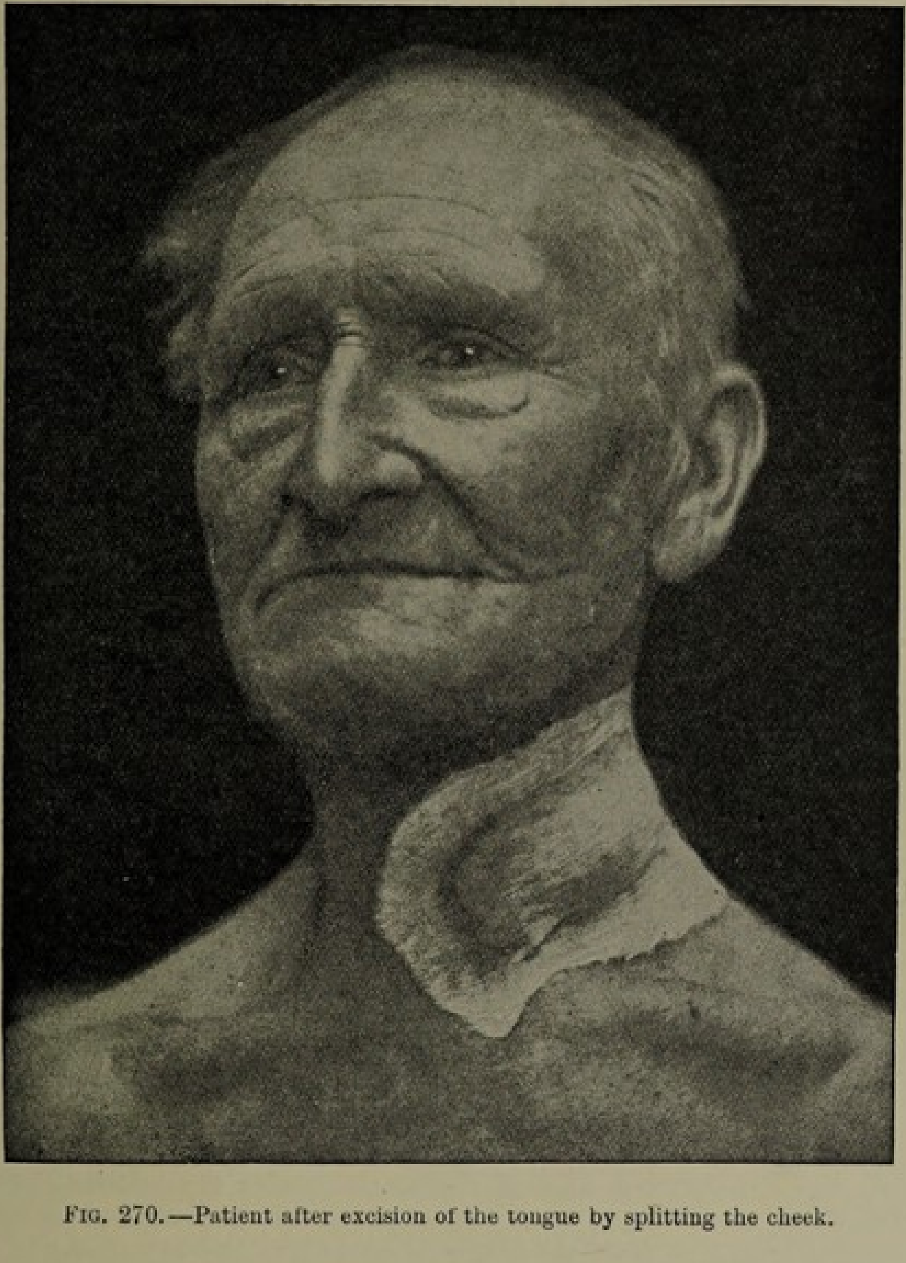


FIG. 270.—Patient after excision of the tongue by splitting the cheek.

incision through the cheek (Fig. 270), as recommended by Roser for exposing the lingual nerve; the incision extends from the angle of the mouth transversely backwards, parallel to the branches of the facial nerve, as far as the masseter, dividing skin, orbicularis oris, buccinator, and mucous membrane. Although the scar tends to become drawn in by contraction, the resulting deformity is inconsiderable (Fig. 269), because the play of the features is in no way diminished, as the branches of the facial

[1] Bedardo and Leriche (*Rev. de chir.* Bd. 12, 1906) recommended resection of the posterior border of the ascending ramus of the jaw, including the condyloid process to ensure total resection.

nerve have been preserved. *Stenson's* duct and the transverse facial artery lie above the incision, but the facial artery is divided and requires two ligatures. Krönlein has employed this incision in his retrobuccal method for resection of the trigeminal nerve, but he does not split the angle of the mouth.

As it is often necessary to obtain free access to the structures of the mouth and upper part of the pharynx up to and including the isthmus of the fauces, it appears to us to be a much better plan to make a mesial incision through the lower lip, jaw, and floor of the mouth. Sédillot had already employed it to a certain extent in excising the tongue, but we have made much more extensive use of it. When properly carried out it gives excellent access, is quite bloodless, does not leave the slightest disfigurement, and not even a temporary disturbance of function. It is important that the dissection be made exactly in the middle line between the genio-hyoids and genio-hyo-glossi. The mucous membrane of the floor of the mouth, on the diseased side, must be divided sufficiently far back to allow of thorough separation of the halves of the jaw. We use for this purpose an ecarteur of our own (Fig. 271). Subsequently the jaw must be firmly united with wire sutures, so that movement may be begun at an early stage. A periosteal suture is unnecessary.

Fig. 271.

If occasionally healing is delayed by slight necrosis, the function of the jaw is during this time not interfered with.

23. Incisions into the Tongue and at the Floor of the Mouth. These are only to be made after thoroughly opening the mouth by the introduction of a suitable gag, and after drawing forward the tongue by means of a silk loop carried deeply through it in the mesial sagittal plane. A considerable degree of anæsthesia is necessary before the mouth can be satisfactorily opened, especially in closure of the jaws caused by inflammation or by other painful infiltration of the soft parts between the upper and lower jaws, or in connection with the latter. Incisions may be made upon the dorsum of the tongue without fear of injuring the larger branches of the vessels and nerves, and whenever practicable, the middle line should be selected, as causing least injury.

The larger vessels, namely, the lingual and sublingual arteries and veins, the hypoglossal, lingual, and posteriorly the glosso-pharyngeal nerves, along with *Wharton's* duct and the ducts of *Rivini*, lie laterally and at the floor of the mouth, so that the nearer the incision is kept to the jaw the more certain are all those structures to be avoided. The lingual vessels and nerve may be exposed close to the edge of the tongue, under the inferior lingualis and upon the outer aspect of the genio-hyo-glossus. Farther back the artery is covered by the hyo-glossus. Near the tip the vessels wind towards the under surface of the tongue. Prophylactic ligature of the lingual artery is to be recommended when there is danger of severe hæmorrhage following incisions into the tongue.

24. Excision of the Tongue from the Mouth. The same method of excision may be applied to simple tumours as well as certain malignant tumours (preferably carcinoma) if the latter are circumscribed on all sides and movable. In the case of malignant tumours, however, a thorough removal of all the glands must always be made in addition.

The question then presents itself: What is the limit at which one may under-

take the removal of a carcinoma of the tongue from the mouth without a preliminary operation being required? Innocent tumours can be removed from the mouth with few exceptions.

The answer is: The tumour must be freely movable on the jaw and the floor of the mouth, and must be so placed that after the application of Museux's forceps, one can cut through healthy tissue behind it, with complete control over the bleeding. Under these circumstances the operation can be designated "the early operation for cancer of the tongue."

If we consider the permanent results of excision of the tongue for cancer, one is driven to the conclusion that, despite improvements in technique, the tongue is an organ in which the least gratifying results are obtained. The immediate mortality has, however, been greatly diminished. Between 1872 and 1889 we operated on 69 cases of cancer of the tongue, the results of which were published by Dr. Sachs. Between 1890 and 1903 our operations numbered 62 more. These cases have been followed up by Dr. Boissonaz, and the results will shortly be published in detail.

The latter series included many more advanced and difficult cases. In only 10 could the operation be performed from the mouth without a preliminary operation, while in 13 the cheek had to be split transversely; in 23 the jaw was divided in the middle line, in 4 laterally, while in 3 cases it had to be partially resected. In 7 cases complete excision of the tongue from its root was undertaken.

Of those operated on from the mouth none died; and of those in which the cheek was split one died of retro-œsophageal abscess with pleurisy and pericarditis; while of the complete excisions only one died—of pneumonia. It will therefore be observed that the operation is only exceptionally fatal, two deaths in 30 cases representing a percentage mortality of 6·6. Of the cases in which the jaw was split in the middle line 4 died, and of those in which it was divided laterally 2 died, thus giving a mortality of 14·51 per cent in the complicated cases.

We were able to obtain the subsequent history in 57 of the 62 patients. Only 5 may be regarded as radical cures, a sufficiently long interval having elapsed. In one case recurrence took place after three years, in another after ten years. Six patients who have been under observation for less than three years are in perfect health up to the present time, so that if we regard all these 6 cases as cured, our statistics as regards radical cure would be 22·8 per cent, but in absolutely certain cases, *i.e.* up to seven years 16·2 per cent have remained free of recurrence.

The importance of early operation is shown by the fact that 40 per cent of the permanent cures of lingual cancer were in cases where the operation was performed through the mouth with or without splitting of the cheek.

These results are by no means ideal, and we believe that, apart from the great importance of early operation,[1] this is largely due to the distribution of the lymphatics from the tongue which is specially favourable to the dissemination of the cancer elements. Küttner and Poirier state that the lingual lymphatics drain into very different lymph gland territories in the neck, those from the tip of the tongue leading to the suprahyoid glands which are situated in the middle line above the hyoid bone and often into glands still lower, and those from the margins of the tongue going to the lymphatic glands around the submaxillary gland in the digastric triangle; those from the centre and edge of the tongue proceed to the bifurcation of the carotid, more especially to a definite gland at the lower border of the posterior belly of the digastric, finally communicating with the chain of glands surrounding the sheath of the great vessels as far as the crossing of the omohyoid muscle. A gland of larger size occupies the angle between the omohyoid and the sterno-mastoid, *i.e.* "the omohyoid gland," and it is singularly liable to infection, of the existence of which gland we are convinced not only by Poirier's admirable injected dissections, but by our own experience.

[1] One has only to look at Butlin's results from very early operations to be convinced of how decisive this factor is: out of 14 cases 10 were free from recurrence after three years, while 4 had died of recurrence in glands.

We were recently able to observe the results of early operation in several cases in which no local recurrence took place, but in which large cancerous masses had developed in the glands at the angle of the jaw on both sides, no glands having been removed at the operation.

There is still another point which must be referred to in connection with the radical operation for cancer of the tongue, viz. that the glands on both sides of the neck may be affected. A short time ago we saw, along with Poirier, a man in whom a small epithelioma had been removed from the edge of the tongue, and in whom Poirier had thoroughly removed all the glands on the same side of the neck. There was no recurrence either on that side of the neck or in the tongue, but a large glandular swelling appeared a year after operation below the angle of the jaw on the opposite side.

What, then, is to be regarded as the ideal operation in the early stage of cancer of the tongue? The ideal operation consists in an excision of the tongue through healthy tissue, while the glands in the middle line and on both sides of the neck must be systematically removed in every case. The following is a description of the method modified by Poirier, which we regard as the best, and which we have adopted in the case of circumscribed tumours at the margin of the tongue.

An incision is made along the whole length of the anterior border of the sterno-mastoid, dividing skin, platysma, fascia, and also the transverse cervical nerve, and either avoiding or dividing the external jugular vein and the great auricular nerve. The muscle is drawn backwards and the great vessels are exposed. The omohyoid gland is next looked for at the point where the omohyoid muscle crosses the vessels, and is separated, after which the whole chain of glands is dissected up in one mass along the sheath of the vessels as far as the posterior belly of the digastric, the operator being careful to avoid the descendens hypoglossi nerve. Only small branches of the internal jugular vein require ligature.

At the upper end of the incision the glands are dissected out as high as the lower border of the parotid, the spinal accessory nerve, if not involved in the glands, being preserved.

A second incision is then made in the region of the bifurcation of the carotid following the line of our normal incision for the neck, *i.e.* from the mastoid process to the body of the hyoid bone. The skin is dissected up, the external jugular and some smaller veins are ligatured, and the flap is retracted upwards over the edge of the jaw, after which the suprahyoid glands lying in the middle line between the two anterior bellies of the digastric muscles are sought for.

The submaxillary gland is now separated from below along with the enlarged lymphatic glands which are often in close contact with it both in front and behind, a gland between the angle of the jaw and anterior border of the internal pterygoid muscle being carefully dissected out, the facial vessels clamped above and the sub-maxillary fossa thoroughly cleared. The facial and a few smaller veins are then tied and divided.

Finally, the external carotid artery, round which the hypoglossal nerve is seen to hook, is ligatured above the origin of the superior thyroid artery, allowing the operator later on to excise a carcinoma on this side of the tongue through the mouth with practically no resultant bleeding.

After a short interval the glands on the opposite side are removed in a similar manner without, however, ligature of the carotid. Poirier has occasionally seen swelling of the face from interference with the lymphatic flow follow operation on both sides, a result which may be obviated by operating in two stages.

Having removed the glands on the affected side, we remove a growth which is circumscribed and easily accessible, by the following method:—Under continuous anæsthesia, and with the mouth kept open by Whitehead's gag (which is least in the way and retains itself in position), the tongue is drawn forcibly forwards with a pair of tongue-forceps and the mucous membrane divided 1 cm. wide of the growth. By beginning the incision on the floor of the mouth, one is able to expose the vessels and nerves at an early stage, and to ligature those entering the portion of tongue to

be removed. The part to be excised is pulled forwards with Museux's forceps, which firmly grasp healthy tissue, and after defining the edges of the induration with the finger, we freely remove the growth by cutting with scissors or knife fully 2 cm. from its margin. As the carotid has been tied the bleeding is very slight, so that only a few pairs of forceps need be applied.

Before excision of the growth, however, it is convenient to transfix the tongue immediately in front of and behind the line of incision with two loops of silk, so that when the latter are tied it is easy to unite the edges of the wound with a deep continuous suture. A second superficial suture is then inserted to bring the epithelial edges into accurate contact, for which purpose Socin's aluminium bronze wire can be conveniently utilised.

It is unnecessary in the case of small growths to ligature the external carotid. Small-sized ulcers can be excised without either pain or hæmorrhage under local anæsthesia (novocain and adrenalin). Five minutes should elapse before the incision is made in the tongue. A 1 per cent solution of novocain should be used, to a gramme of which 1 min. of adrenalin has been added.

Heidenhain also strongly advocates extensive excision of the glands in cancer of the tongue as well as in cancer of the lip and other parts of the face, performing the whole operation in one stage. To ensure against local recurrence he makes a point of dividing the tongue transversely even when only one side is affected, the patients regaining the use of the muscles of the root of the tongue and floor of the mouth in a remarkable manner.

On the other hand, we have seen a number of cases where local recovery after circumscribed excision was complete, but where fatal recurrence took place in the glands. Even routine division of the whole breadth of the tongue, leaving its base and the floor of the mouth, can certainly not be regarded as a radical removal of the disease in very many cases.

To confirm this statement, one need only examine the results obtained by Butlin, who does not perform a complete excision in circumscribed cancers of the tongue. Of 14 cases, 10 were free from recurrence after three years, while 4 died from recurrence in the glands. In 38 cases where the disease recurred in our practice, in only 9 did it recur locally.

25. Operation for Advanced Cancer of the Tongue. When a lingual cancer can no longer be removed from the mouth without a preliminary operation, simultaneous removal of the primary tumour and the glands is to be avoided, because infection of the large wound in the neck will almost certainly occur and interfere with recovery.

Difficult excisions of adherent glands have the disadvantage that they involve cutting across numerous vessels, both arteries and veins, as a result of which the nutrition of the tissues in the corresponding areas of the mouth and tongue is impaired, and the edges of the wound undergo more sloughing than if one waits for the re-establishment of collateral circulation.

If the excision of the glands is undertaken secondarily, the glands are often found to be enlarged by inflammatory infection from the mouth, thus increasing the difficulty of the operation, and frequently necessitating its postponement.

It is preferable first of all to clear out the glands on both sides of the neck, as already described, and then, after the wound is healed (which, despite its size, may occur in the course of a week) to undertake the excision of the tumour in the tongue eight days later.

If the wound is to be kept free from serious infection, and if aspiration-pneumonia is to be prevented, it is essential to have the teeth, mouth and pharynx thoroughly cleansed by scraping away all tartar, by extracting all bad teeth, and by cauterising all ulcerating patches, an anæsthetic being often required to effect this when the mouth cannot be fully opened. Small abscesses and collections of decomposing matter in the crypts of the tonsils should be disinfected after their cavities have been carefully split up.

We would lay stress on the importance of not injuring the mechanism of swallowing more than is necessary, *i.e.* the muscles of the floor of the mouth, tongue and

pharynx, with their nerves of supply. Further, free escape must be provided for the discharge and secretions from the mouth. It is only by careful attention to these two points that the danger from decomposition of the exudation from the wound can be reduced to a minimum. Again, the remarks we have already made about the half-sitting position the patient is to occupy during the operation, and as long as he is in bed, must be carefully attended to.

We still prefer to use the thermo-cautery to divide the muscles, in order to limit the primary infection of the freshly cut surface.

On the other hand, we no longer pack the larynx or perform a preliminary operation to control the hæmorrhage, this constituting an important advance in our present procedure. The great advantage of a tracheotomy is that the administration of the anæsthetic is simplified. We give ether by the drop method after having administered tea and brandy and a hypodermic injection of morphia half an hour beforehand.

Our "normal procedure" now consists in dividing the jaw in the middle line in all cases where the cancer extends as far back as the isthmus of the fauces, and where it has involved the arch of the palate, the fold passing to the upper jaw, the walls of the pharynx, and the soft palate. The division is performed by a modification of Roux and Sédillot's method. It can be effected with a minimum of bleeding, and gives ample room, if properly carried out, to expose and remove even pharyngeal cancer in the region of the isthmus of the fauces. No real injury is done by this method, as the jaw is sutured back in position, and movements can be performed at once without pain. The incision through the lip, if carefully sutured, leaves a hardly perceptible scar. The method has the following advantages:—The hæmorrhage is very slight, as it is more effectively controlled; the secretions of the wound are drained away in front of the hyoid much more satisfactorily; and, what is most important to our mind, by preserving the muscles of deglutition along with their nerves a better functional result is obtained than by any other method. This non-interference with deglutition is of the greatest importance in preventing secondary aspiration-pneumonia, the greatest danger which threatens the patient. It is astonishing to see how patients can swallow on the same day, on the following, or at most the third day after this operation, and hence they are able to get rid of the wound secretions and prevent their entry into the larynx.

We will take as an example a carcinoma situated far back on the side of the tongue, involving also the floor of the mouth, the anterior pillar of the fauces, the soft palate, and the lateral wall of the pharynx. The operation is performed in the following manner:—An incision is made in the middle line through the lower lip down to the bone, and extending as far as the hyoid bone, the lymphatic glands in the region of the middle line being removed and forceps applied to the divided vessels in the lip. Two holes are then drilled, without detachment of the periosteum, through the jaw on either side of the middle line, and the latter is sawn through in the interval between the first and second incisors on the affected side, a fine saw being used so that the attachments of the genio-hyoids and genio-hyo-glossi to the genial spines are left intact. Sharp hooks are inserted into the sawn surface, the mylo-hyoids and digastrics are separated in the middle line and the outer surface of the genio-hyoids and genio-hyo-glossi is reached. The two halves of the jaw are then held forcibly apart with our ecarteur shown in Fig. 271.

The tongue is drawn out of the mouth and towards the healthy side by means of a loop of silk passed through it. If this cannot be done owing to the extent of the disease it must be raised up with a finger passed behind the root of the tongue. The mucous membrane of the floor of the mouth is then divided backwards, as it tears close to the jaw if it is pulled on too much. This exposes the lingual vein, running backwards and outwards across the lateral surface of the hyo-glossus muscle, and the lingual nerve passing forward close to the edge of the tongue immediately under the mucous membrane. The hypoglossal nerve is seen crossing the outer surface of the hyo-glossus and then passing forward towards the middle line, to enter the muscular fibres of the genio-glossus. The lingual artery passes forward and

upward between the hyo-glossus and genio-hyo-glossus ; it is clearly visible and can be easily ligatured at a later stage. The hyo-glossus is divided [1] and, as in all muscular

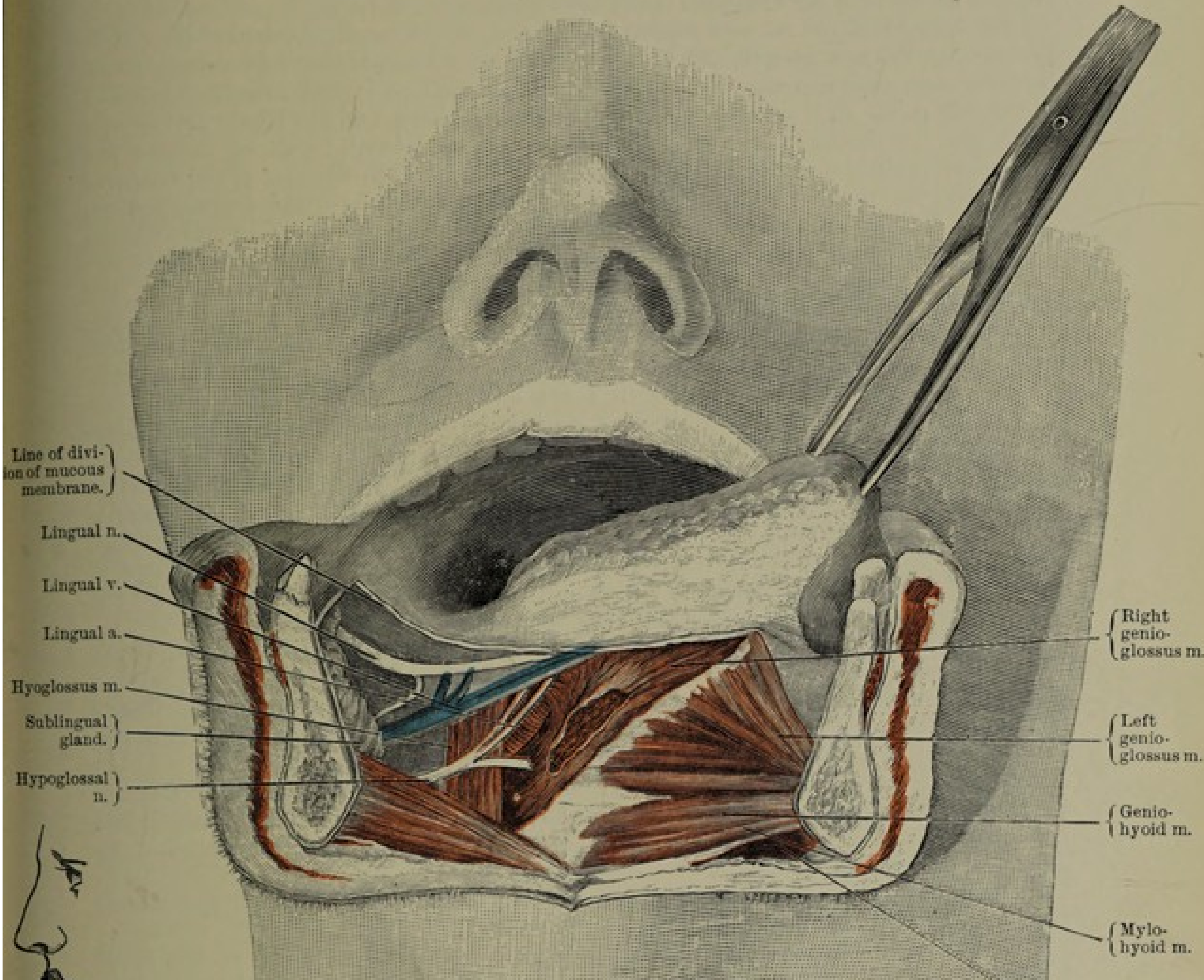


FIG. 272*a*. FIG. 272*b*.

FIG. 272*a* illustrates the incision by which the lower lip and chin are split in the middle line down to the hyoid bone.

FIG. 272*b*.—Our normal operation for advanced cancer of the tongue. The lower jaw has been split in the middle line, and the right genioglossus separated from it (as a rule we divide the muscle behind at a distance from the tumour). The mucous membrane has been divided along the side of the tongue as far back as the anterior pillar of the fauces, and the tongue (along with the tumour) detached from the jaw and forcibly pulled over to the left.

incisions immediately outside the limits of a new growth, is cauterised, a procedure which improves the prognosis by aiding in the complete removal of the disease. The

[1] All incisions should be made through healthy tissue, but as near the seat of the disease as possible to retain the greatest number of muscles and nerves.

tongue is then firmly dragged forward, and the mucous membrane far back is likewise divided with the cautery well away from the tumour if it has involved the palate and pharynx, while the stylo-glossus muscle, which is visible, and the glosso-pharyngeal nerve lying alongside it are both divided.

By division of the mucous membrane in front of the tonsil, the latter, even when invaded by the new growth, can be separated with a blunt instrument passed round its outer side, thus exposing the surface of the internal pterygoid muscle. As much of the soft palate as is affected is divided with the cautery, and the tensor and levator palati are cut through, the mucous membrane on the posterior wall of the pharynx being then divided down to the longus colli and anteriorly to the root of the tongue.

Lastly, the tongue is cut through, where it is healthy, with the thermo-cautery, and the nerves, muscles and vessels (previously ligatured) are divided on the under surface before they pass into the region of the new growth. The nerves and muscles are preserved as much as possible, in order not to interfere with the mechanism of swallowing more than is necessary.

Xeroform is rubbed into the cut surfaces, but only in a thin layer, so as not to produce toxic symptoms if swallowed. The two halves of the jaw are then approximated, and holes are bored with a drill a few millimetres from the edge of the sawn surfaces (if it has not been done before section of the jaw), the drill being pushed through the deeper soft parts in the manner Albert Kocher has described for making an exploratory puncture of the brain, without separating the periosteum, strong silver wire being pushed through, and the edges of the jaw firmly united. An opening is left a little above the hyoid bone at the posterior end of the incision, into which a strip of xeroform gauze is inserted. Bismuth paste is smeared over the line of suture. The patient is allowed to sit up next day, and may try to swallow a little tea or wine and water. Nourishment may be given through a stomach tube.

As mentioned before, this method of excising the tongue has the advantage that it can be employed whatever be the situation and extent of the disease, provided the jaw is not involved, and it can be performed with the patient in Trendelenburg's sloping position with complete anæsthesia and without a preliminary tracheotomy. It gives the best access and causes the minimum of injury.

26. Excision of the Tongue with simultaneous Resection of the Central portion of the Jaw. When the tumour has invaded the floor of the mouth and cannot be moved on the jaw, a portion of the bone corresponding to the extent of the adhesion must also be removed.

The following is a description of the method to be employed when the central portion of the jaw has been invaded from the floor of the mouth.

The lip is split in the middle line, the incision being carried down to the hyoid bone, and the skin and mucous membrane are separated on one side until a healthy portion of the jaw is reached, after which the bone is cleared of the soft parts and divided with a saw. By pulling the jaw forcibly downwards with a sharp hook, the floor of the mouth can now be examined in its whole thickness, and the limits of the new growth defined, before dividing the soft parts. Vessels and nerves can also be seen and secured before they are cut, after which the separation of the floor of the mouth is proceeded with.

The skin on the opposite side is next dissected back and the jaw divided through healthy bone in precisely the same manner. The floor of the mouth can now be divided laterally on this side, care being taken to keep wide of the disease. Finally the muscles in the middle line are divided and the dissection is carried from below into the tongue which is then cut across through healthy tissue without any resultant bleeding.

It has been our recent invariable practice to replace the portion of the jaw resected with a mould (consisting of a piece of a mandible), a method which renders swallowing possible and reduces the discomfort of the patient to a minimum.

27. Excision of the Tongue where there is Lateral Disease of the Jaw. If the cancerous growth has extended beyond the limits of the tongue and has invaded the floor of the mouth and jaw, then the nature of the interference will be so much influenced by the seat of the disease in the bone that the above normal procedure

must be departed from. If recurrence is to be prevented any adherent portion of jaw must always be freely removed. *Resection of the jaw* has been employed by many surgeons as a preliminary to the removal of extensive carcinoma of the tongue, and one would begin with this when the indications for resection are clearly present. When, however, this is not the case, we still maintain that in an extensive carcinoma of the tongue the method of extirpating the organ from its base as proposed by us is the preferable procedure.

Resection of the Tongue at its Root

This operation has in these circumstances the following advantages as compared with other operations (1) because it gives the best access, (2) because it permits of the simultaneous removal of the glands as well as all the tissue which intervenes between them and the primary seat of disease,[1] (3) because it admits of preliminary ligature of the lingual or external carotid arteries, and (4) because it allows at least the anterior attachments of the muscles of the floor of the mouth to be preserved. Von Givel has by comparisons established the advantage of this method.

According to the very exact records of our former assistant, Dr. Sachs, we have only lost one out of twelve cases; and out of five patients who remained free from recurrence seven years after operation three were operated upon by this method.

The incision begins below the mastoid process and extends along the anterior border of the sterno-mastoid, and then forwards along the crease between the floor of the mouth and the neck to the middle line, and, lastly, upwards to the lower border of the jaw. In cases where the extent of the carcinoma is limited, it need only correspond to the middle two-thirds of this incision, *i.e.* from the sterno-mastoid as far as the hyoid bone. After the subcutaneous veins have been ligatured, the flap thus formed is dissected up and fixed with a suture to the cheek. Next comes the removal of all enlarged glands under the upper end of the sterno-mastoid and beneath the angle and the body of the jaw. The anterior border of the sterno-mastoid is exposed as far down as the sheath of the large cervical vessels and the greater cornu of the hyoid bone. All the glands on the sheath of the large vessels (often extending far downwards) are excised, after the vessels proceeding to them have been ligatured.

If the carcinoma has involved the floor of the mouth, the pharynx, or the jaw, it is best to ligature at once the external carotid after ligaturing the facial vein at the anterior border of the sterno-mastoid. The anterior belly of the digastric is then exposed as far as the hyoid bone, the veins running underneath having been ligatured, after which the bunch of glands is freed below, and raised up until the entire length of the posterior belly of the digastric and the stylo-hyoid muscles are exposed in the posterior and lower part of the wound. The facial vein and the facial artery, which are put on the stretch when the submaxillary gland is turned upwards, are ligatured. The salivary and lymphatic glands are then reflected up over the border of the jaw and freed from their connections on the outer surface of the jaw, during which procedure the facial artery and vein must again be ligatured.

The lingual artery is easily exposed and ligatured by dividing the fibres of the hyo-glossus muscle a little above the posterior part of the greater cornu of the hyoid bone. The hypoglossal nerve and lingual vein, which lie upon the outer surface of the muscle, are to be preserved.

The outer surface of the mylo-hyoid muscle is now exposed, with its nerve lying on it. Above the mylo-hyoid muscle the mucous membrane is felt. After we have investigated the limits of the new growths the mucous membrane is incised from the mouth, cutting upon the finger. From the opening the mucous membrane is further divided beyond the tumour, artery forceps being applied to the more important bleeding vessels of the mucous membrane. Further hæmorrhage is readily arrested by dragging forward the soft parts by means of the finger introduced through the wound in the mouth.

[1] The glands lower down and those on the opposite side must be removed later on.

It is now an easy matter to define the anterior and posterior limits of the tumour as well as the extent to which the jaw is involved, and to remove the latter with the keyhole saw.

The tongue is detached from the hyoid bone and all infiltrated tissue removed, any hæmorrhage being readily and securely arrested. The tongue can be well drawn out through the floor of the mouth as soon as the mucous membrane has been divided.

If, in order to facilitate the administration of the anæsthetic, a preliminary tracheotomy has been performed, the entrance to the larynx is at once plugged with sterilised gauze introduced from the pharynx. A morphia injection is here clearly indicated to assist the action of small doses of the chloroform, the morphia being administered a quarter to half an hour before the anæsthetic, $\frac{1}{5}$ grain for strong and $\frac{1}{6}$ for weak individuals.

The after treatment is to leave the wound open so that the entrance to the larynx may be plugged with sterilised moist (salt solution) gauze, which is to be frequently changed, a carbolic or sublimate gauze dressing being applied over the wound, and the patient fed with a tube each time the wound is dressed.

As long as swallowing is much interfered with the patient must remain in the sloped position with the head and neck dependent.

28. Excision of a Carcinoma of the Base of the Tongue. The root of the tongue and hyoid bone can be reached by dividing the jaw in the middle line, if at the same time the anterior pillars of the fauces are divided close to the tongue.

In cases of cancer of the tongue which are not accessible from the front, *i.e.* cancer of the root of the tongue, between the isthmus of the fauces and the hyoid bone, the most suitable and least injurious method to employ is subhyoid pharyngotomy, or even suprahyoid pharyngotomy. The patient being anæsthetised, and a low tracheotomy performed, the epiglottis is then exposed by the previously-described incision through skin and muscles, along the lower border of the hyoid bone. If the epiglottis is involved, the mucous membrane is divided along the upper border of the thyroid cartilage, the epiglottis is then hooked forward, and the mucous membrane on either side is divided.

The finger is now passed on to the base of the tongue, and the mucous membrane of the pharynx beyond the disease is drawn forward and divided. As soon as the pharynx is opened, the mucous membrane is anæsthetised by swabbing it with 1 per cent novocain and adrenalin (1 drop of adrenalin in 1 g. of the solution) to prevent reflex retching and coughing. It is advisable to plug the larynx if severe venous bleeding occurs, for then the dependent position is no longer required. If the disease has spread forwards into the tongue, and especially if the hyoid bone is involved, it must be split (Sallas and Esmarch). The healthy muscles on its upper surface are then divided after the vessels (especially the veins) have been ligatured, and the deep cancerous infiltration of the tongue is reached, and can be attacked from in front and behind. The lingual nerve, which is exposed on the lateral aspect of the tongue, must be divided if it is seen to enter the growth; if not, it must be freed, the vessels being similarly treated. The muscles and other tissues are then grasped with artery forceps and divided, so that the back part of the tongue can be pulled into the wound, and the organ divided transversely in front of the disease with the thermo-cautery. By this method we recently removed an extensive carcinoma which involved the whole of the base of the tongue, and had infiltrated the right wall of the pharynx and epiglottis. The bleeding was not severe, and the various structures could be well observed as they were divided.

The after-treatment consists in the free application of iodoform while the wound is kept open and packed, this being the only means of preventing aspiration-pneumonia.

When a carcinoma involves the whole breadth of the root of the tongue, there is a risk of resulting local necrosis of the remains of the tongue after excision, and decomposition and consequent sepsis may prove fatal. It is advisable, therefore, to extirpate the whole tongue, whenever its nerves and vessels have been injured laterally. In this case it is better not only to split the jaw in the middle line, but to divide the

hyoid bone into the thyrohyoid membrane, preserving the mucous membrane of the floor of the mouth as far as the condition of the growth will allow, and then, after slitting the tongue and holding the two halves apart, to decide how far the operation must extend in order to remove the disease completely.

This free median incision affords the best opportunity of dissecting towards the sides of the tongue where the vessels lie, with the least possible damage, and of carrying out thorough open-wound treatment.

29. Operation for Cleft Palate. A notable advance has been made in the treatment of cleft palate since the introduction by Wolf of the two-stage operation, which is more likely to succeed, especially in infants and in cases where the tissues are scanty. The muco-periosteal coverings of the hard palate are separated through two short incisions near the teeth, and the flaps are prepared for union by dividing the muscles laterally in the soft palate. Four to five days later the edges of the flap are united. The separated flaps readily adhere at first, and become well-vascularised and somewhat thickened, while there is the further advantage that the bleeding at the second operation is very insignificant, so that the stitches can be inserted securely and are less likely to cut out, and the child is subjected to less pain as the result of the operation.

The procedure is as follows:—Chloroform is administered, the head being dependent (ether anæsthesia is not satisfactory as it is more frequently interrupted). An incision is carried from behind forwards down to the bone near the roots of the teeth, the bleeding being controlled by pressure with the finger, after which the mucous membrane and periosteum are separated with an angled elevator. This should be done very freely, so that one can easily raise the edges of the cleft with a sharp hook and approximate them in their whole length. Division of the tensor palati on both sides close to the hamular process greatly facilitates this procedure. Gely's half-wire suture can be used with advantage (Bunge). Any smart bleeding is controlled by pressure with the finger.

30. Tonsillotomy. In tonsillotomy an injury to the internal carotid artery is, according to Zuckerkandl, not easily produced, as the artery is separated from the pharyngeal wall by the stylo-glossus and stylo-pharyngeus muscles. The tonsillar artery, on the other hand, which usually springs from the ascending palatine, may bleed severely, because it is adherent to the lower wall of the capsule of the tonsil and cannot retract. In such a case it may be necessary to ligature the external carotid.

The operation may be performed under local anæsthesia, the novocain and adrenalin solution being injected into the base of the tonsil. In simple hypertrophy of the tonsil it is not necessary to remove the whole tonsil, as only the projecting portion need be excised. In the case of malignant disease, however, it is quite different. The simplest method is to use a tonsillotome. When very severe bleeding from the tonsil occurs, Nicoladoni has suggested (Burkhard) going in above the digastric and stylo-hyoid through the posterior part of our normal incision in the neck, the operator exposing the bleeding vessel and after division of the stylo-glossus excising the tonsil from without, with subsequent closure of the wound.

31. Excision of Tumours of the Tonsils. We have lately had occasion to operate on two cases of carcinoma of the tonsil, both of them making an uneventful recovery, so that we regard the operative procedure employed as having largely influenced the result.

It appears to us important that the secondary glandular growth should not be removed at the same time. One of the patients had a hard swelling, irregular in outline, scarcely movable, and as large as two fists, situated on the left side of the neck. This was completely excised right down to the vertebral column by an angular incision with excision of the sterno-mastoid, the common jugular vein along with all the nerves, with the exception of the vagus, the phrenic, and the brachial plexus, the carotid being preserved.

The wound healed by first intention, and fourteen days later the primary sarcoma of the tonsil was excised from the mouth by splitting the cheek transversely.

If the tongue be dragged out by means of a suture passed through it, the tumour can be cut out with the thermo-cautery without any excessive bleeding, cocaine being injected into the tissues round the growth.

In the other case the access obtained by dividing the cheek transversely was not sufficient as the tumour had spread so far. We (Dec. 1899) divided the jaw in the middle line, split the muscles mesially and the mucous membrane of the floor of the mouth close to the tongue, in order to be able to forcibly separate the two halves of the lower jaw. The tongue was then dragged outwards and downwards between them. In this way excellent access to the pharynx is got, and we can warmly recommend this preliminary method of operation to expose the pharynx and structures in the region of the isthmus.

If the two halves of the lower jaw are subsequently accurately united, the patient can immediately open and close the mouth, and runs no risk of injury to the mechanism of deglutition, pneumonia by this means being prevented.

In excising the tonsil it is important first of all to divide the mucous membrane round the new growth, that is, of the soft palate, the roof of the mouth, and the base of the tongue. This can be done with little hæmorrhage by using the thermo-cautery. It will be seen then how comparatively easily, after separating the mucous membrane, one can pass the finger beneath the tumour and detach it completely from the muscles. Even in the case of a sarcoma (the size of a small apple), for which an external incision had been recommended by another surgeon, we were able to remove it successfully from the mouth.

When the tumour has been separated in this way as far as where it joins the mucous membrane of the posterior wall of the pharynx, one is, as a rule, able to tear through the thin mucous membrane with the finger, and then to pull forward the tumour sufficiently to obtain a pedicle containing the vessels, which are ligatured prior to division.

B. SURGERY OF THE NECK

(a) Normal Incisions in the Cervical Region

32. Normal Incision for the Upper Lateral Triangle of the Neck. According to our principle of arranging skin incisions along the natural cleavage lines of the skin, we find that the best incision for exposing the organs in the fossa below and behind the jaw is that which we have already given for resection of the lower jaw. It runs from the anterior part of the apex of the mastoid process to the middle of the hyoid bone, passing a finger's-breadth below and behind the angle of the jaw, where it crosses the anterior border of the sterno-mastoid muscle. This incision possesses the great advantage of falling along the boundary line, at which the muscles, running from above downwards, viz. the digastric, stylo-hyoid, genio-hyoid, mylo-hyoid, and hyo-glossus, and those running from below upwards, viz. sterno-hyoid, thyro-hyoid, and omo-hyoid, meet or terminate. The muscles which cross this boundary line are either unimportant, like the platysma, or lie to one side or posteriorly, like the sterno-mastoid and the muscles of the vertebral column.

Moreover, by this incision it is possible to avoid the important nerves, inasmuch as the main trunks lie above or posteriorly and can be drawn aside, whilst their branches ramify upwards and downwards from the line of incision. Thus the vagus, the sympathetic, the spinal accessory, and the descendens noni lie posteriorly along with the sterno-mastoid muscle, while the lowest branch of the facial, the hypoglossal, the lingual, and the glosso-pharyngeal lie above. The superior laryngeal branch of the vagus is drawn downwards.

In the third place, the incision gives access to the bifurcation of the common carotid artery and to the origin of the branches of the external carotid. The common carotid bifurcates at the level of the upper border of the thyroid cartilage, and above

it follow, in close order, the origins of the branches of the external carotid. At the same level the facial and anterior temporo-maxillary veins join to form the common facial vein, which opens into the internal jugular. With this normal incision, therefore, we can expose and ligature not only the trunks of the great vessels of the neck, but also the greater number of their branches.

We have, therefore, designated this incision *the normal incision for the superior triangle of the neck*, and all other incisions for this triangle, whether longer or shorter, are made along the same line.

Quervain has recently discussed the incisions which we regard as normal incisions

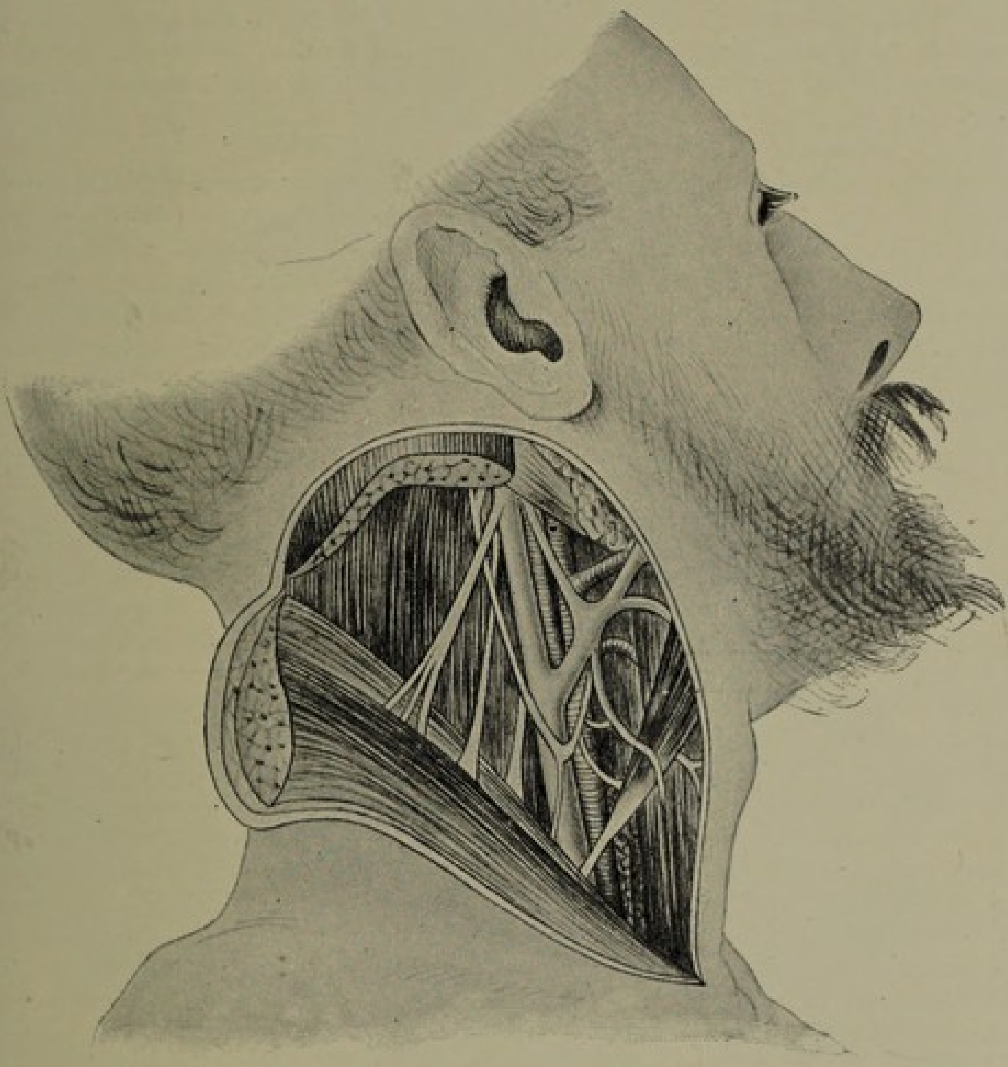


FIG. 273.—Küttner's muscle flap for exposure of the deep structures in the upper part of the anterior triangle.

for the neck, and suggested that they could be still further improved by carrying the incision through the muscles so as to form a flap, which would thoroughly expose the deep structures (*e.g.* in excising large or multiple tumours). We have satisfied ourselves of the advantage which Quervain ascribes to this additional procedure, and we reproduce one of his illustrations, which represents the admirable incision recommended by Küttner for exposing not only the anterior triangle but all the structures lying underneath the sterno-mastoid. The sterno-mastoid is divided high up (above the point of entrance of the spinal accessory) by the same incision as the skin, and is turned down with the skin flap. It is evident that a much better view is obtained by this musculo-cutaneous flap.

The muscle is subsequently united with sutures, and as its nerve has been preserved

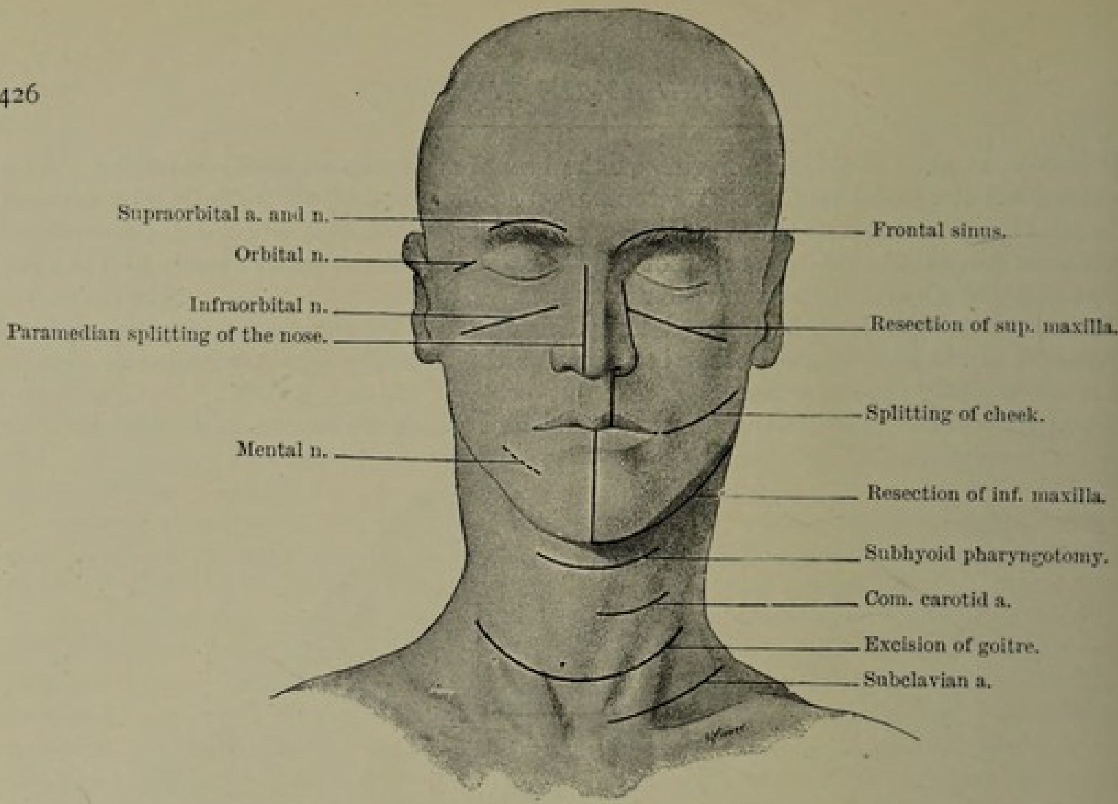


Fig. 274.

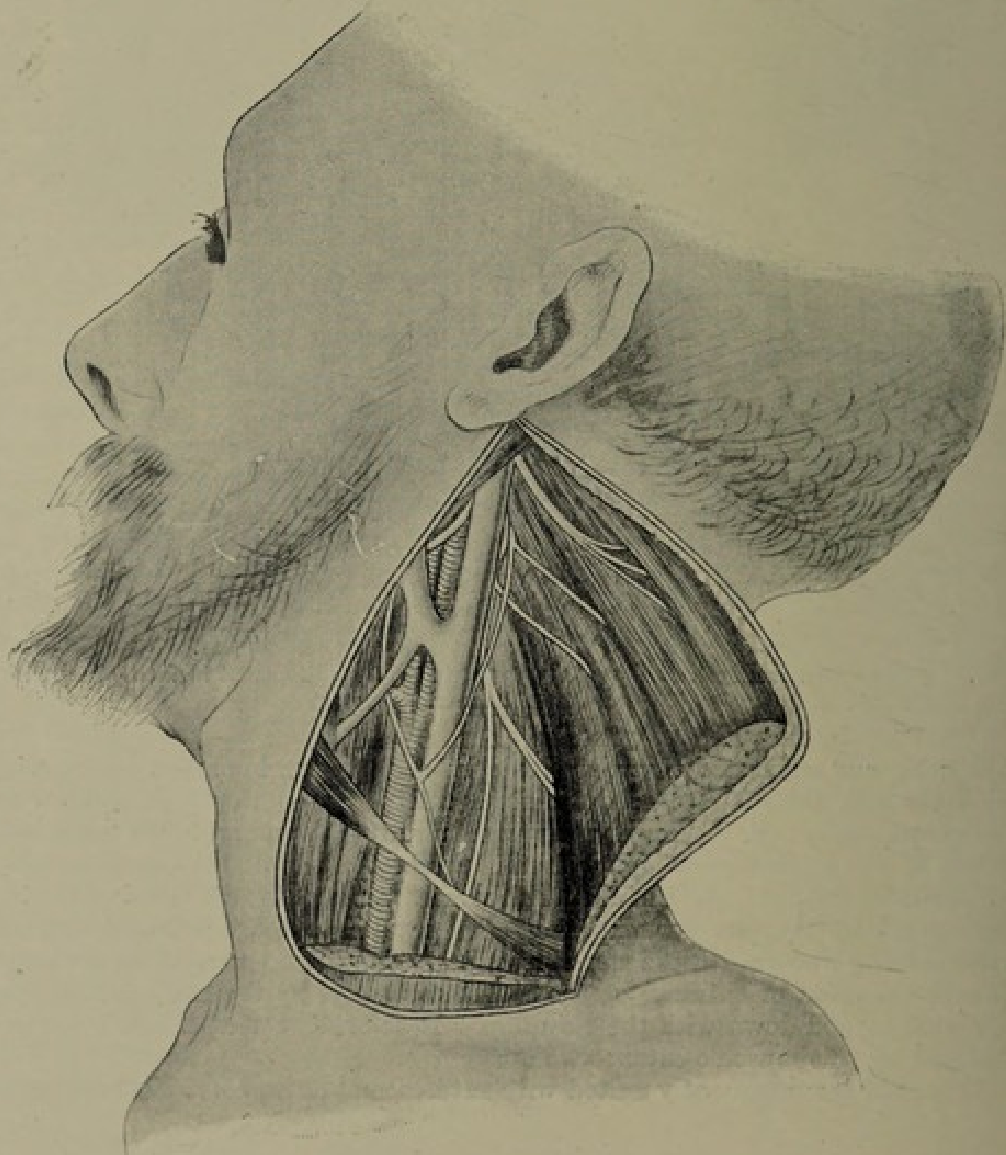


Fig. 275.—Quervain's muscle flap for exposing the deep structures of the neck.

its action is not interfered with. Division of the muscle is, however, not often necessary, as the sterno-mastoid can be sufficiently retracted to afford a good view of the vessels and structures surrounding them.

33. Normal Incision for the Inferior Lateral Triangle of the Neck (Figs. 274 and 275). This triangle is bounded by the clavicle, the sterno-mastoid, and the trapezius. The surgery of this region is simpler than that of the upper lateral triangle. It is here that the great vessels and nerves pass to the arm, and that many of the branches of the subclavian artery and vein are to be found. The floor of the triangle is formed by the first rib and the first intercostal space, together with the lateral muscles of the neck, especially the scaleni.

The *normal incision* for this region corresponds to the line of cleavage of the skin, and is almost transverse, passing from the origin of the sterno-mastoid at the clavicle outwards and slightly upwards to the edge of the trapezius. This incision is employed in ligaturing the subclavian artery, and is described with that operation (see p. 105).

Quervain, as we have already stated, turns down a flap containing the sterno-mastoid muscle in order to thoroughly expose the deep structures of the neck (Fig. 275).

We have often utilised this angled incision for the removal of a bunch of enlarged glands in the neck, but we only carry it through the skin. De Quervain's method naturally provides an easier access, but one must be careful when dividing the muscle below not to injure the transverse vein situated behind it, nor the external jugular vein at its posterior border.

(b) Surgery of the Larynx

34. Median Laryngotomy and Circumscribed Laryngectomy. Opening into the larynx is definitely indicated in intralaryngeal malignant growths, while it may also be necessary in comparatively simple tumours, as laryngeal papillomata, and in ulcers and infective diseases, as laryngeal tuberculosis. To expose the interior of the larynx by a mesial incision is a comparatively simple operation. The body and neck occupying a sloping position, the skin and fascia are divided in the middle line from the hyoid bone down to the upper part of the trachea. The following vessels are divided:—The hyoid branch of the lingual artery on the hyoid bone; the crico-thyroid artery; a transverse branch of the superior thyroid to the pyramidal process of the thyroid gland; numerous veins, some superficial (transverse connections between the two anterior jugulars), others situated under the fascia. All these vessels are carefully ligatured to prevent any after-bleeding. After dividing the skin and fascia, the muscles which ascend from the sternum to the larynx and hyoid bone are drawn aside, and the uppermost rings of the trachea exposed. The isthmus of the thyroid gland must be separated with a blunt dissector from the trachea and firmly ligatured on both sides. The upper and lower communicating veins running along its upper and lower border must be isolated and ligatured.

When severe dyspnœa is present, tracheotomy is first performed to ensure respiration, the edges of the wound are held apart, and the larynx is divided with scissors upwards exactly in the middle line. Before division of the thyroid cartilage a grooved director is introduced so as to be able to divide it exactly in the middle line between the anterior ends of the vocal cords. If the incision is carried carefully and slowly upwards, and the edges retracted with hooks, a satisfactory view is obtained, and one can avoid cutting into a possible new growth. The incision may be continued upwards in the middle line if necessary, into or completely through the epiglottis, or, if it be infiltrated by the new growth, past its sides. The division must always be carried far enough beyond the growth to allow of its thorough examination.

After the trachea has been divided a solution of novocain and adrenalin should be repeatedly painted on the surface of the mucous membrane. For this purpose we formerly used a solution composed of 5 per cent cocaine, 5 per cent antipyrin, and 1 per cent carbolic acid (introduced by Professor Stein of Moscow). According to

Valentin, it is better to inject the novocain solution at the point of entrance of the superior laryngeal nerve, the needle being inserted between the great cornu of the hyoid bone and the superior cornu of the thyroid cartilage at a distance of 3 cm. from the middle line (Frey).[1]

If the tumour is distinctly visible inside the larynx it is best to cut round it with the galvano-cautery or with a fine-bladed thermo-cautery. If it is firmly adherent at its base, the corresponding part of the wall of the larynx should be excised, the muscles being separated from its outer aspect with a blunt instrument, provided they are healthy and not infiltrated with the new growth. The cartilage is divided with strong scissors. There are a few vessels which bleed, but they can be easily secured.

It has lately been our rule to perform laryngotomy without using a general anæsthetic, and we consider a local injection of novocain (1 per cent solution for the skin incision) is preferable. If severe dyspnœa is present the novocain solution should also be injected at the point of entrance of the superior laryngeal nerve. If the operation is performed with the lower part of the body elevated, the Trendelenburg tampon, which we formerly recommended, can be dispensed with, and a more favourable view obtained, as the canula is always in the way, or a long thick rubber tube can be introduced, so as to avoid being inconvenienced by the coughing.

In regard to the after-treatment, the patient should lie with the head at a slightly lower level so as to prevent the secretions from entering the trachea, but if the sensibility of the larynx has not been destroyed, and the act of reflex coughing is unimpaired, *i.e.* if the patient can get rid of mucus by coughing, he should be allowed to sit up. Iodoform powder should always be rubbed into the raw surfaces and the wound packed, while the larynx must be plugged with iodoform gauze (wrung out of lotion) as far as the tracheotomy wound, the gauze being retained for the first few days.

As soon as the swelling in the region of the aditus laryngis is shown by the laryngoscope to have decreased, the packing may be removed, secondary sutures inserted and the tube dispensed with.

35. Partial Pharyngo-Laryngotomy. When the disease has involved not more than half of the larynx, but has invaded the aditus, splitting the larynx in the middle line no longer provides sufficient room to examine and determine the boundaries of the new growth. In these cases it must be combined with subhyoid pharyngotomy, or even better with median division of the hyoid and adjacent part of the base of the tongue.

36. Median Subhyoid Laryngo-Pharyngotomy (Fig. 276). Median subhyoid pharyngotomy is performed as follows :—An incision is made in the middle line from the hyoid bone downwards through skin and fascia over the thyroid and cricoid cartilages as far as the isthmus of the thyroid gland. The fascia (forming the suspensory ligament of the isthmus) is detached from the lower border of the cricoid, and the isthmus, along with the superior transverse communicating vein, is pushed downwards with a blunt dissector. In cases where the isthmus reaches high up, it is to be freed in the middle line at its upper and lower border, and a blunt dissector passed behind it, so that it may be divided between two strong catgut ligatures. The trachea is then opened and the patient put in the hanging position, so that blood may be prevented from running down into the trachea. The Trendelenburg position is not advisable previous to opening the trachea, as there is often marked dyspnœa due to venous congestion, and asphyxia may occur unless the patient's head be raised.

After the trachea has been opened, a thick rubber tube is inserted if necessary. The tube should be long enough to allow of its being turned on one side so as to be out of the way of further procedures. As a rule we do not use any tube at all. The incision is carried from the wound in the trachea upwards through the larynx exactly in the middle line. The surgeon must be quite certain that he reaches well above the limits of the diseased mucous membrane so that the thermo-cautery may

[1] *Arch. f. Laryngol.* Bd. 18.

be applied all round beyond the edges of the tumour. All points at which the new growth is cut into must be burnt with the thermo-cautery.

A transverse incision is now made through skin and fascia along the hyoid bone, the upper ends of the anterior jugular veins being ligatured close to the bone. The incision may be prolonged outwards along the hyoid bone through the fibres of the sterno-mastoid, the omo-hyoid, and the subjacent thyro-hyoid. The hyoid bone is

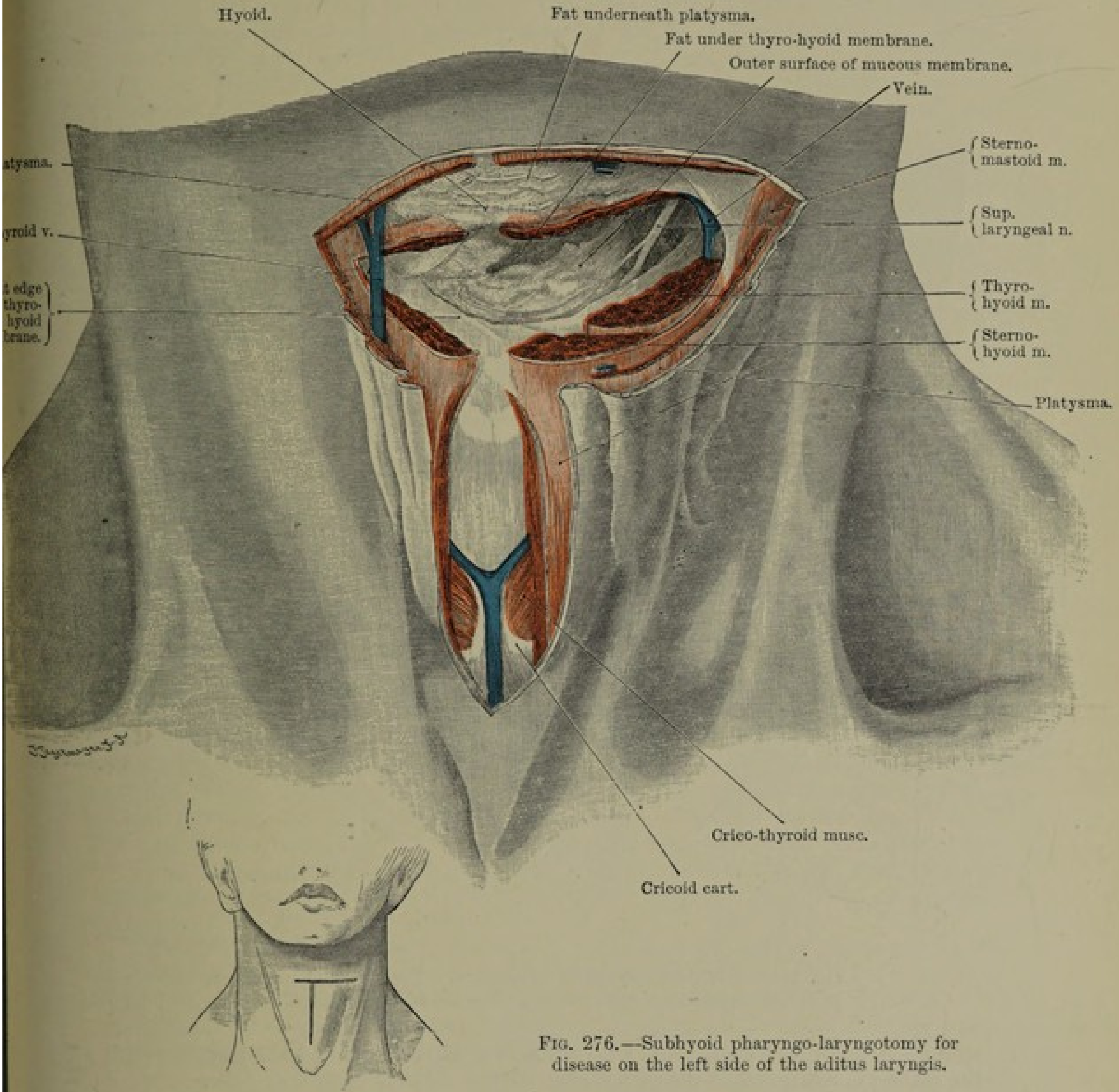


FIG. 276.—Subhyoid pharyngo-laryngotomy for disease on the left side of the aditus laryngis.

pulled upwards with a strong sharp hook. The strong central portion of the thyro-hyoid membrane, which is attached to the posterior border of the hyoid bone, is separated from the hyoid, and the projecting mucous membrane divided where it is attached to the anterior surface of the epiglottis. The tip of the epiglottis can now be seized and drawn forwards with a sharp hook. One must be careful not to divide the mucous membrane too high up behind the hyoid, as the bleeding will then be more difficult to control.

If the epiglottis is found to be healthy it is split mesially ; if diseased, the mucous membrane round it is divided and the posterior horns of the thyroid cartilage are cut through with bone forceps. Small double sharp hooks are now introduced between the edges of the wound in the thyroid cartilage, and its alæ drawn apart so as to give a clear view of the extent of the disease. The mucous membrane is then divided with the thermo-cautery and the tumour excised.

If the new growth has spread upwards on to the pharynx, the division of the

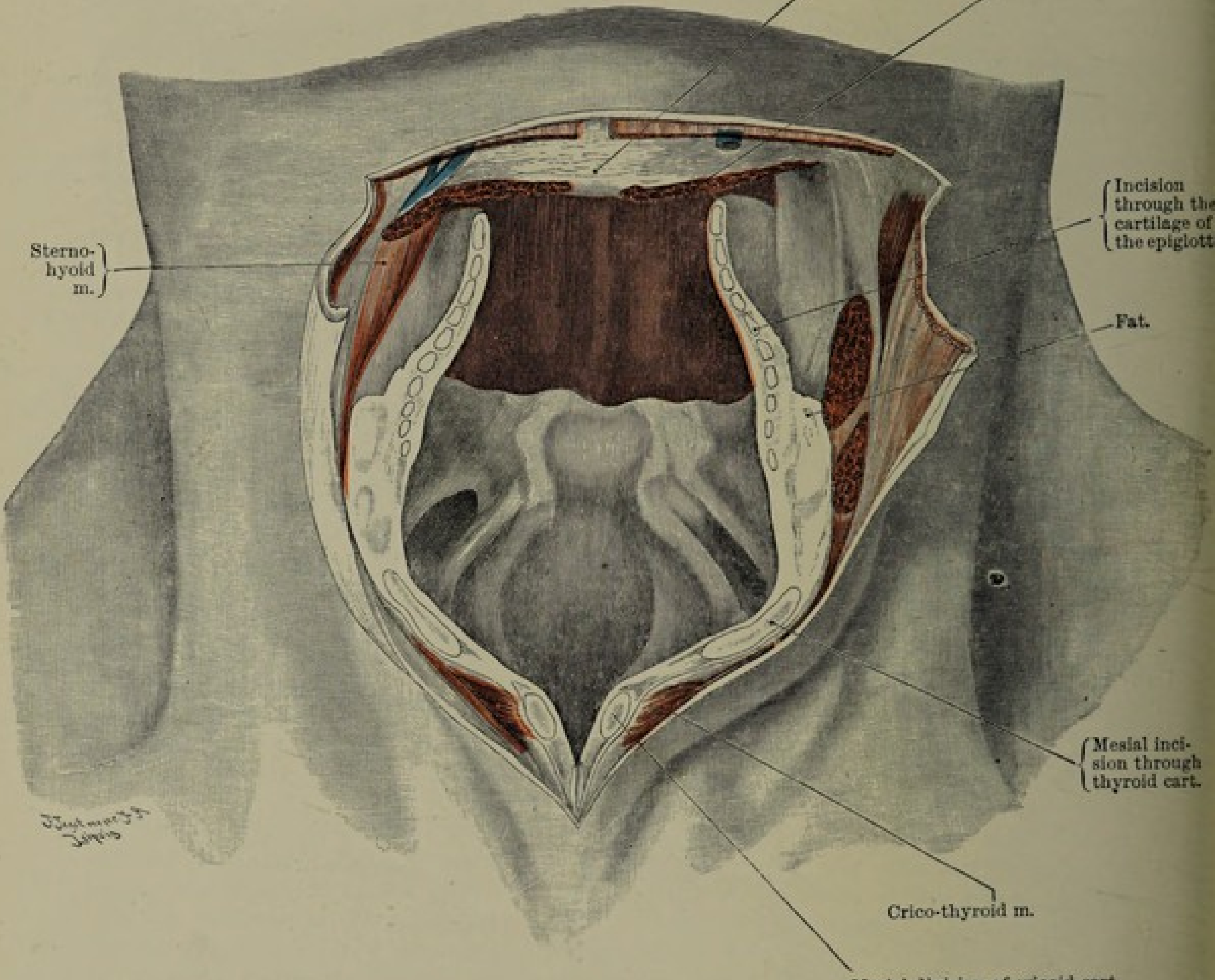


FIG. 277.—Subhyoid laryngo-pharyngotomy. The larynx is opened up, the epiglottis is split, and the edges are widely separated.

mucous membrane is continued along the arytenoid cartilage and the posterior wall of the cricoid cartilage on to the pharyngeal wall.

The soft parts have now to be separated from the outer surface of the larynx. The muscles which can be separated may be preserved, but those which are in firm contact with the cartilage must be excised over an area corresponding to that occupied by the cancer internally, the cartilage and muscles being divided with strong scissors in the groove made by the thermo-cautery.

If there is any healthy mucous membrane covering the arytenoid cartilages and posterior surface of the cricoid, it is to be freed and united to the mucous membrane of the epiglottis in front.

37. Total Laryngectomy (Operation of Watson and Czerny).[1] It generally happens that the extent of a carcinoma in the interior of the larynx, or even of the pharynx as well, is only discovered in the course of the operation. As a rule, therefore, the median incision recommended by Billroth is unavoidable for exploratory laryngotomy (*vide* Salzer, *Arch. f. klin. Chir.* Bd. 39).

In this connection we would specially observe that when the superior aperture of the larynx is free, and it is consequently unnecessary to perform subhyoid pharyngotomy to begin with, the access afforded by the longitudinal incision can be increased by splitting the hyoid bone in the middle line. We drew attention to this point in earlier editions, although it has recently been referred to as a new procedure. Keen operates on the same lines.

If it is obvious from the first that total excision alone will suffice, the operation can be simplified by avoiding splitting the larynx. For this purpose a transverse curved incision extending from one sterno-mastoid to the other across the larynx (our "collar incision," only at a higher level) will be found very satisfactory. After dissecting up the skin, fascia, and platysma as far as the hyoid bone above and the upper rings of the trachea below, the sterno-thyroid muscles are held apart with hooks, and tracheotomy is performed by cutting the trachea across below the cricoid cartilage. The cricoid cartilage is then firmly pulled up with a sharp hook, and the mucous membrane of the pharynx separated posteriorly where it is loosely attached, while the attachments of the pharyngeal constrictor muscles to the larynx are divided, and the cavity of the pharynx behind the arytenoid cartilages is entered. The larynx can now be raised up with the finger, and all the soft parts and muscles on one side which cannot be lifted off it but are only loosely connected with it, are grasped with forceps and divided. The larynx can then be partially dislocated over to the other side and a similar separation performed here.

The excision can now be completed above the upper and lateral limits of the disease by turning the larynx upwards and cutting through the superior cornua of the thyroid cartilage and the thyro-hyoid membrane in front. The trachea is stitched into a small separate opening or into the lower end of the wound so that any discharge from above does not enter it. When possible, the pharynx should be closed either by direct suture or by a plastic operation, or it may be simply packed.

The condition of the glands is an important factor in regard to the success of the operation. In none of our patients who were traced some years afterwards by Rutsch, and who exhibited no enlarged glands in the neck at the time of operation, was there cachexia, the lungs, moreover, being healthy. If there is malignant disease of the glands a radical cure cannot be expected, and total excision should not be attempted, as the epiglottis and aryepiglottidean folds are in that event invariably involved, a condition which, according to de Santi, leads to early and rapid invasion of the glands. In these circumstances simple tracheotomy serves the purpose equally well. The fact must not be overlooked that the results even of extensive excisions have improved, Garré estimating the mortality in these cases at 20 per cent, and the permanent cures at 10 per cent (1898), while our statistics show very conclusively the great advantages of early operation.

Up to the present we have performed extirpation of the larynx for cancer on 29 occasions and for sarcoma once (*vide* works of Dr. Lanz, Dr. Rutsch, and Dr. Kasansky, 1890, 1899, and 1904). In the case of the sarcoma a radical cure was obtained. On tracing the other patients some years later, seven were found to be cured (24·1 per cent), so that if we include the sarcoma case the percentage of radical cures amounts to 26·6 per cent. Of 6 cases of total excision of the larynx only one died of pneumonia, and he was free from recurrence for two years. Out of 9 cases of unilateral excision two died of other diseases, one and one and a quarter years later; two are in good health after six and eight years respectively, while of 10 circumscribed laryngectomies two are healthy after six and six and a quarter years. Further, of

[1] *Vide Wiener med. Wochenschr.*, 1870. According to Réal, Albers had already made experiments in 1829, and Watson performed the first successful total resection in 1868, while Billroth performed the second in 1872 on the basis of Czerny's experiments.

4 cases of subhyoid pharyngotomy two remain cured after periods of fourteen months and ten years.

When the operation was undertaken at an early stage of the disease, *i.e.* when the cancer was still circumscribed, and there were no enlarged glands, 50 per cent of permanent cures was obtained, a result which is very gratifying, and which shows that early diagnosis alone is required in order to make cancer in this region, as well as in other parts of the body a disease curable by surgical measures.

These favourable results obtained by circumscribed internal laryngectomy (simple median thyrotomy) are also upheld by the statistics of Semon, Sendziak, and Cuneo, while further, a sharp line of distinction must be drawn between the so-called internal carcinoma of the larynx (when the tumour is limited to the true and false vocal cords) and the so-called external cancer, in which the tumour originates in the epiglottis and aryepiglottidean folds (*vide* de Santi).[1] That a cure in laryngeal cancer, as in cancer of the tongue and other organs, depends on early operation and not on the actual method of removal employed, may be seen from earlier publications, such as Salzer's report on 29 laryngeal operations for cancer performed by Billroth up to 1889. Of these 29 cases, in which various operative methods were employed, only four remained free from recurrence, and of these only two for more than three years. *Vide* also Kraus' statistics.[2]

After-Treatment of, and Plastic Operations to follow, Extensive Resections of the Larynx and Total Laryngectomy

When the trachea has been divided transversely, Gluck's[3] procedure is at the present time the one most commonly followed, *i.e.* the trachea is stitched into the lower angle of the wound or brought out through a special opening. As a rule, a tracheotomy tube need not be worn. Gluck's procedure affords the best guarantee against aspiration-pneumonia.

Gluck's method of dealing with the pharynx is also generally accepted. It consists in stitching the anterior wall of the pharynx to the soft parts below the hyoid bone, or if this cannot be effected, in closing the pharynx by means of a plastic operation, which, if not undertaken at once, may be successfully performed at a later date, as has been shown in a series of cases.[4]

The defect is closed by dissecting up a flap of skin, which is most satisfactorily done, according to Witzel, by Gersuny's method. The epidermis is directed towards the pharynx, while the raw surface, left by the removal of the flap, is either covered in by another plastic operation, or by grafting.

Mangoldt has devised an ingenious method by which portions of the thyroid cartilage may be replaced. He removes a wedge-shaped portion from the eighth costal cartilage 5 cm. long and $\frac{1}{2}$ cm. thick, which he transplants under the skin of the neck, the perichondrium being directed outwards.

After an interval of five months he covers the deep surface of the grafted cartilage with a flap of skin, and three weeks later cuts out the skin containing the cartilage and inserts it between the lateral plates of the thyroid cartilage, employing intubation of the larynx for some time subsequently. An easier method of restoring the cartilages of the trachea and larynx, and one which we have employed with success, is to turn up a long narrow flap containing skin, periosteum, and bone from the sternum or clavicle.

38. Tracheotomy. (*a*) *High Tracheotomy* (*Crico-tracheotomy*) Fig. 278. In the great majority of cases where we are compelled to perform this operation very rapidly, *crico-tracheotomy* is the safest, and is attended with least hæmorrhage.

The uppermost tracheal rings are often covered by a well-developed thyroid

[1] De Santi, *Lancet*, June 1904.
[2] Kraus, *Policlinico*, 1890.
[3] Cf. Depage, *Annales de la Soc. belg. de Chir.*, 1897, and Keen, *Annals of Surgery*, July 1899.
[4] Cf. Gluck, *Monatschr. f. Ohrenheilk.*, April 1904.

isthmus, at the upper and lower edges of which are the large transverse communicating branches between the thyroid veins. They receive branches which descend from the pyramidal process of the thyroid, when this is present, while ascending to the process are vessels from the crico-thyroid branches of the superior thyroid artery, so that arterial branches may also cross the middle line at the upper border of the isthmus. At the posterior surface of the isthmus the inferior laryngeal branch of the inferior thyroid artery is seen passing upwards. Below the isthmus are the large and constant inferior thyroid veins, which descend vertically one on either side of the mesial plane, and along with them the occasional thyroidea ima artery. All those vessels may be avoided if crico-tracheotomy be performed. In dealing with

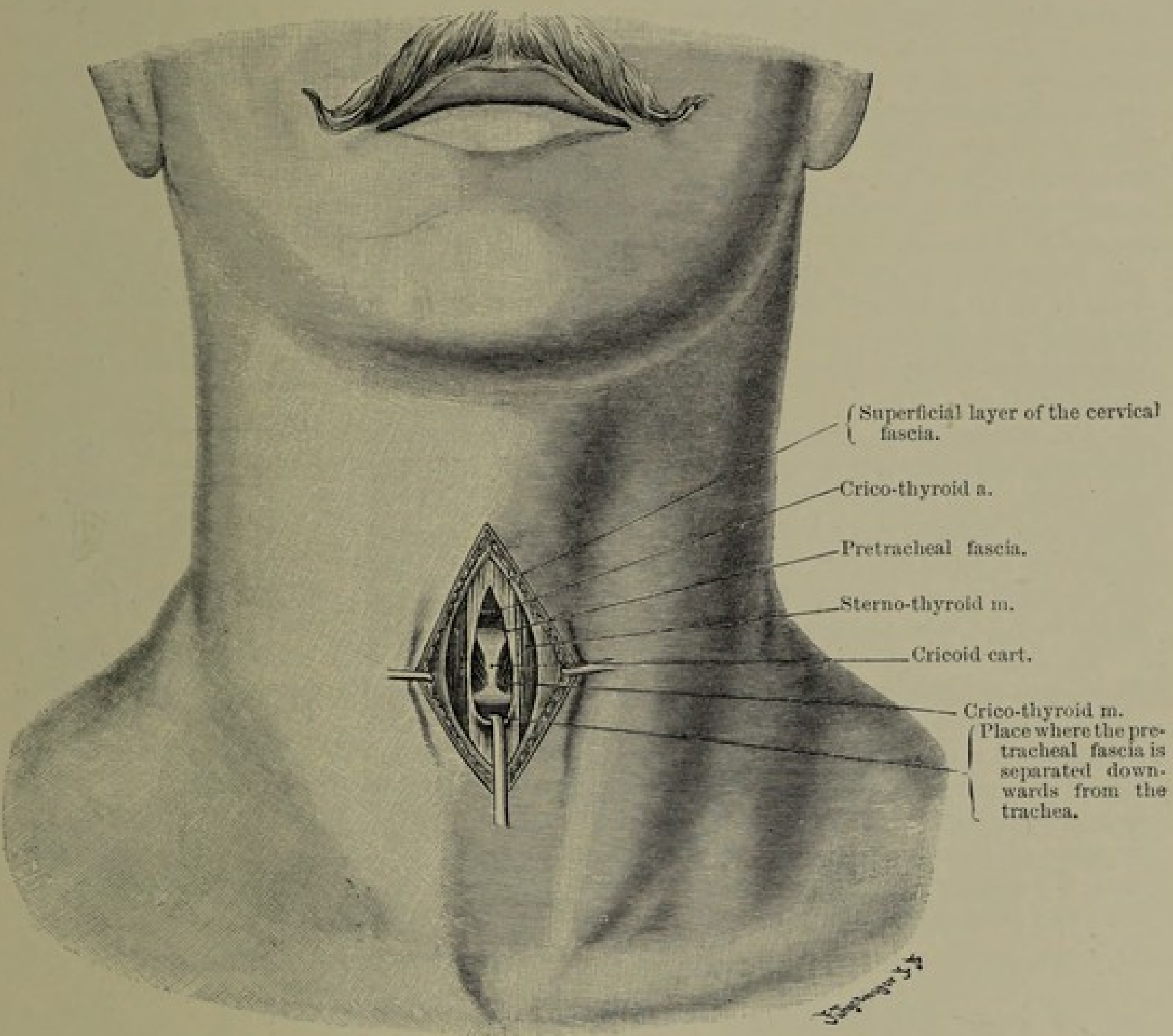


FIG. 278.—High tracheotomy.

children, especially when aggravated dyspnœa is present (in diphtheria, for example), it is advantageous to begin the incision directly over the thyroid cartilage. After dividing the skin and fascia, the adjacent edges of the sterno-hyoid muscles are exposed and drawn apart with blunt hooks. Bleeding veins are seized with artery forceps. The lower border of the cricoid cartilage, which may almost invariably be distinguished readily, is now felt for, and the fascia over it is grasped with forceps, while a small incision is made into it in the manner recommended by Bose. In young children, and when there are marked dyspnœal ascent and descent of the larynx, it is an advantage to place a small sharp hook in the exposed lower edge of the cricoid to fix it, and then to thoroughly separate the thyroid isthmus, along with the fascia and veins downwards from the front of the trachea, with a blunt dissector (Kropponde),

and to keep them held downwards with a retractor. The trachea is now rapidly penetrated with a sharp-pointed knife immediately above the retractor, and the trachea and cricoid are divided in an upward direction. The edges of the tracheal wound are at once seized with fine hooks and drawn asunder.

Unless the trachea is stabbed with a sharp-pointed knife there is a risk of its mucous membrane becoming detached.

(*b*) *Low Tracheotomy* (*below the thyroid isthmus*). If sufficient room is not got by crico-tracheotomy, or if it is desired to place the tracheal wound farther from the larynx, an incision must be carried through the skin and fascia in the middle line between the sternal muscles below the isthmus. The fascia is divided and forcibly retracted upwards with a sharp hook, along with the muscles. The inferior thyroid veins remain uninjured as they descend vertically one on either side of the mesial plane. After dividing the pretracheal fascia the trachea itself is reached: the transverse veins of the thyroid isthmus are pulled upwards with blunt hooks, while the small communicating veins at the suprasternal notch are hooked downwards. The trachea is thus exposed with a blunt instrument without injuring any vessels; in adults it is often as deep as 6 cm. ($2\frac{1}{2}$ in.) or more. If necessary, an aneurysm needle may be introduced between the trachea and the thyroid isthmus (previously separated from the trachea by a blunt dissector from above and below), in order that the isthmus may be divided in the middle line between two firmly tied ligatures. This is to be preferred when the trachea is to be fully exposed. It should be borne in mind that the tube must be longer than that used in high tracheotomy in case it may slip out of the trachea and come to lie behind the sternum, thereby causing serious dyspnœa.

In tracheotomy performed preliminary to pharyngotomy, laryngotomy, and laryngectomy, the low operation is preferable, as it leaves a clear field for the second operation. If there is much dyspnœa, these preliminary tracheotomies should be performed several days before the chief operation. Inferior tracheotomy, however, is always a more difficult operation to perform when there is a goitre or an enlarged isthmus involved, because the trachea is then much deeper, and there is no palpable guide to it to take the place of the cricoid cartilage.

In a number of cases serious hæmorrhage has been reported after tracheotomy. Taute has published three cases from v. Bruns' clinic, and Klauber one from Wölfler's clinic, the latter being performed for an aneurysm of the aorta. We have also experienced a case in which bleeding occurred from erosion of the innominate artery. There are now 87 cases reported in which erosion occurred, the innominate artery being involved in 56. Unfortunately, one cannot ascertain from the reports the number of these cases in which low tracheotomy was performed. There is no doubt that the danger of this fatal complication is incomparably greater in low tracheotomy, *i.e.* from pressure of the tube.

(c) Surgery of the Pharynx and Œsophagus

39. Subhyoid Pharyngotomy (Langenbeck's Operation). Subhyoid pharyngotomy, introduced by Malgaigne and Langenbeck, deserves special attention. By utilising all the advantages of this procedure the operation becomes much more frequently indicated than former authors supposed. It has the advantage of giving excellent access with little injury to the surrounding structures. Not only is the operation indicated for the removal of all growths situated at the entrance to the larynx, *e.g.* growths involving the epiglottis, aryteno-epiglottidean folds, arytenoid cartilages, mucous membrane at the level of the hyoid bone and of the sinus pyriformis, but equally for growths situated at the root of the tongue and on the lateral and posterior walls of the pharynx as far down as the œsophagus. In these conditions it is the operation *par excellence*, as it allows of an exact dissection and free removal with the least possible disturbance of function.

We have found preliminary tracheotomy and packing unnecessary when there is no

dyspnœa. Blood can be prevented entering the larynx by having the patient in the correct oblique position. Honsell too has lately deprecated preliminary tracheotomy. A general anæsthetic can be dispensed with in simple cases, and instead a 1 per cent solution of cocain can be injected for the skin incision, and 5 to 10 per cent solution can be repeatedly painted on the mucous membrane.

The incision, 4 inches long, is made along the hyoid bone from the greater horn on one side to that on the other, dividing the skin and muscular fibres of the platysma. The hyoid bone is then exposed and the anastomosis of veins crossing it is ligatured. The hyoid artery and vein lie on the bone and are retracted to the upper side of the wound. The muscles inserted into the lower border of the hyoid bone, viz. the sterno-hyoids, omo-hyoids, and the thyro-hyoids, are divided at their insertions. When the disease is unilateral the muscles on one side can be retained.

The thyro-hyoid membrane is now exposed. The central part appears as a broad, tense ligament, but the lateral parts are thinner. The central portion, which encloses fat and often a bursa, is divided transversely along the bone. The mucous membrane is similarly divided, giving rise to some spouting from small vessels. We do not consider it advisable to divide it at a distance from the hyoid, on account of the superior laryngeal nerve, which enters the larynx by piercing the lateral part of the thyro-hyoid membrane. If the twigs of the nerve are cut, the larynx becomes insensitive, and allows of the entrance of food, mucus, and wound secretions into the larynx, and as these foreign bodies cannot be reflexly coughed up, aspiration-pneumonia is developed.

The epiglottis can now be seized with a hook at its upper border and drawn forwards. This gives an excellent view of the entrance of the larynx, especially the neighbourhood of the arytenoid cartilages, which is so often the seat of disease (tuberculosis and cancer), and also of the lowest part of the pharynx and the root of the tongue. If the epiglottis must be removed, it is seized with a hook at its lowest point (which can be easily felt above the dip in the thyroid cartilage) and dragged outwards. After the mucous membrane has been divided it can be easily pulled out and cut away. As in laryngotomy, the reflex irritation of the mucous membrane must be quieted by frequent applications of a 5 per cent novocain solution, or direct anæsthesia of the superior laryngeal nerve, so as to enable the operation to be continued in comfort.

The new growth should be thoroughly removed with the thermo-cautery, the parts being clearly exposed to view. The cautery arrests all oozing and gives a better chance of a radical cure. As regards after-treatment, it is advisable to perform tracheotomy to avoid the risk of œdema glottidis, which frequently develops in an extremely insidious way, and which may give rise to asphyxia. The main wound is stuffed with iodoform gauze to prevent the chance of aspiration-pneumonia. The patient must lie with the head low whenever he is recumbent; but he should be allowed to sit up very early, to allow of easy expectoration of the secretions of the wound.

We have already described under excision of the tongue the method by which the root of the tongue is removed by a subhyoid pharyngotomy.

Honsell[1] has collected 93 cases of subhyoid pharyngotomy of which the percentage mortality in simple tumours was 25, but in the malignant cases as much as 35. The prognosis must, however, be regarded as considerably better than is indicated by these figures.

40. Medio-Lateral Pharyngectomy (Retro-Laryngeal Resection of the Pharynx) (Fig. 279). Owing to the extreme frequency of tumours, especially carcinoma, in the region of the entrance of the larynx, *i.e.* affecting one of the arytenoid cartilages and the aryepiglottidean folds, and infiltrating the lateral wall of the pharynx and the sinus pyriformis, it is advisable to give a definite description of the method of exposing the lowest part of the pharynx with the least destruction of the parts.

Just as we have lately, on principle, employed a median incision for the tongue and upper part of the pharynx, we have similarly restricted the use of lateral pharyngotomy in favour of median pharyngotomy, for cases of carcinoma such as

[1] *Beitr. z. klin. Chir.* Bd. 25.

those for which we have frequently been called upon to operate, and the results have been thoroughly gratifying as regards its precision and the minimum damage done to the surrounding structures.

The incision is made, as in subhyoid pharyngotomy, along the lower border of the hyoid, through skin and platysma, but extending farther outwards on the diseased side, and only about $1\frac{1}{2}$ inches across the middle line on the healthy side. From

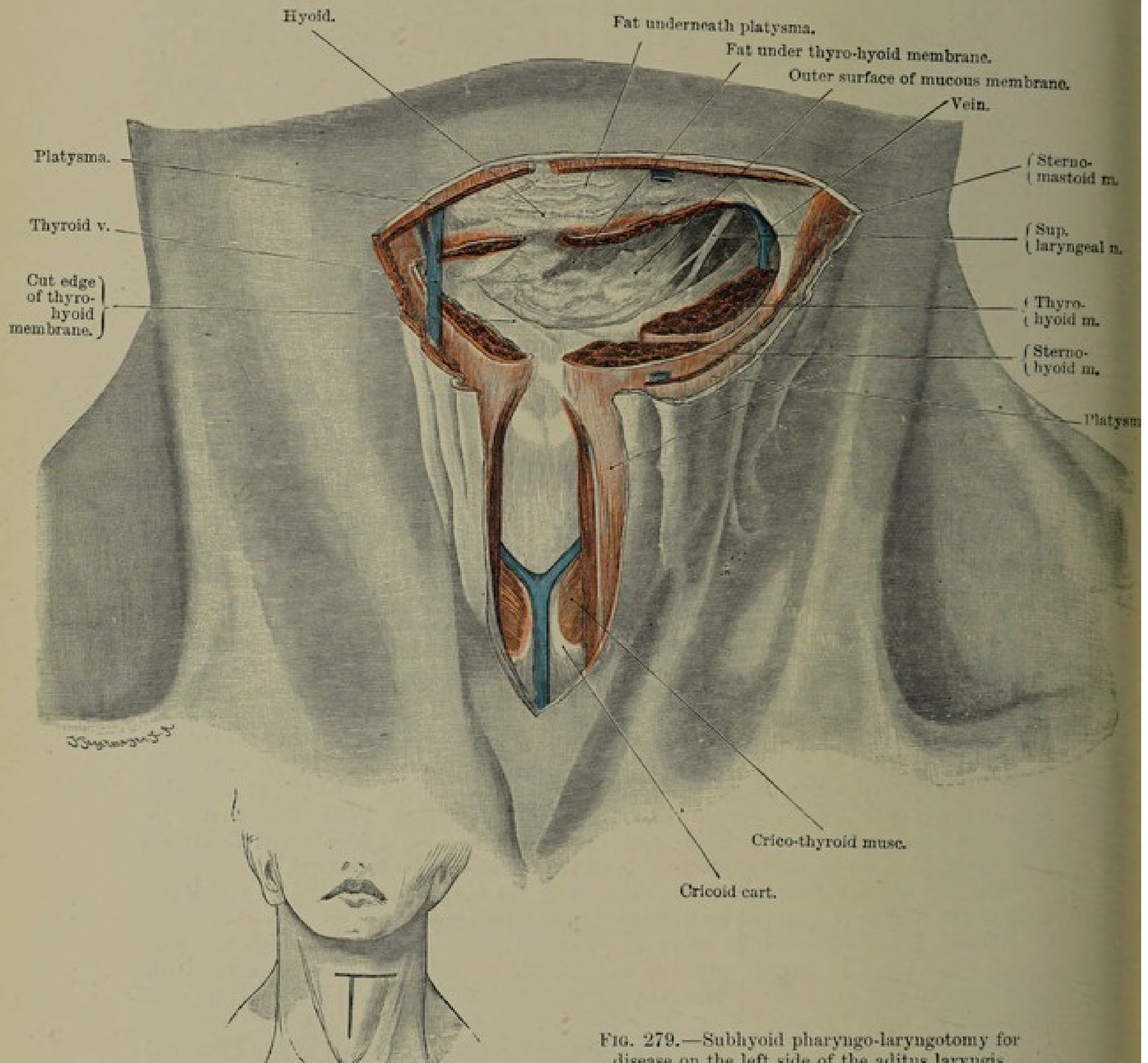


Fig. 279.—Subhyoid pharyngo-laryngotomy for disease on the left side of the aditus laryngis.

this another incision is carried through skin and fascia down to the thyroid and cricoid cartilages in the middle line as far as the isthmus of the thyroid, care being taken to avoid the vertical veins, the transverse veins being ligatured as in median laryngotomy.

On the diseased side the sterno-hyoid, thyro-hyoid, and omo-hyoid are divided parallel to the hyoid, a large lateral vein being ligatured, and the subjacent thyro-hyoid membrane is cut across as described in subhyoid pharyngotomy, the tip of the

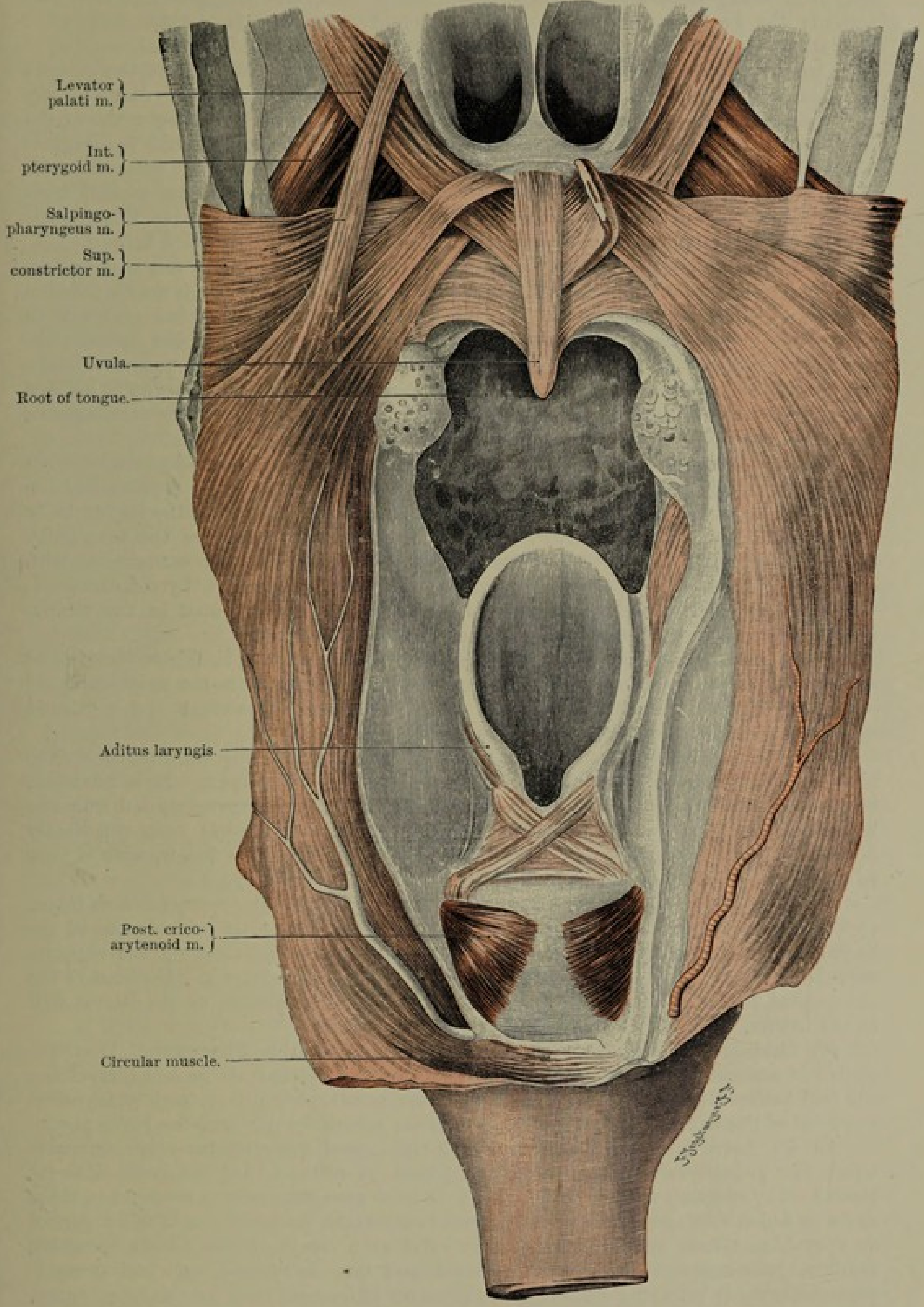


Fig. 280.—(From a dissection by Tramond.) To illustrate the relation of the structures in operations on the palate and pharynx. The entire pharynx is here split open from behind. Part of the mucous membrane has been removed in order to show the muscles.

epiglottis being then seized with a small sharp hook and dragged forwards and towards the healthy side, while the thyro-hyoid membrane is divided close to it vertically downwards as far as the thyroid cartilage.

The upper and anterior limits of the new growth are now defined, and the mucous membrane between the larynx and pharynx is divided ½ cm. wide of the disease. By this means a better view is obtained, and one is able to decide how much of the cartilaginous plate of the thyroid will have to be excised. The thyroid cartilage is not divided mesially as in pharyngo-laryngotomy (No. 35), but is split wherever it is considered best to do so, the muscles and perichondrium being first incised from without down to the cartilage, after which the latter is divided down to the mucous membrane of the larynx. If necessary, also, the cricoid may be divided behind.

The lower limits of the new growth in the pharynx or œsophagus can now be felt, and the latter opened below it. The anterior border of the cartilage is drawn forward and the mucous membrane on the posterior wall of the larynx separated as far down as the level to which the tumour in the pharynx (or œsophagus) has invaded the cartilage by which it is covered. Finally, a controlling finger is passed into the œsophagus and the mucous membrane between the larynx and pharynx is divided above, near—and often between—the arytenoid cartilages, and also the cartilaginous plate of the cricoid so far as the tumour is related to it.

As will be gathered from the description, we get at the lateral and posterior walls of the pharynx by adding to the incision parallel to the hyoid the median incision with splitting of the thyro-hyoid membrane. This allows one-half of the larynx to be powerfully pulled downwards and forwards. Removal of the base of the tongue by means of median pharyngotomy has already been described in connection with excision of the tongue. The incision extends from the chin to the thyroid cartilage; the hyoid is divided and the muscles attached to it are separated in the middle line, and thus a clear view of the root of the tongue is obtained.

This method of medio-lateral pharyngotomy is especially applicable to those cases of carcinoma of the pharynx in which the tumour is situated in the neighbourhood of the sinus pyriformis and involving to a greater or less extent the arytenoid cartilages and the œsophagus behind the cricoid.

Preliminary tracheotomy is necessary in all excisions involving simultaneously the pharynx (commencement of the œsophagus) and part of the larynx. It is advisable to perform gastrostomy in addition, so that the patient may be properly fed from the beginning, and to allow of the pharynx being plugged, or if it has been completely divided, so that it may be closed above and sutured to the skin below, with a view to a subsequent plastic operation.

Quénu and Sébileau report two cases of retro-thyroid pharyngotomy (*Rev. de Chir.*, Oct. 1904) in which a longitudinal incision was made along the outer edge of the larynx, and after dividing the superficial and deep fascia and ligaturing the superior thyroid artery and vein, the pharynx was opened behind the larynx. Division of the pharyngeal wall is facilitated if it is put on the stretch by pulling on the lateral wall of the larynx.

41. Lateral Pharyngotomy (Lateral Resection of the Pharynx). We have shown in connection with the operations on the tongue that all growths involving the fold between the upper and lower jaws, the tonsil, soft palate, and pharynx at the level of the isthmus, can be reached from the mouth by splitting the lower jaw.

As we have further shown that a medio-lateral pharyngotomy is preferable when the growth is situated below the hyoid, it follows that the indications for lateral pharyngotomy are few in number. Lateral pharyngotomy is confined to those cases in which adhesions have already formed externally, if such a case is still regarded as operable. These adhesions frequently arise as a result of the glands becoming swollen, inflamed and occasionally softened, and the pharyngeal wall and the soft parts covering it becoming adherent, the prospect of radical cure in this case being, of course, very slight.

The normal incision for the anterior triangle is used in all operations in which we have not only to expose the lateral aspect of the pharynx, the tonsils, and the base

of the tongue from without, but in which the soft tissues lying over them, and even the bones, have to be removed.

If the incision be employed in its full length, *i.e.* from the mastoid process to the hyoid bone, the lateral aspect of the tongue as far as the epiglottis and the lateral wall of the pharynx, together with the whole of the retro-pharyngeal space, may be exposed. As the posterior part of the incision must, in some cases, be taken full advantage of, the great auricular nerve and the external jugular vein must occasionally be divided.

After dividing the skin, platysma, and fascia, the submaxillary region is exposed. The facial vein which lies upon the outer surface of the posterior belly of the digastric, and the facial artery which lies beneath the submaxillary gland, together with the gland itself, must be dealt with before the floor of the mouth and the wall of the pharynx can be reached. The vessels are divided between two ligatures, while the gland is drawn out and turned upwards, or extirpated. It may be necessary also to ligature, close to their origins, the lingual, ascending pharyngeal, and ascending palatine arteries, or to tie the external carotid. In this way it is possible to draw backwards the great vessels of the neck, together with the vagus and spinal-accessory, while the arch of the hypoglossal nerve is drawn upwards. It is easier to ligature the external carotid, but ligature of a large vessel in the region of a necessarily septic wound is always attended by the danger of severe secondary hæmorrhage.

The superior-laryngeal nerve and the superior thyroid artery remain beneath the lower edge of the wound. Those muscles which lie anteriorly and can be avoided must, in the interest of the swallowing mechanism, be preserved by working upwards along the inner surface of the jaw and along the internal pterygoid towards the mucous membrane. If, on account of adhesion or insufficient access, the muscles must be divided, then this is to be done in such a way that the innervation of the portions of the muscles which are spared is not interfered with. The posterior belly of the digastric and the stylo-hyoid are divided as near as possible to the hyoid bone, because their nerves of supply (from the facial) enter posteriorly; and for the same reason the stylo-glossus is divided near the tongue, the lingual and glosso-pharyngeal nerves which lie on it being avoided. The stylo-pharyngeus is divided in the region of its pharyngeal insertion, and the hyo-glossus and mylo-hyoid muscles, as far as may be necessary, at their insertions into the hyoid bone. The pharyngeal wall is now exposed, the superior constrictor above, the inferior constrictor below. When the lingual and glosso-pharyngeal nerves are involved they must, of course, be divided.

The upper part of the pharynx, however, is only thoroughly exposed to view by the *osteoplastic resection of the lower jaw* which we have already mentioned, or, expressed more exactly, by the oblique division of the jaw (from behind internally and above, obliquely forwards, outwards, and downwards) at the anterior border of the masseter, the ascending ramus being then drawn forcibly upwards and the horizontal portion forwards, or the posterior half of the ascending ramus of the jaw along with the condyle may be excised.

If the new growth involving the tongue and pharynx has extended to the fold between the upper and lower jaw and to the bone itself, it is best, after dividing the lower jaw as above described, and separating the capsule of the joint and the external pterygoid, to disarticulate and remove the ascending ramus, after detaching the healthy muscles, including the masseter. In this way subsequent closure of the jaws is most certainly avoided. The inferior dental nerve and artery are divided and the latter ligatured, as already described in resection of the lower jaw.

If the *lower part of the pharynx* behind the larynx is to be exposed, the muscles of the tongue and pharynx along with their nerves, as well as the branches of the external carotid artery, are all left undisturbed. The pharynx is opened below the superior laryngeal nerve, between it and the superior thyroid artery (which is divided). In order to expose the lowest part of the pharynx it is necessary to add to the normal incision (which is then correspondingly shortened posteriorly) a longitudinal incision, extending downwards along the anterior border of the sterno-mastoid muscle. When the lymphatic glands are adherent to the external soft parts only and can be thoroughly

removed without injury to the pharynx, it is better to perform the operation at two sittings—that is to say, first to excise the glands down to the pharynx, and it may be also to the œsophagus, and then to postpone opening the pharynx for a few days until the wound has granulated (in order that the fresh wound may not become infected with pharyngeal contents), after which medio-lateral pharyngotomy is performed.

Appendix. Suprahyoid Pharyngotomy. Jeremitsch has described a suprahyoid pharyngotomy which Spisharny has performed and for the introduction of which Grünwald claims priority. It is, however, identical with the lateral pharyngotomy described by us. If, on the other hand, the operation is performed through a mesial incision, division of the muscles attached to the hyoid bone above results, as Grünwald admits, in sinking downwards of the larynx, which makes fixation of the latter necessary. By dividing the muscles at the upper border of the hyoid bone, one gets of course a very good view into the pharynx, so good, in fact, that Hofmann's suggestion of attacking naso-pharyngeal tumours by this route appears quite justified. v. Hacker seems to have performed the first operation in man for a round-celled sarcoma of the root of the tongue.[1]

42. Œsophagotomy. The œsophagus is opened from the left anterior triangle of the neck, because it projects to the left of the trachea. If it be desired to expose it on account of the presence of a foreign body, Langenbeck's incision should be used. (According to Langenbeck, Goursand in 1738 first performed the operation.) This incision resembles that of Guattani and extends along the edge of the sterno-mastoid from the hyoid to a point one finger's-breadth above the clavicle. The skin and platysma are incised, and after dividing the fascia, the sterno-mastoid is drawn outwards, the depressors of the larynx inwards, and the omo-hyoid is divided. The thyroid fascia (outer capsule) is now incised, the gland itself is drawn inwards, and the large cervical vessels along with the descendens noni nerve are drawn outwards. The capsule of the thyroid is a part of the deep cervical fascia which is firmly blended laterally with the sheath of the large vessels. This fascia must be divided before access can be got to the œsophagus. Upon the anterior surface of the vertebral column is the longus colli muscle, and crossing it transversely, behind the common carotid, is the large inferior thyroid artery, which is to be divided between two ligatures. The red œsophageal tube now appears. Great care must be taken to avoid the recurrent laryngeal nerve, which, if necessary, is to be drawn downwards and inwards with a small hook. The nerve ascends along the groove between the trachea and the œsophagus, so that the latter must be opened quite laterally, or towards its postero-lateral aspect. It is difficult to open it in the collapsed condition. It should, therefore, be expanded by the introduction of a bougie or an olive-shaped probang. The patient is fed through a soft œsophageal tube which is passed from the wound and retained in position; the wound is stuffed with iodoform gauze. After a simple incision into the œsophagus, the latter may be closed with catgut, in which case the main wound must be left completely open, and a gauze tampon inserted in the lower end. Gussenbauer has incised deeply-situated fibrous strictures of the œsophagus through an œsophagotomy wound in the neck.

43. Resection of the Œsophagus. Resection of the cervical portion of the œsophagus is here considered, an operation which is practically always undertaken for carcinoma. We have performed it several times, and intend to publish the details of our cases.

The portion of œsophagus to be dealt with extends from behind the cricoid cartilage to the level of the episternal notch.

In 1873 Czerny first performed *œsophagectomy for carcinoma* with success. Since that date a large number of excisions have been performed, mostly in conjunction with excision of the larynx, the thyroid gland, the internal jugular vein, or lymphatic glands. Mikulicz recorded ten cases in 1886, and Rose a successful case in 1887.

The following is a description of the operation by which we successfully excised a carcinoma situated 19 cm. ($7\frac{1}{4}$ inches) from the upper incisor teeth.

[1] *Centralbl. f. Chir.*, 1906, No. 45.

The collar incision was made as for excision of the thyroid, and the skin, platysma, and fascia were dissected up. After ligaturing the thyroidea ima vein, inferior thyroid vessels and accessory lateral thyroid veins, the left lobe of the gland, which was much enlarged, was turned over to the right, and subsequently excised, the superior thyroid artery and vein being ligatured, and the isthmus crushed, tied and cut across—exactly as described for excision of the thyroid gland.

The œsophageal growth could now be readily felt and its upper and lower limits defined. It extended upwards a little beyond the cricoid, but was chiefly placed behind the upper rings of the trachea. The œsophagus was first freed at the level of the manubrium sterni, and raised up by passing an aneurysm needle behind it. Before, however, this could be effected the recurrent laryngeal nerve ascending from the thorax had to be divided. The nerve was exposed without difficulty, but on following it upwards, we found that it was flattened out on the surface of the tumour to which it was firmly adherent.

In a similar manner the lowest portion of the pharynx above the tumour on the posterior surface of the cricoid cartilage was freed by dividing the inferior constrictors.

The indurated portion of the œsophagus was now raised off the front of the vertebræ, and an attempt made to separate it from the trachea by blunt dissection; but as it was adherent to the membranous part of the trachea for most of its length, we had to remove the posterior ends of the tracheal cartilages for a distance of 4 cm. as well as a large piece of the posterior plate of the cricoid, together with the membranous part of the trachea. The tumour having been freed in this way, the œsophagus below it was drawn up on the finger, and opened in its long axis, a stiff stomach tube being inserted through the opening. The œsophagus was then firmly ligatured round the tube below the point at which the opening had been made, and cut across.

The freed portion of the œsophagus could now be completely separated from its surroundings by drawing the trachea forward with a sharp hook, after which a circular ligature was applied above the tumour, and the pharynx divided, by which means the tumour was cleanly excised wide of the disease.

The œsophageal tube was left *in situ*, the wound plugged with xeroform gauze, and the trachea opened in front, above the sternum.

The patient was kept with the head low and the trunk in an oblique position. He was allowed up the next day, and fed as generously as possible. By this method there was no soiling of the wound either at the operation or in the first few days immediately succeeding. As a precaution the edges of the mucous membrane on both stumps were touched with the thermo-cautery, while the œsophageal tube was left in position.

In a second similar case the curved transverse incision above the episternal notch proved equally satisfactory, and here also the left lobe of the thyroid had to be removed and the recurrent laryngeal nerve divided. On the other hand, the affected portion of the œsophagus, 4 cm. in length, could be separated from the trachea by blunt dissection.

In this case also an œsophageal tube was firmly tied into the lower end of the œsophagus, but it was at the same time brought out through the upper part of the pharynx and mouth, after the pharynx had been divided above the tumour and tied in position here also. The œsophagus was thus closed above and below, while the two parts were connected by the rubber tube. Tracheotomy was not immediately performed, but was found necessary later on on account of dyspnœa. On the other hand, a preliminary gastrostomy was made.

Tracheotomy and gastrostomy are necessary preliminaries to resection of the œsophagus. If a portion of the trachea has to be excised, it is better to cut the trachea across and stitch it to the skin at once, in order to avoid the danger of decomposing mucus entering its lumen. The lower end of the divided œsophagus may also conveniently be stitched to the skin, the upper end being closed and dealt with at a subsequent plastic operation. The wound must always be packed with xeroform or in part with iodoform gauze.

In regard to the direction of the skin incision, we are convinced from our experience in a third case in which an annular carcinoma extended behind the cricoid and uppermost ring of the trachea, that when the disease is situated high up, the longitudinal incision described for œsophagotomy affords sufficient access.

Hans has also described a mesial incision by which he opens the anterior wall of the œsophagus behind the trachea.

44. Pharyngoplasty and Œsophagoplasty. After an excision of the larynx and pharynx, Helferich restored the continuity with the cavity of the mouth by a plastic operation. The lower end of the pharynx, which had been closed at the first operation, was reopened and the interval between it and the œsophagus replaced by a tongue-shaped flap of skin, the cutaneous surface of which was directed inwards. The patient was able to eat and drink without discomfort. Bougies were passed at intervals, while the tracheotomy opening in the neck was left. Schalita (Mandelberg) has also restored a defect in the œsophagus after operation in a similar manner, excellent swallowing power being obtained.

Roux has recently, and with success, attempted œsophagoplasty in a very interesting manner, viz. by implanting a portion of intestine under the skin and connecting it with the œsophagus in the neck (*vide* Section on resection of the thoracic portion of the œsophagus).

45. Surgery of the Retro-pharyngeal Space. Congenital tumours are not infrequently met with in the region of the pharynx. With the exception of branchial-cleft carcinoma, they have as a rule no intimate connection with the pharyngeal wall, and can therefore be removed with comparative ease by our normal incision, without the necessity of opening the pharynx.

Special attention should be paid to the retro-pharyngeal glands, which have been accurately described by Giletti. Suppuration in these glands may occur secondary to disease in the pharynx or middle ear in children, as a result of which an acute retro-pharyngeal abscess is formed. In addition they are frequently the seat of tuberculous disease and give rise to prevertebral abscesses. A retro-pharyngeal abscess may further occur as the result of spinal caries.

The abscess pushes forwards the posterior wall of the pharynx, and may be opened by puncture at the level of the velum palati. Great care must, however, be taken to prevent the pus from entering the pharynx owing to the risk of choking or aspiration pneumonia. The method is only to be adopted in opening acute abscesses which cannot be felt from the exterior.

Tuberculous abscesses tend to spread towards the side of the neck, displacing forwards the great vessels of the neck. We were able recently to correct a diagnosis by this sign, the condition having been previously regarded as acute struma.

Such an abscess should always be opened from the exterior, as the operation can thus be performed aseptically in contrast to the method of opening through the pharynx.

For fluctuating tumours in the upper division of the anterior triangle Burkhardt recommends making the incision along the anterior border of the sterno-mastoid, and then passing inwards close to the larynx. But it is better in abscesses reaching further down to adopt Chiene's procedure, according to Bruns and Haas, and pass in at the posterior border of the sterno-mastoid. The incision is made parallel to the posterior border of the muscle, which is exposed after dividing the fascia; the superficial cervical nerves and the external jugular vein are avoided and the muscle retracted forwards with a blunt hook. The large internal jugular vein then appears and is retracted forwards after dividing the omo-hyoid. The scaleni muscles are exposed and the dissection is carried obliquely inwards along the side of the vertebral column. The abscess is now seen in front of the vertebral column, lying underneath the prevertebral fascia. Lower down in the neck, the inferior thyroid artery, which passes obliquely upwards in front of it towards the middle line, is divided between two ligatures. It is sufficient simply to push a blunt instrument through the deep fascia. Retro-œsophageal abscesses can also be evacuated by this method.

These abscesses, which result chiefly from tubercular disease of the vertebræ and

the lymphatic glands, are dangerous not only through obstructing the entrance to the larynx, but also on account of the possibility of sudden asphyxia if they be allowed to burst.

If there is necrosis of a vertebra the sequestrum can, in many cases, be removed with Lorenz's right-angled curved spoon.

Most (Breslau) has also removed a retro-pharyngeal lymphoma which had undergone caseous degeneration by dissecting between the common facial and internal jugular veins.

46. Radical Operation for Congenital Fistula in the Neck. These fistulæ which generally open at the lower end of the sterno-mastoid muscle obstinately resist all half measures of treatment. They can only be cured by complete excision of the canal, an operation which is not difficult, in spite of the deep situation of the upper part of the sinus, if the technique is properly carried out.

It is very desirable to introduce a probe, so that the direction of the canal can be defined. In one of our latest cases an excellent radiograph was obtained by injecting an emulsion of bismuth into the canal. The skin and platysma are incised down to the wall of the canal and the latter is then dissected out without difficulty as a tube, half as thick as a quill and irregularly dilated in places.

After excising an ellipse of skin round the opening, the tube is dissected up as far as the back of the great cornu of the hyoid and the posterior belly of the digastric and stylohyoid muscles. From this point onwards the tube is fairly loosely imbedded in the tissues, and is best freed by blunt dissection (v. Hacker's method). The upper end of the tube is dealt with by drawing it through the pharyngeal orifice, which generally must be dilated for this purpose, either by invaginating it from below with a fine pair of forceps, or by passing a probe from the opening in the pharynx and withdrawing it after firmly tying the tube round it. The tube is then drawn into the pharynx and mouth, ligatured and removed. By this method one can be sure of completely removing it, while at the same time its internal opening is closed. The external wound heals readily after drainage for a day or two.

47. Operation for Spasmodic Torticollis. The operative treatment of this distressing condition varies according to the nature of the spasm. Simple rotary spasm must be sharply distinguished from extensor spasm. In the former it is sufficient to throw the rotator muscles on the affected side out of gear; while in the latter, where the head is retracted, one has to paralyse temporarily a considerable extent of the extensor muscles of the back of the neck.

Neurotomy of the upper four cervical nerves is the treatment most usually adopted for rotary spasm. It is, however, a severe operation, and one which is very difficult to perform with accuracy, while it has the further disadvantage that the successive division of all the motor nerves to the muscles of the neck results in a definite paralysis. In our opinion it is a fortunate occurrence that some of the branches occasionally escape division.

If the large flap that is recommended by Gardner and Keen,[1] who originally proposed the resection of the first four cervical nerves, is made, *i.e.* by an incision extending from the external occipital protuberance to the mastoid process, and from the latter point to the spine of the sixth cervical vertebra, in order to expose the exits of the cervical nerves, one has to divide the muscles of the back of the neck to a considerable extent. We reproduce in Fig. 281 a diagram taken from Spalteholz's *Anatomy* (vol. iii.) which gives an admirable illustration of the nerves referred to.

In preference to this operation we simply divide all the affected muscles[2] and have obtained excellent results in a series of cases. We will here describe the method of performing the operation on the living subject in a case of simple rotator spasm to the right, and append an illustration of the muscles affected from a dissection made by Tramond (Fig. 282).

The first point of importance which arises in a case of right-sided rotator spasm is the division of the left sterno-mastoid, section of the spinal accessory nerve being

[1] Tubby, *Brit. Med. Journ.*, June 1906. [2] De Quervain, *Semaine médicale*, Oct. 1896.

also permissible on account of the accuracy and ease with which the branch of the nerve supplying this muscle can be reached.

To divide the sterno-mastoid an incision is made through skin and fascia along the upper third of its anterior border, after which the muscle is clearly defined (care being taken to avoid the small occipital nerve at its posterior border), and a blunt dissector passed underneath it. The whole muscle is then cut across a little below the mastoid process. In the milder cases, instead of simply cutting it across less disfigurement may be produced by elongating the muscle, while if the Z incision is used for this purpose (*vide* Tenoplasty in the introduction to Surgery of the

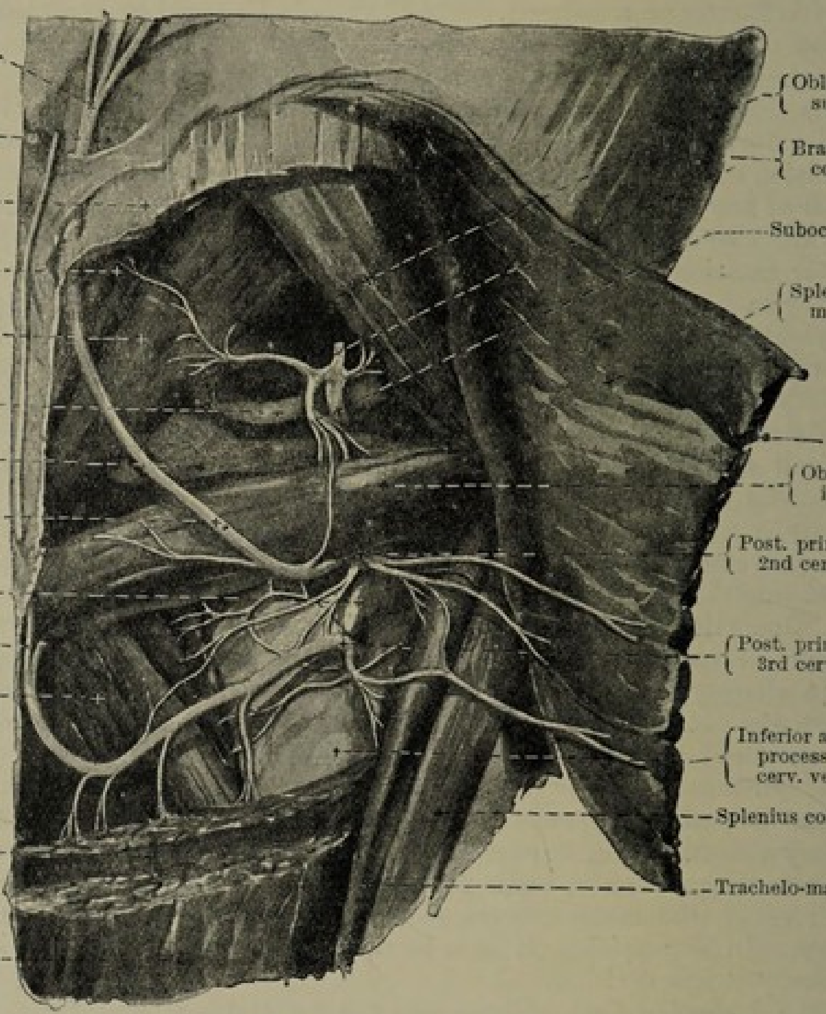


FIG. 281.

Extremities), the amount of elongation obtained must not be less than 6 cm. ($2\frac{1}{2}$ inches).

Division of the nerve, which is a simpler operation (*vide* Spinal Accessory Nerve in the surgery of the peripheral nervous system), is performed through an incision along the anterior border of the muscle, dividing the skin and platysma, and retracting the external jugular vein and great auricular nerve backwards and the facial and temporo-maxillary veins forwards.

The transverse process of the atlas is now defined, in front of which the spinal accessory is recognised as a fairly large nerve passing backwards to the deep surface of the sterno-mastoid. By raising it up on a hook, the branch proceeding to the sterno-mastoid can be readily distinguished from that supplying the trapezius. The latter, which is of large size, runs directly backwards from the sterno-mastoid and must be preserved.

The muscles of the neck, which must be divided in a case of right rotary spasm, are the right splenius capitis and colli, the right trachelo-mastoid, and the right obliquus capitis inferior.

A transverse incision, two fingers'-breadth below the superior curved line of the occipital bone, is now carried outwards and downwards from the anterior border of

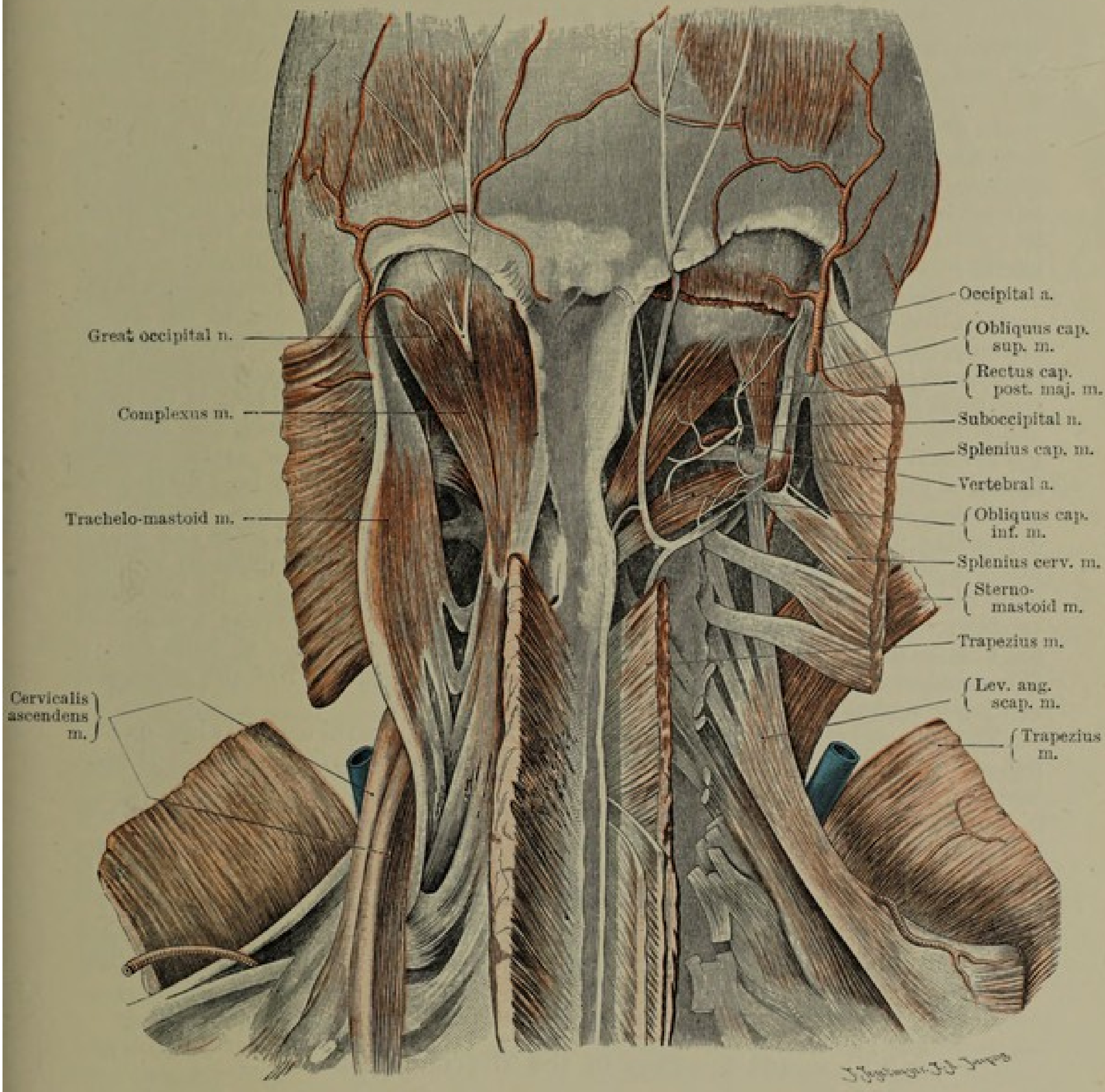


FIG. 282.—Dissection of the muscles of the neck (Tramond), to illustrate the relations of the muscles, vessels, and nerves in Kocher's operation for spasmodic wry-neck.

the trapezius to the sterno-mastoid. The splenius capitis is first divided in its entire breadth, not too near the bone, the small occipital nerve and the occipital artery being avoided. External to the splenius capitis the slender trachelo-mastoid is divided below its insertion into the mastoid process, and close to it the slips of the splenius colli to the transverse processes of the first and second cervical vertebræ are also cut across. The outer border of the thick complexus is now drawn inwards with a hook (or incised) exposing beneath it one of the most important of the rotator

muscles, viz. the obliquus capitis inferior, which passes from the spine of the second cervical vertebra to the transverse process of the atlas. This muscle must be thoroughly divided, care being taken to avoid the sensory great occipital nerve which hooks round its lower border.

The operation gives excellent results in pure rotary spasm, primary union being readily secured. On the other hand, in cases where an extensor spasm also exists, a much more drastic procedure is required. Not only must the attachments to the skull of the trapezius and complexus (sometimes also the slip of the semispinalis cervicis to the spine of the second cervical spine) be divided, but the small muscles of the neck, viz. rectus capitis posticus, major and minor, and obliquus superior as well, and occasionally on both sides.

In order to prevent excessive sinking-in of the transverse scar below the occiput, a transplantation operation may be considered, which is effected by freeing the trachelo-mastoid and stitching it to the peripheral portion of the trapezius after the latter has been divided at a distance from the occiput. Tavel recently operated on two cases by this method, and obtained satisfactory results, in the second case a plaster of Paris bandage being found of great service after the operation.

48. Exposure of the Thoracic Duct. The exposure of the thoracic duct is the same as that of the subclavian artery above the clavicle. In the root of the neck it arches outwards behind the left common carotid and opens into the subclavian vein close to its junction with the internal jugular vein. The duct may be exposed by a transverse incision through skin and fascia above the clavicle, dividing at the inner end of the incision part of the clavicular origin of the sterno-mastoid, and avoiding the external jugular vein, the incision being carried outwards as far as the anterior border of the trapezius. After the fascia and the fatty tissues have been divided the subclavian vein is seen lying on the scalenus anticus with the internal jugular vein descending towards it. The latter vein is freed along its outer border and drawn inwards, exposing the phrenic nerve (which must on no account be injured), running obliquely downwards and inwards on the scalenus anticus muscle. By dissecting carefully along the internal border of the scalenus anticus, transverse branches of the inferior thyroid artery are encountered, on dividing which the thoracic duct is discovered ascending from the mediastinum to reach the junction of the subclavian and jugular veins.

The exposure of the duct is undertaken not for the purpose of operative interference but as a precautionary measure in operations in the supra-clavicular fossa. It may, however, be ligatured or sutured in cases of injury.

Cushing was probably one of the first to suture the duct for injury. Thin silk and fine needles are required as in arteriorraphy, while the insertion of a magnesium tube, according to Payr's method, deserves occasional consideration. As a rule it is sufficient to ligature the duct or simply to pack the wound. The escape of chyle following division of the duct may prove very exhausting, but it generally ceases of its own accord. Unterberger (Garré's clinic) has collected 29 cases where the duct was injured during operation.

(d) Surgery of the Thyroid Gland

49. Indications for and Results of Operation for Goitre. The greatest number of tumours of the thyroid gland which call for surgical interference are of an innocent character. They are all included under the old term "goitre," the amount of mechanical interference with respiration depending on the relative position of the tumour. Too little attention has been paid to the altered character of the heart's action, associated with a simple goitre, which, although partly due to mechanical causes, is also greatly benefited by surgical treatment.[1]

[1] We hope shortly to deal fully with this subject, but have already expressed our opinion on it at the Medical Congress in Munich, April 1906, and on the occasion of two lectures to the Medical Societies of London and Cardiff, May 1906.

In addition, the question of surgical interference has also to be considered in Basedow's disease, as well as in inflamed and malignant goitres; in the former case early operation affords the most speedy and certain chance of success.

As a rule, a portion of the gland is excised in diseased conditions of the thyroid. In inflammatory goitres the treatment consists in incision, while in vascular goitres and in Basedow's disease, ligature of the vessels is undertaken. Apart from these minor operations (we have treated a great number of vascular goitres by ligature of the vessels), we have up to the present [1] performed excision on 3333 occasions.

The remarkable advances that have been made in wound-treatment are probably more conspicuous in this than in any other branch of surgery, notwithstanding the difficulties and the complicated character of the operation.

As we stated in a communication delivered at the German Surgical Congress, only three deaths occurred in 904 operations for simple goitre (in our third series of a thousand cases), the fatal termination in each case being attributable to cachexia, existing paralysis of both recurrent laryngeal nerves, and lesions of the heart and kidneys. If we bring up the total to 1000 by including 96 cases from our fourth series of a thousand, the percentage mortality of 0·4 per cent is obtained. In the 333 cases of our fourth thousand cases we have only lost one patient, who suffered from a high degree of dyspnœa associated with bronchitis and emphysema.

One may, therefore, conclude that in the various forms of colloid goitre, operative treatment, if carried out on definite lines, is free from danger, and should therefore be undertaken in all cases where medicinal treatment has failed, or—as happens in a large number of cases—has actually proved harmful.[2] In many cases medical treatment is hopeless from the beginning.

The iodine treatment is of no use, for instance, in the cystic goitres. It does harm in all cases where "goitre-heart" is present either in a mild or more severe degree, as well as in the inflammatory forms, while it offers no prospects of success in large nodular or in malignant goitres, especially in the latter where the favourable time for radical cure is allowed to elapse.

All goitres should be operated on when they are nodular, cystic, or becoming adherent, especially in the case of adults; when they extend into the thoracic inlet, or compress the trachea, and, lastly, when there is the least suspicion of malignancy, *i.e.* from the character of their growth, their hardness, irregularity, and fixation.

Notwithstanding these wide indications, however, one must bear in mind that here, as in all operations elsewhere, there is a limit fixed, beyond which surgery treads on uncertain ground.

50. Conditions influencing Extirpation of a Goitre. Notwithstanding all aseptic precautions and improved technique, we may lose our patient after excision of the thyroid when one or other of the following conditions exist:—

1. When there has been marked tracheal stenosis of long duration with constant emphysema and bronchitis, which, by causing imperfect oxygenation of the blood in the lungs, has interfered with the functions of other organs, especially the heart, the latter becoming dilated as a result of emphysema.

2. When the cardiac tone has been weakened by other causes, *e.g.* by general adiposity, with fatty heart; by atheroma, especially of the coronary arteries, with resulting myocarditis; by all conditions of venous stasis which have led to marked dilatation of the right side of the heart, with irregular, weak, and rapid pulse.

3. Where there is marked interference with the venous circulation, *e.g.* by a goitre pressing on the large vessels at the inlet of the chest, especially if thrombosis has occurred.

All these conditions are characterised by severe dyspnœa (which is frequently more marked and more troublesome than would be expected from the existing enlargement) and by deep cyanosis of the face, and occasionally of the hands, and, finally, by œdema of the face, hands, and feet. The puffiness of the face is often very striking.

[1] 9th Feb. 1907.

[2] Careless treatment with iodine is now more dangerous than excision of the goitre.

4. Where the entire thyroid is in a state of diffuse follicular colloid degeneration, with the healthy gland tissue reduced to a minimum. Such goitres are often of large size, and surround the trachea as a dense mass which is very slightly movable, having a firm nodulated consistence. To excise them is a difficult and bloody operation. Acute tetany may set in, and cannot always be combated by administering thyroid preparations. It is best, under these circumstances, to begin by ligaturing the vessels of supply to the gland, and, later on, when the tumour has diminished in size, to perform a unilateral excision.

5. In debilitated patients suffering from Basedow's disease, with extreme emaciation, irregularity of pulse, and a high degree of tachycardia. Even although we refrain from using either a general anæsthetic, or any antiseptic, these patients occasionally die in a few days, the wound remaining perfectly healthy. Here also preliminary ligature of the arteries is the rule, excision being performed later, if there are any indications of pressure on the trachea.

6. Where the tumour is malignant with marked infiltration and enlargement of the glands, where there are signs of thrombosis, and where the general condition of the patient is deteriorating, in which cases we have had better results and prolonged life with the administration of arsenic.

7. Where the goitre is inflamed, the inflammation involving the capsule and the structures adjacent to it. Removal of the thyroid in an acute inflammatory condition exposes the patient to the danger of a spreading wound infection ; and if the goitre is in a state of chronic inflammation, its removal is often attended with severe hæmorrhage and shock (recurrent paralysis).

In those numerous cases where the above dangers (which are chiefly due to undue delay in operation) do not exist, we aim at a rapid, sure, and successful cure by operation under the following conditions :—

1. By avoiding all antiseptics, both in preparing the patient and during the operation, and by using the strictest aseptic precautions.[1]

2. By substituting novocain and adrenalin for a general anæsthetic. Nervous and sensitive patients with healthy lungs and heart may be anæsthetised with a mixture of air and ether (Braun's method) without hesitation. Vomiting during and after the operation often prevents primary healing by causing restlessness and secondary venous hæmorrhage, and by soiling of the dressings.

3. By using a large incision properly placed. We recommend our symmetrical "collar incision" as shown in Fig. 283. This incision leaves a scar which is hardly perceptible, while it gives plenty of room, and has the great advantage of enabling one to determine, in doubtful cases, which lobe is causing the greater amount of compression. We would especially warn the beginner against using small incisions which interfere with the arrest of hæmorrhage, and make it more difficult to remove more deeply-seated processes of the tumour. Our angled incision is to be preferred only in difficult highly-situated and adherent goitres, as it then greatly simplifies their removal.

4. By careful ligature of the chief arteries and veins (superior and inferior thyroid artery and veins, thyroid ima vessels, and the accessory veins), and at the same time by freeing the goitre within its fibrous capsule. This is the only way in which one can guard against severe loss of blood during the operation, against injury to the recurrent laryngeal nerve, reactionary hæmorrhage, and especially against tetany as the result of interference with the parathyroids which are related to the lower poles of the gland. Special care must be taken, if the removal of both lower poles is indicated, not to interfere with the parathyroids.

5. By preserving the sterno-laryngeal muscles along with their nerve-supply. If they are not preserved, the deformity, which results from the sinking-in of the soft parts, is considerable. We enter in the middle line between the muscles and detach

[1] The precautions we take to prevent infection have been already stated in the discussion of wound-treatment, where we showed how infection from the nose and mouth is guarded against by stretching a cloth transversely on a hoop between the neck and the head. Bungener has attempted to simplify this measure by using a small hoop hung over the ears and fixed to the chin.

them, if necessary, from their upper insertions. In this way their nerve supply remains uninjured, while the principle of muscle "disinsertion" is carried out (cf. Küttner's and Quervain's flap incisions). The divided muscles should always be carefully re-sutured.

51. Comparison with other Methods. It is convenient to call attention here to the differences between our method of operating and that of Billroth, for as Burkhard[1] has observed, various misconceptions exist in regard to their respective features. Our method is distinguished from Billroth's by the totally different skin incision that is adopted. Billroth, as a rule, employs an oblique incision which fails to leave so fine a scar as that given by the collar incision, at the same time affording less satisfactory access. A second distinction is that in our method we carefully preserve the muscles, which play an important part in the prevention of subsequent deformity.

A further difference of which too little notice has been taken, is that we dislocate the goitre *before* the main vessels are ligatured, the accessory veins alone being previously tied. It is only in this way that, as Wölfler has pointed out, the main vessels (superior and inferior thyroid artery and vein and thyroidæ imæ veins which run independently) can be ligatured at a distance from the surface of the tumour.

The latter procedure possesses great advantages, because in dissecting close to the goitre troublesome bleeding from the veins or from the parenchyma may be encountered. Finally, we shell the tumour out of its capsule, *i.e.* the outer sheath of connective tissue, with greater accuracy than is possible by Billroth's method.

We attach great importance to the careful separation of the external capsule, not only because by this method the removal of the tumour is facilitated and the application of the ligatures is rendered easier, but because it enables one to make sure that the external parathyroid bodies are detached and retained along with the capsule round the entrance of the inferior thyroid artery at the lower pole of the gland. Before the capsule can be separated, the dilated veins which we have termed the accessory veins, running from the capsule to the goitre must be double ligatured and divided as they become stretched out in the course of the dissection.

When the exteranl capsule, which might be termed the perithyroideum, and which is generally quite loose, is adherent as the result of inflammation, malignancy, or Basedow's disease, our method of operation becomes more difficult, and one has frequently to tie the vessels close to the goitre as recommended by Billroth.

Lastly, our method of dealing with the isthmus and the portion of the thyroid left behind by means of our goitre crushing-forceps is a new departure which greatly simplifies the operation. This was one of the first objects for which crushing was employed.

52. Normal Procedure for the Excision of a Movable Goitre. A symmetrical transverse curved incision is made, extending from the outer border of the one sterno-mastoid to the outer border of the other. The incision is placed at a higher or lower level according to the position of the goitre. In those lying entirely in the neck and fairly high up, the middle of the incision should be just below the cricoid cartilage, while in those which dip into the thorax it is placed just above the episternal notch. (The lower incisions as a rule leave better scars.) The skin and platysma are divided. This exposes, on the fascia, close to the middle line, the two anterior jugular veins (often double), which are frequently pushed to one side by the goitre (Fig. 285), also an oblique vein which is almost always encountered at the anterior border of the sterno-mastoid. We have termed this the oblique jugular vein (see Fig. 284). All these veins are divided between two ligatures. The external jugular vein, which crosses the sterno-mastoid obliquely from above downwards, may be avoided.

The sterno-hyoid, sterno-thyroid, and omo-hyoid muscles are now seen in the interval between the anterior borders of the two sterno-mastoids. It is important to separate the skin and subcutaneous fascia, along with the veins upwards and downwards off the muscles, so that the veins do not require to be divided a second time.

The sterno-laryngeal muscles are then separated in the middle line, and the

[1] *Centralbl. f. Chir.*, 1904, No. 29.

subjacent fascia is divided upwards and downwards upon the finger passed beneath it. The muscles are then pushed upwards towards the larynx, or incised as much as is necessary, the small muscular vessels coming from above being ligatured (Fig. 290). It is very important to see whether the fibrous external capsule of the goitre is divided at this stage or not. It must be divided, for as a rule it is only the subcapsular separation which can be easily accomplished with a blunt instrument.

Now comes an important step in the operation, viz. the dislocation of the goitre. The finger, introduced underneath the separated muscles and capsule, is carried round

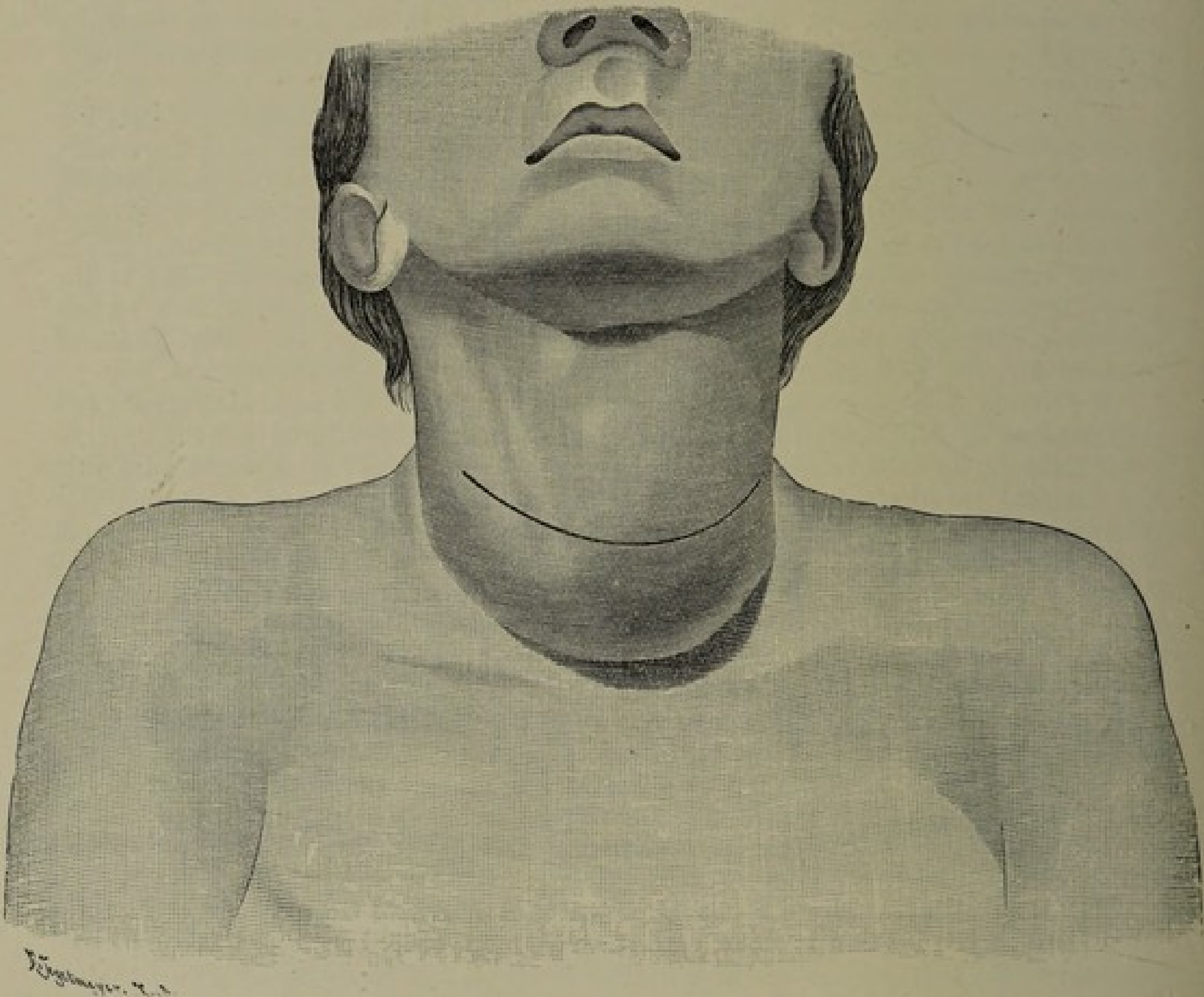


Fig. 283.—Symmetrical transverse curved incision (collar incision) for excision of the thyroid gland. The incision follows the line of cleavage of the skin of the neck, hence a fine cicatrix is obtained.

the tumour, so as to isolate and hook forward the bands which stretch from the neighbouring tissues to the gland, and which contain the veins called by us the accessory veins (Fig. 286, *a*, *b*). These veins are very well developed in large goitres. During the above procedure the muscles and external capsule are drawn aside with blunt retractors. After the accessory veins have been ligatured and divided, the dislocation of the goitre is effected by dragging it forwards with the fingers. Severe dyspnœa, if it exists, at once ceases when the dislocation is effected.

The next step is the ligation of the main vessels, which can be done seriatim. With a blunt dissector (Kropfsonde) the capsule is separated internally and externally from the upper cornu until one can isolate a pedicle consisting of the superior thyroid artery and vein, which pass downwards and inwards. These main vessels are then divided between two carefully-applied ligatures (Fig. 291).

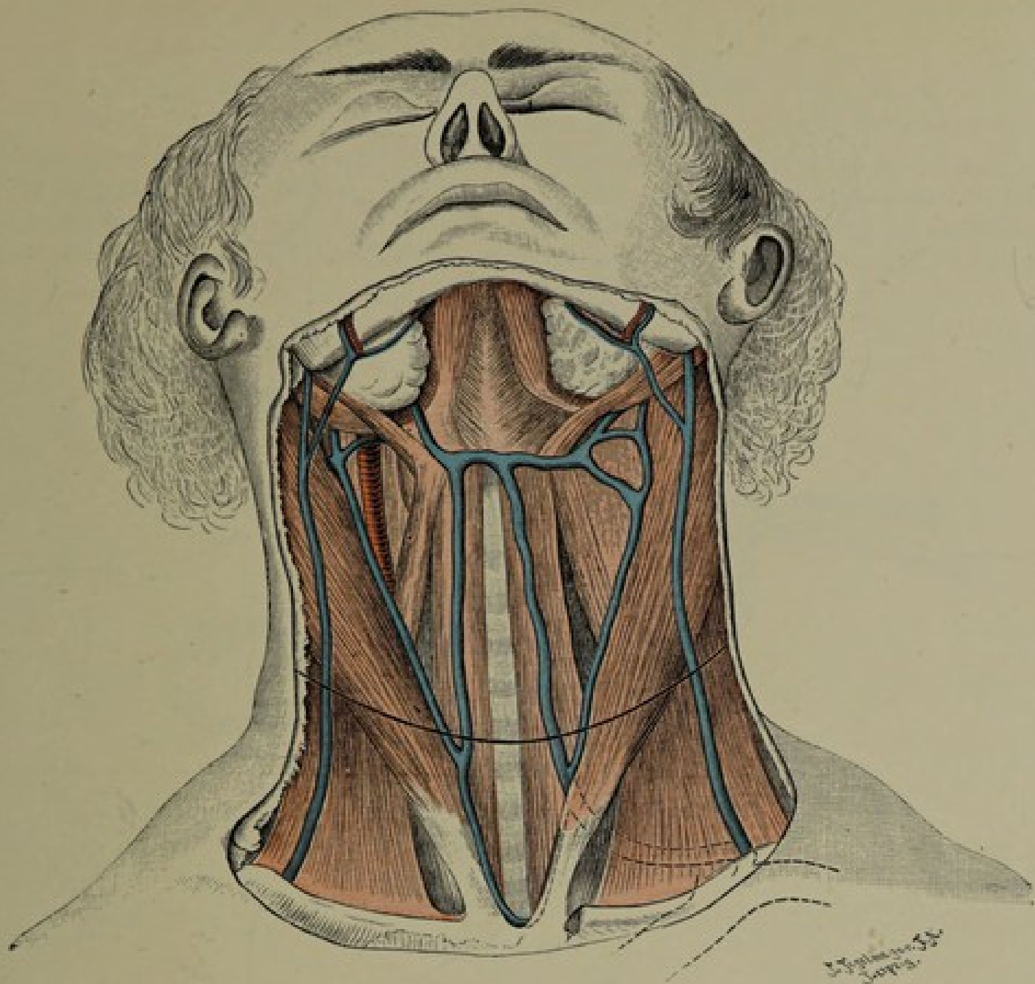


FIG. 284.—Dissection to illustrate the external, oblique, and anterior jugular veins, skin and platysma having been removed. The anterior and oblique veins are necessarily divided in making our collar incision, but the external jugular veins as a rule escape. After division of the skin, platysma, and the veins, the deep fascia is incised down to the muscles.

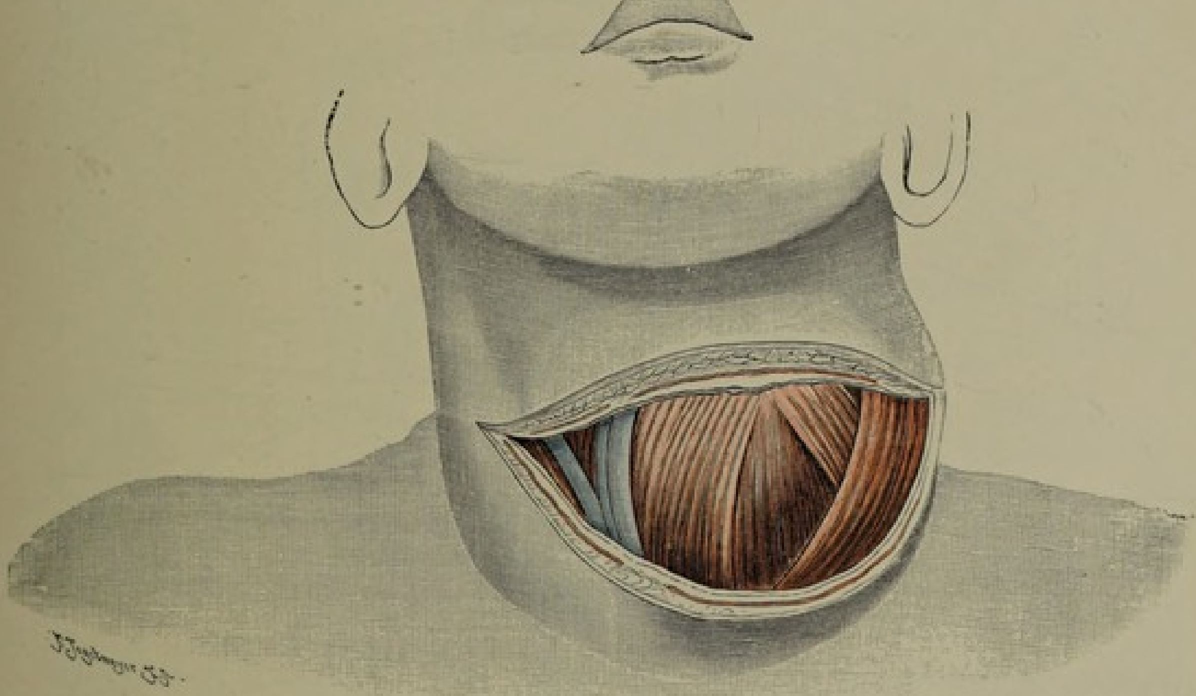


FIG. 285.—On the left of the figure are seen the anterior jugular veins, pushed well over to the right side of the neck. The sterno-hyoid and sterno-thyroid muscles are spread out over the tumour. On the right of the figure is the sterno-mastoid with the omo-hyoid seen running obliquely upwards towards the middle line, all the muscles on this side being displaced outwards.

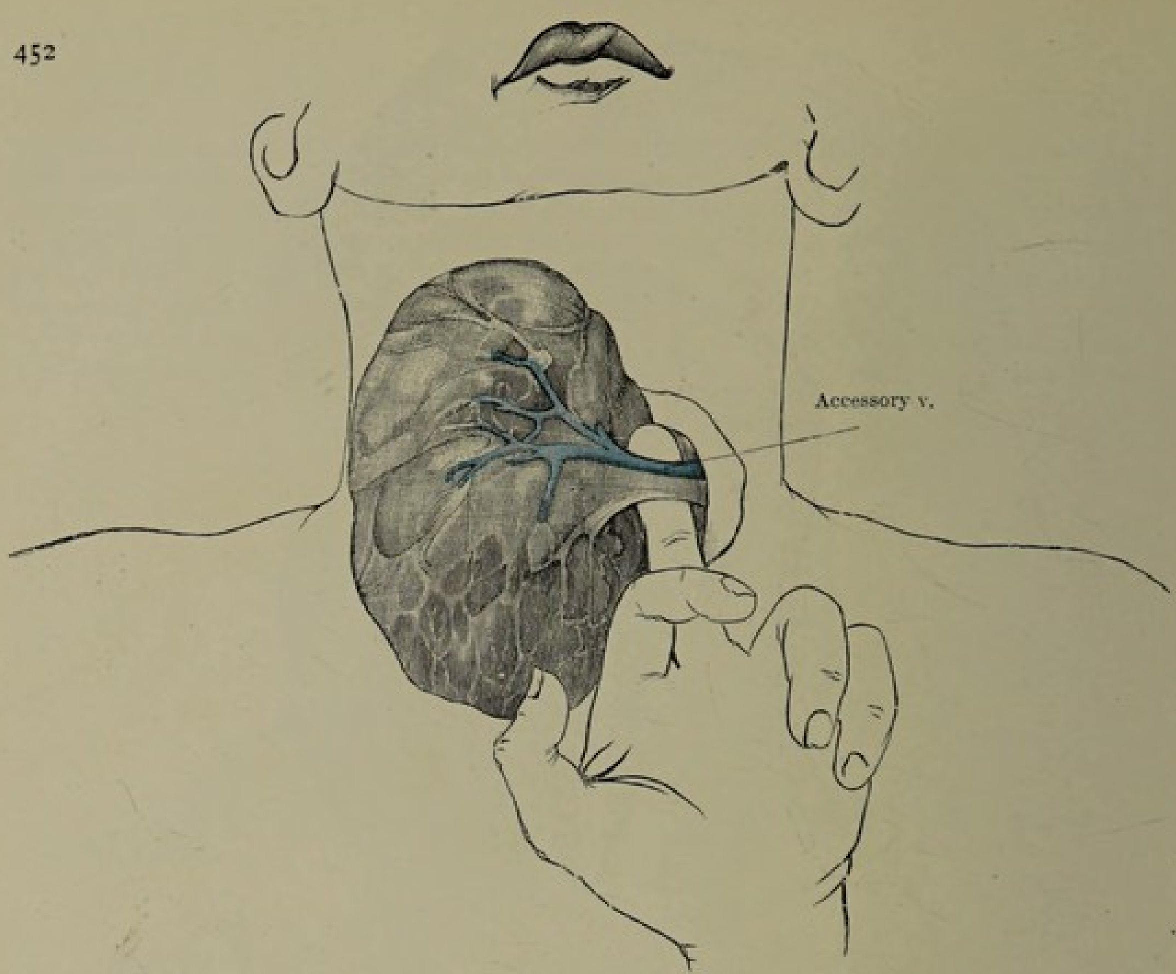


FIG. 286*a*.—The lateral and lower fibrous connection with the strands which contain the accessory veins as they pass from the inner capsule to the outer capsule are seen isolated by the finger prior to being ligatured.

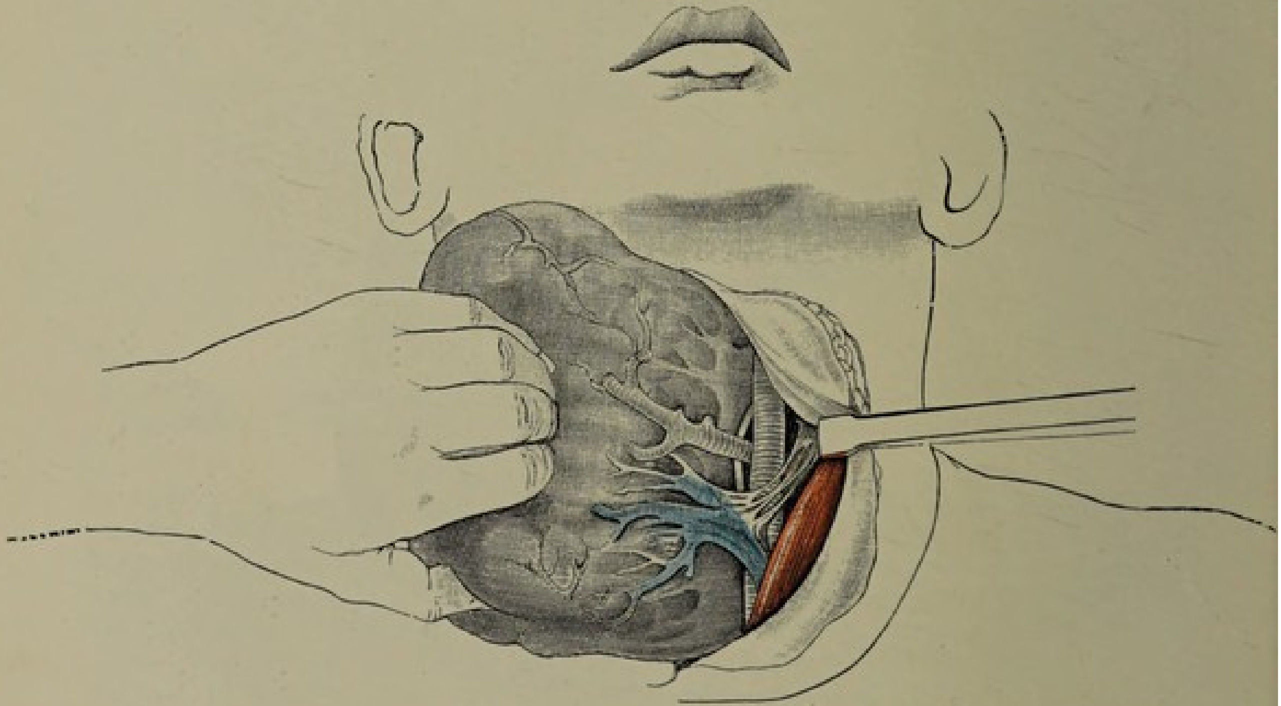
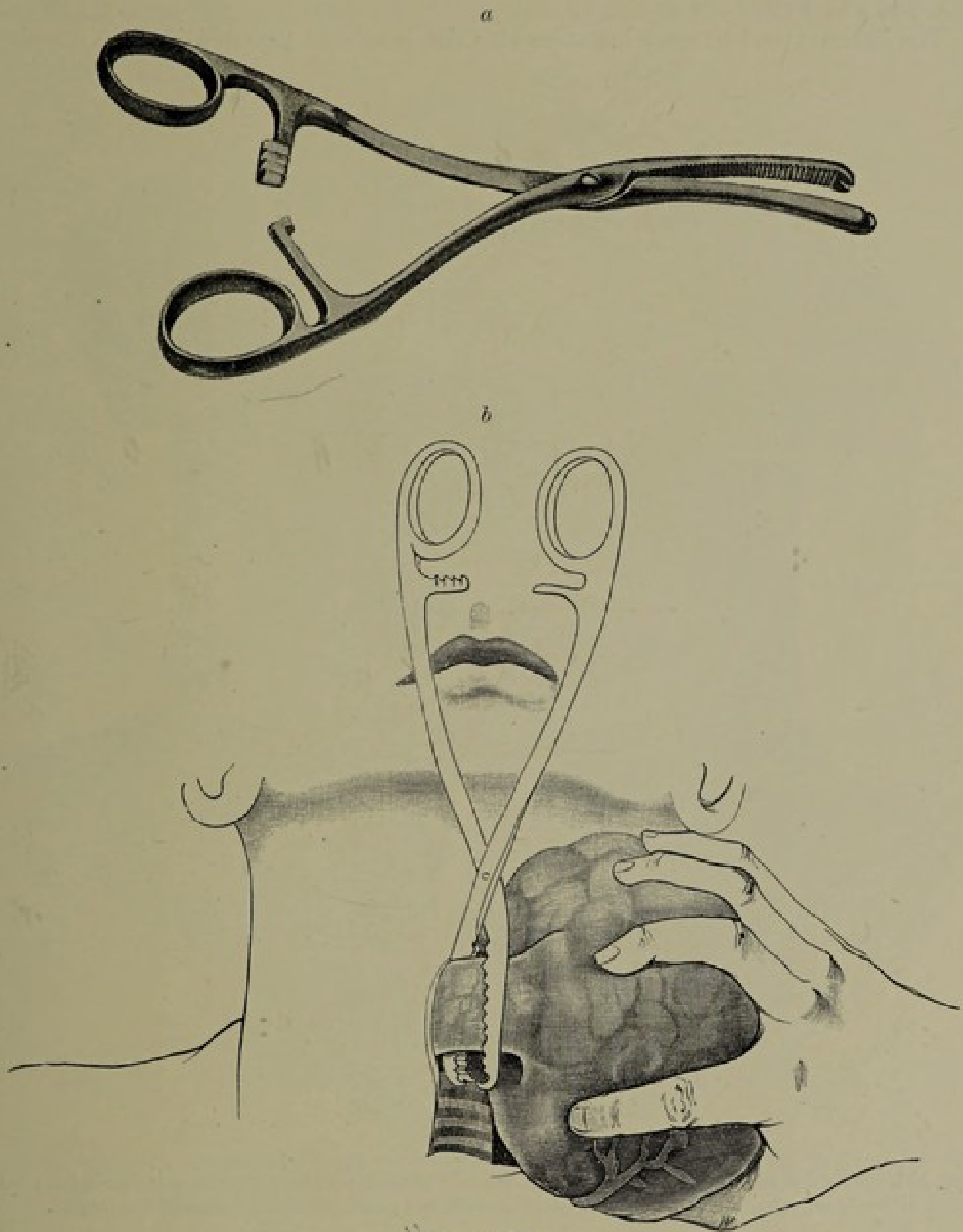


FIG. 286*b*.—The goitre is dislocated and pulled over to the opposite side, the left sterno-mastoid bein well retracted to the same side (more force than shown in the figure). The common caroti artery is seen lying deeply (it is here represented as too superficial and too near the trachea). Crossing in front of it, to the posterior and lateral aspects of the goitre, are the accessory veins, and passing inwards behind it is the inferior thyroid artery, with the recurrent laryngea nerve ascending behind it and dragged forwards by the traction on the goitre.

The inferior thyroid artery lies on the deep muscles of the neck. To expose it the tumour must be forcibly pulled to the opposite side and the muscles on the same side retracted. The vessel is then felt as a pulsating cord emerging in an oblique or transverse direction from behind the carotid, and then passing inwards to enter the



FIGS. 287 *a* and *b*.—*a*, Goitre crushing-forceps. *b*, Application of the crushing-forceps before ligaturing the isthmus.

thyroid at its attachment to the trachea. In ligaturing it, care must be taken to avoid the recurrent laryngeal nerve which ascends behind it (Fig. 291).[1]

[1] In favour of early ligature of the arteries in excision of the thyroid it is pointed out by Doyen, and extensively confirmed by Gubaroff, that venous bleeding is reduced to a minimum, not by tying the veins, because this causes congestion in other veins, but by cutting them through, and by arresting the arterial inflow by tying the arteries.

At the lower pole of the tumour, and generally entering its median surface, there is to be found occasionally a single artery, the arteria thyroidea ima. There are usually two or three large venæ thyroideæ imæ, which leave the inner and anterior aspects of the lower lobe. The outer capsule of the gland having been pushed back, these vessels are isolated with the finger or dissector and divided between two ligatures (Fig. 286 and 292).

The isthmus, and in some instances also the processus pyramidalis, still remain to

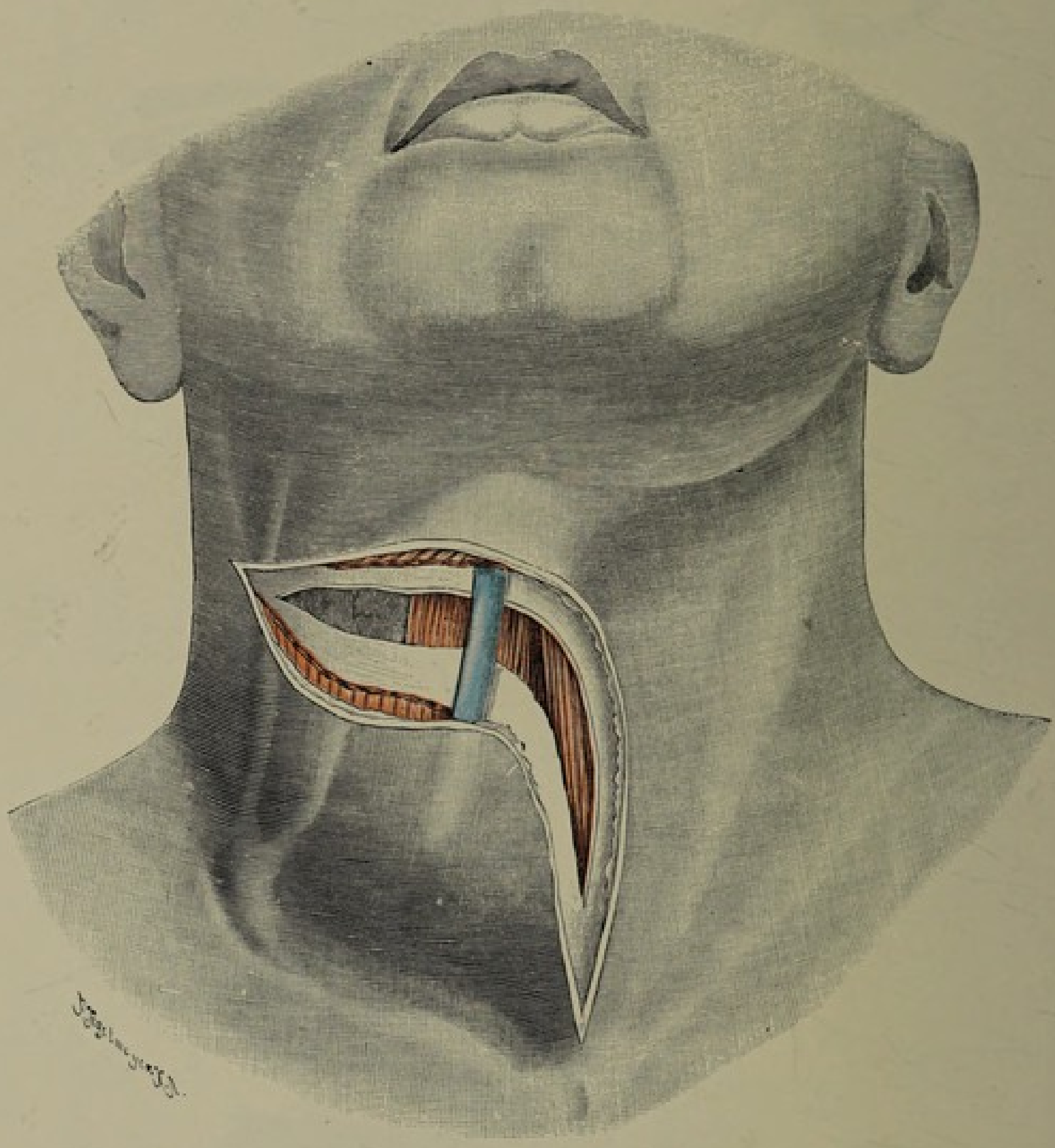


FIG. 288.—Excision of goitre by the angular incision. Stage 1: Skin, platysma and fascia have been divided, exposing the right anterior jugular vein and the depressor muscles of the larynx.

be isolated and divided. The latter is more easily freed and is supplied by a special branch of the superior thyroid artery and vein. In isolating the isthmus it is, as a rule, desirable to separate and divide the communicating branches between the veins of the two sides, which run along the upper and lower borders of the isthmus, and sometimes on its anterior surface. On account of their constant presence and size we have termed them the superior and inferior communicating veins. The isthmus can be separated from the trachea with the blunt dissector without any great bleeding, but care must be taken not to tear the trachea (Fig. 293).

Special forceps are then applied (Fig. 287a), and the isthmus, which is frequently

very thick, is so compressed that after removing the forceps only the vessels and connective tissues are left, which are then firmly tied with a strong ligature before being divided.

The diseased half of the thyroid is now only attached to the trachea and cricoid cartilage. If this part is healthy it should be allowed to remain, a thin layer of gland tissue being left to protect the recurrent laryngeal nerve and parathyroid from

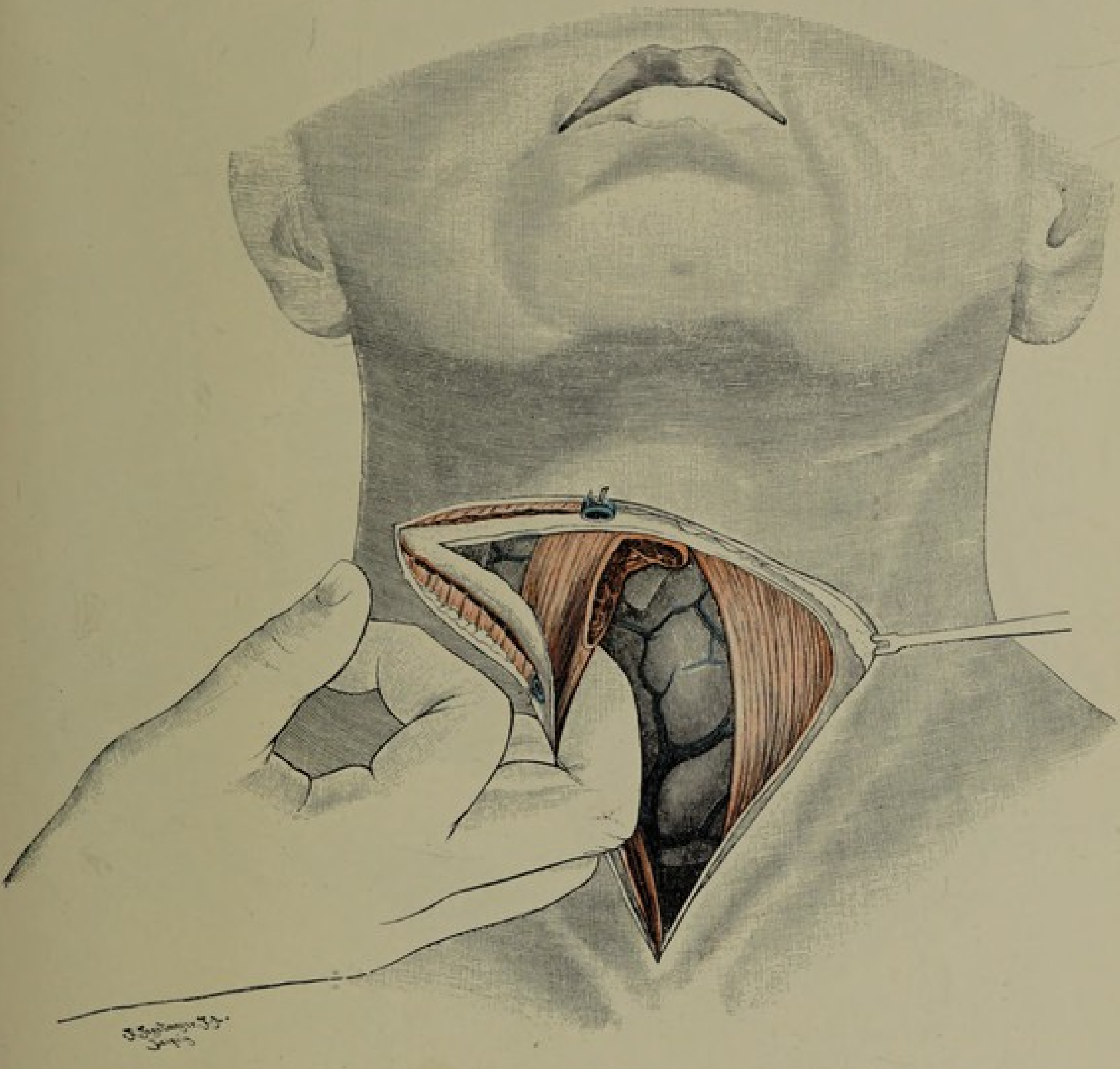


FIG. 289.—Excision of goitre by the angular incision. Stage 2: The fascia between the sterno-laryngeal muscles has been divided and a finger has been pushed underneath the right sterno-hyoid muscle, the upper insertion of which has been nicked.

being cut through or enucleated. One cannot be too careful to avoid injuring this nerve at the last moment, and it is desirable, therefore, to catch every bleeding point.

After ascertaining that the wound is dry, it is stuffed with gauze and covered with gauze towels, while the surrounding parts and the hands are purified, after which the numerous ligatures and sutures are tied, clean sterilised cotton gloves being worn for this purpose. If it has been necessary to completely cut across the upper attachments of the muscles, they should be sutured in position again, the fascia being united in the middle line. The wound is then closed with a continuous suture of fine silk (the platysma and, in stout individuals, the subcutaneous fat must also be

sutured), and a small short glass drainage tube inserted, which may generally be left in for twenty-four hours.

53. Procedure in Difficult Cases. The curved transverse incision is not invariably successful in goitres which extend high up and low down in the neck, and which are very large or firmly adherent. It is therefore in such cases as a large diffuse colloid goitre, an inflamed, or a malignant goitre, or in Basedow's disease that the angled incision greatly simplifies the operation.

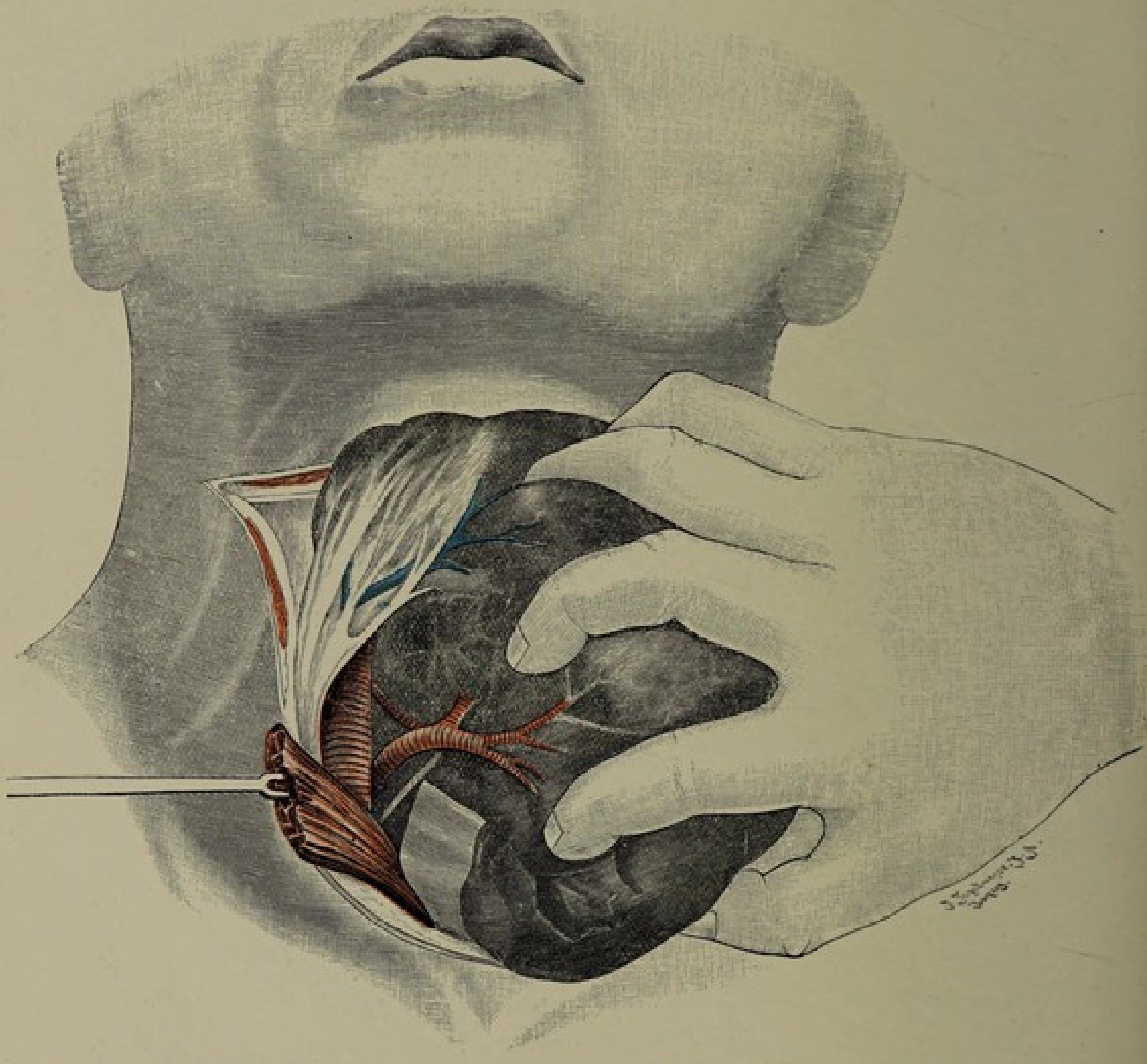


FIG. 290.—Excision of goitre by the angular incision. Stage 3: The fibrous (outer) capsule of the gland has been divided and the goitre displaced to the healthy side (dislocated). The sterno-hyoid and thyroid muscles have been cut across above and turned downwards in order to obtain more room. In the lower angle of the wound the trachea is exposed, and is crossed by the inferior thyroid artery, which passes inwards from under cover of the carotid. The recurrent laryngeal nerve is seen behind the artery. The common carotid is shown more externally, while a portion of the external gland capsule, containing an accessory jugular vein, has not yet been divided.

The angular incision begins at the level of the thyroid cartilage over the prominent part of the sterno-mastoid, and is carried forwards to the middle line following the fold of the neck, and then vertically downwards as far as the suprasternal notch. In deeply situated tumours it may be prolonged on to the manubrium sterni. To facilitate the subsequent suturing a few transverse scratches should be made with the

knife across the line of incision. The skin, and, in the transverse part of the incision, a distinct layer of platysma, are divided (Fig. 288). In the middle line, the large anterior jugular vein, and, at the anterior border of the sterno-mastoid, the "oblique

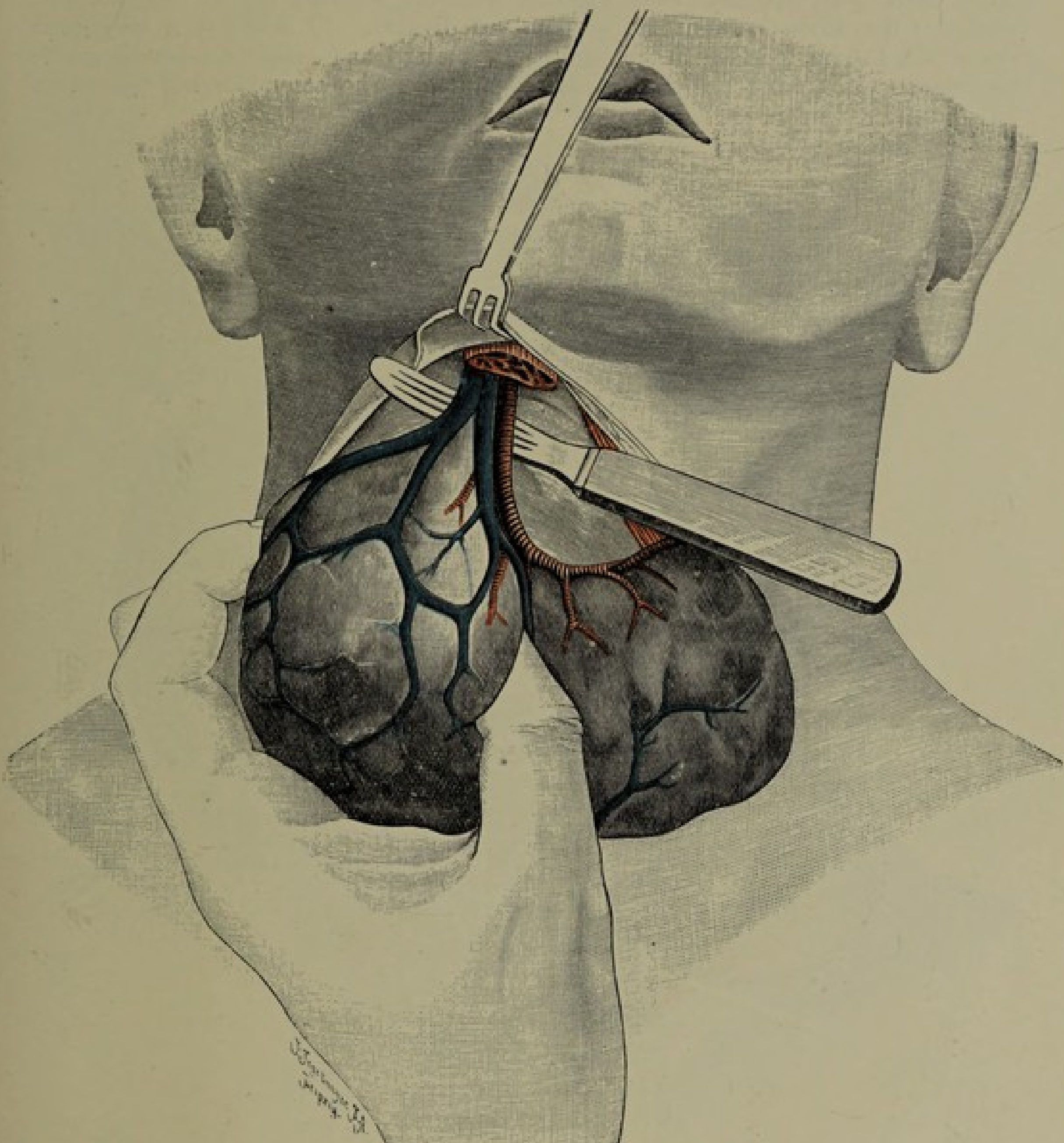


FIG. 291.—Excision of goitre by the angular incision. Stage 4: The outer gland capsule has been divided high up and the accessory veins have been ligatured, allowing the superior thyroid artery and veins to be isolated. They are here shown raised on a blunt dissector, the goitre being at the same time depressed with the left hand. In the upper angle of the wound is seen the cut end of the sterno-hyoid muscle.

jugular" vein, are double ligatured and divided. The external jugular vein, which crosses the sterno-mastoid from above downwards, can be preserved.

After division of the fascia the muscular fibres of the sterno-mastoid are freely exposed at the outer part of the horizontal limb of the incision. The muscle is thoroughly freed along its anterior border and retracted by means of blunt hooks.

In a similar manner the fibres of the sterno-hyoid and sterno-thyroid muscles are exposed and retracted upwards, with the superficial fascia covering then.

The sterno-hyoid muscles are now divided below the hyoid, and the sterno-thyroid muscles below their insertion into the thyroid, and are turned down along with the flap of skin, platysma and fascia together with the external thyroid capsule. In doing this the accessory veins are secured and divided. In this way a very good view of the anterior surface of the tumour is obtained and excellent access is got to the vessels, which are thus more readily ligatured. The accompanying figures, in

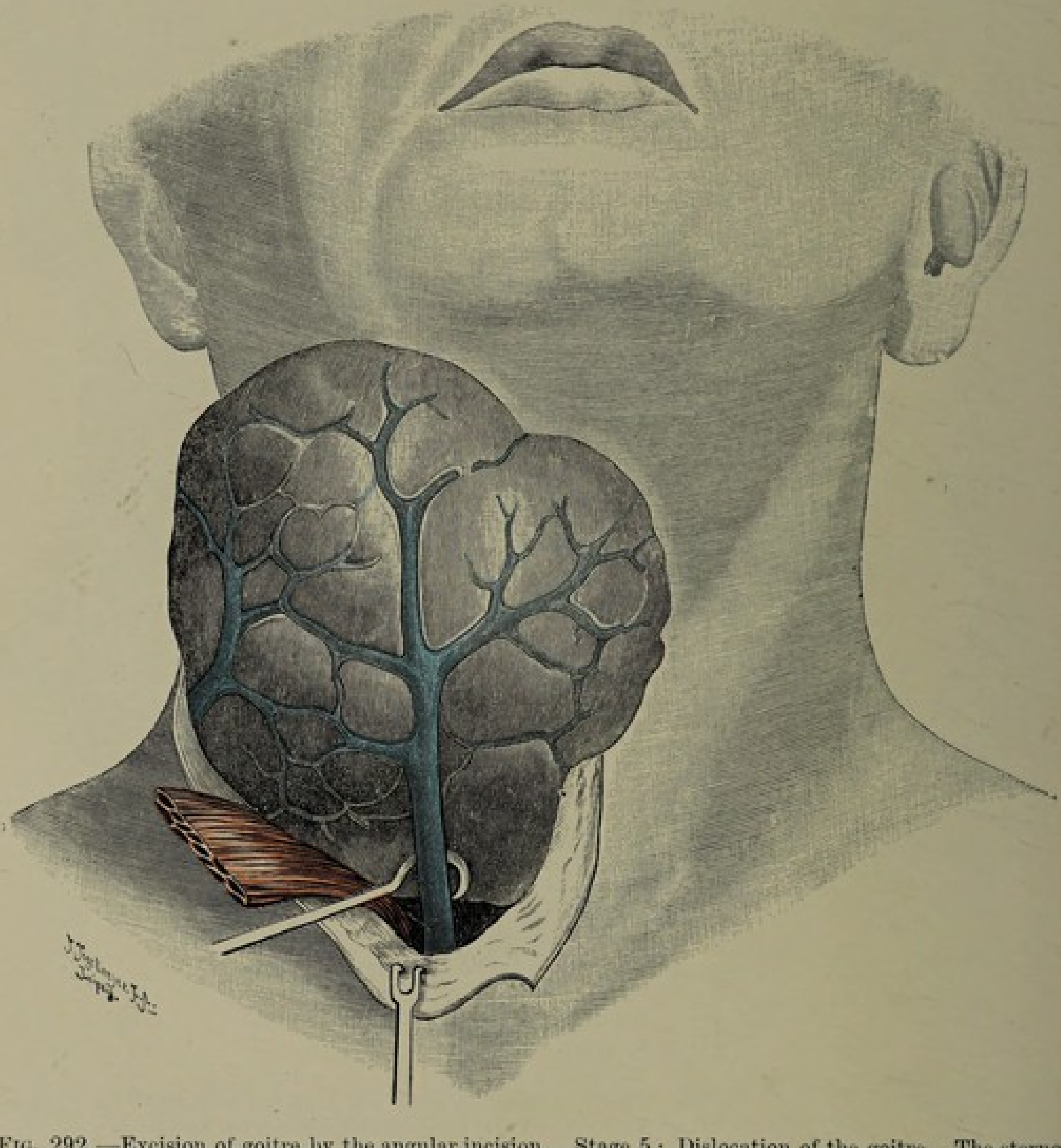


FIG. 292.—Excision of goitre by the angular incision. Stage 5 : Dislocation of the goitre. The sterno-laryngeal muscles have been divided high up and drawn backwards (as a rule one should avoid cutting them completely across), the goitre has been turned upwards, and the right thyroidea ima vein isolated and raised on a hook.

conjunction with the description of the normal operation already given in detail, will sufficiently explain the subsequent steps when the angular incision is used.

54. Excision of a Median Goitre. It is comparatively uncommon to find a goitre developing from the isthmus, and one generally observes on careful examination that mesial goitres have really grown from the inner portion of one or other lateral lobe.

If, however, the tumour is actually situated in the isthmus, peculiar difficulties

are presented, since its removal entails a double division, *i.e.* of both the right and left lobes, into one or other of which the tumour often extends for some distance. It is particularly in these cases that excision is more urgently indicated, as the pressure exerted by the tumour on the front of the trachea is very considerable.

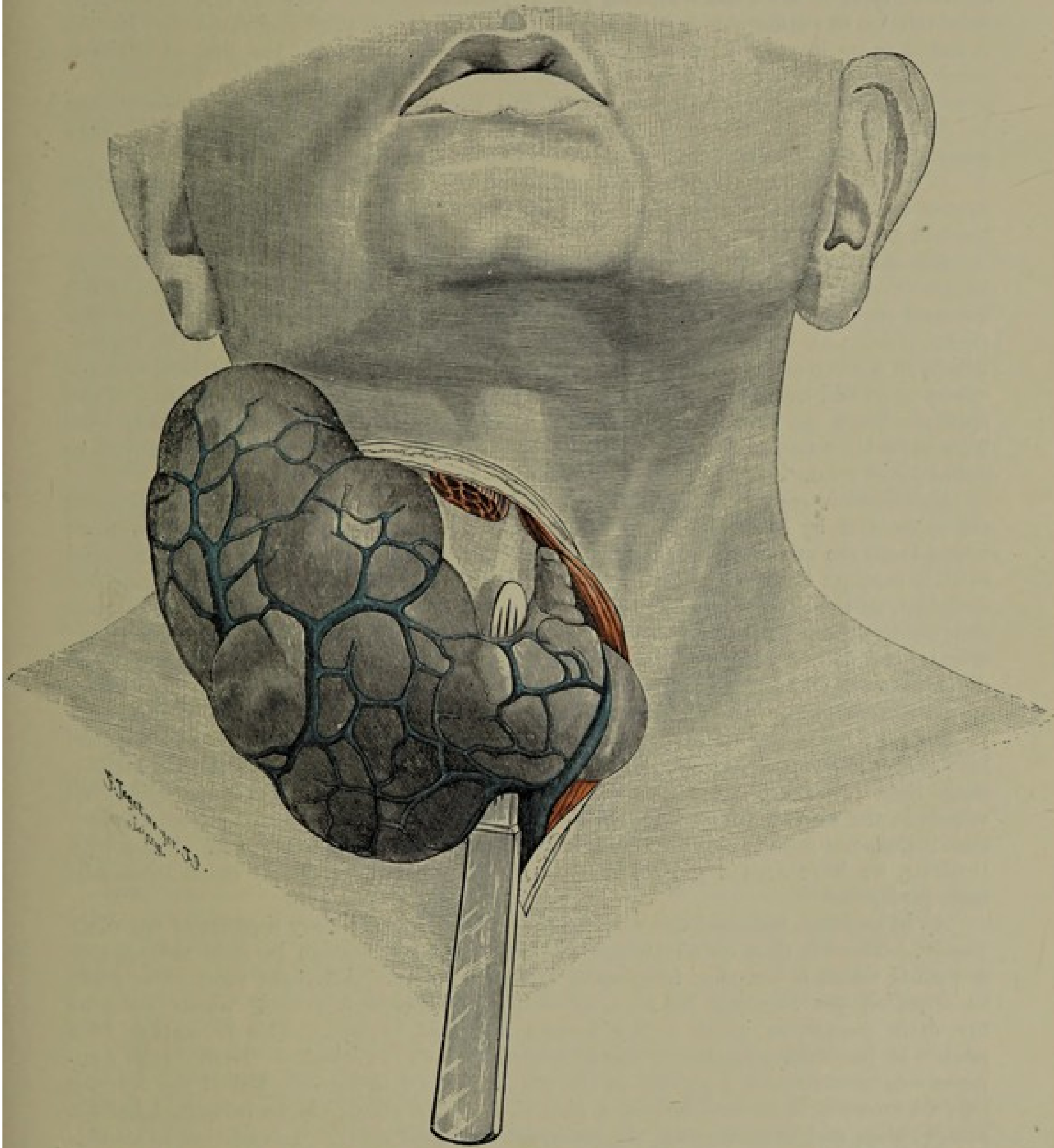


FIG. 293.—Excision of goitre by the angular incision. Stage 6: The right lobe of the gland has been completely freed from its vascular connections and a blunt dissector pushed underneath the isthmus, between it and the trachea, preparatory to the application of crushing-forceps.

In disease of the isthmus our curved transverse incision (collar incision) is specially suitable, since access must be got from both sides. As soon as the muscles are separated and the external capsule is incised, the exact relation of the tumour to the lateral lobes must be defined.

Should there be a constriction on one side of the tumour, the procedure is similar to that for the removal of a lateral nodule, *i.e.* the narrow portion is exposed, crushed, and divided. The tumour is then dissected off the trachea, the branches (not the trunk) of the superior thyroid vessels and the superior communicating veins being ligatured and divided above, while the thyroideæ imæ veins and the inferior communicating veins are dealt with in a similar manner below. One has then to attempt to obtain on the other side a pedicle which can also be crushed and divided. If this is found to be impossible, a resection must be undertaken, *i.e.* the line of division must be through the thyroid tissue itself.

The operation is much less embarrassing when the mesially-placed tumour can be enucleated, as is the case more especially with a cyst. Enucleation is here permissible, to a limited extent at least, on one or other side.

If one or other lateral lobe is diseased as well as the isthmus, the former must first of all be freed and dislocated, after which the isthmus can be dissected off the trachea as far as the other side.

55. Enucleation of the Goitre. It was v. Burkhardt who drew special attention to the difference between intra-capsular excision and enucleation. In the former the external capsule of enveloping connective tissue alone is stripped off the tumour (the peri-thyroideum), whereas in the latter one cuts into the vascular tissue of the thyroid which, in a more or less thinned and atrophied condition, covers the contained cyst (or cysts) or colloid masses (epithyroideum). On account of the great vascularity of the epithyroideum, the operation of enucleation must not be confounded in any way with intra-capsular excision, while it cannot be compared with the latter in respect to certainty of success.

Enucleation, recommended by Porta, and brought into general use by Burkhardt for cysts, and by Socin for colloid tumours, is especially indicated in those cases where there are numerous well-defined colloid nodules, both large and small, scattered equally through both halves of the thyroid. Unilateral excision is in such cases not sufficient, as the pressure on the trachea may not be more marked on one side than the other. Enucleation is therefore indicated, but in this way only the larger nodules can be removed. The operation, though not a radical one, is free from some disadvantages which the radical operations possess, as it preserves healthy gland tissue, causes no injury to the recurrent laryngeal nerve, and is simple to perform.

It is the simplicity of the procedure that frequently misleads the inexperienced into giving it the preference over excision. It is attended with more serious hæmorrhage than excision, because bleeding and general oozing occur from numerous small vessels in the capsule which is left behind. On this account, as well as from the fact that it does not ensure a radical cure, it is not a good method to employ. Along with Brunner, we have seen a great number of cases recur where merely enucleation had been performed.

As in excision, hæmorrhage must be prevented by preliminary ligature of the main vessels. There is thus no advantage in performing enucleation because the part of the gland which is left dies from want of blood-supply. Attempts have been made to diminish the bleeding by forming above and below a pedicle which contains the main vessels, to which artery forceps are then applied. This formation of a pedicle is, however, a relatively coarse procedure, as is enucleation itself. It is comparatively easy to form a pedicle at the upper pole of the goitre, but if the inferior thyroid artery is to be included in a pedicle, one has absolutely no safeguard against compressing, and so paralysing, the recurrent laryngeal nerve. In addition to all this there still remains the disadvantage that recurrence may take place. Enucleation should therefore only be performed in the following circumstances :—

1. When the other half of the thyroid is atrophied, or has already been removed at a previous operation.

2. When isolated nodules are to be felt in otherwise healthy gland tissue, especially if they are present on both sides and are giving rise to pressure symptoms.

3. When a single nodule exists which has caused extensive pressure-atrophy of the surrounding gland structure, so that vascular gland tissue is only present to a

limited extent, generally posteriorly. It is in this manner that large cysts and old colloid nodules are imbedded in the gland. Enucleation is almost forced upon us if we mistake the thin layer of gland tissue (gland capsule) for the external capsule (adventitious or false capsule) and divide it, and are satisfied that the mass can be easily separated. It is often necessary to apply numerous ligatures in the neighbourhood of less atrophied parts of the gland. The enucleation of large cysts, as is recommended by Burkhardt, is therefore justifiable, as the hæmorrhage is considerably lessened.

4. Lastly, when the goitre is very adherent to the external capsule, as a result of acute or chronic inflammation (*e.g.* after repeated hæmorrhage or a prolonged course of treatment with iodine).

Enucleation is performed as follows :—The surface of the goitre is thoroughly freed and exposed in the manner previously stated, and the muscles are retracted. At the most prominent part of the tumour, where the inner capsule (capsule proper) is thinnest, the gland tissue is incised until the nodules appear, artery forceps being applied to the edges and to each bleeding vessel. A blunt dissector is then introduced between the normal tissue (gland capsule) and the nodules, and the latter are separated and shelled out. It is often advisable to reduce the bulk of the mass by removal of its contents, or by evacuating a cyst.

The farther back one dissects with the blunt instrument the more the bleeding, so that numerous artery forceps have to be applied. As soon as it has become evident that the enucleation is going to be a matter of great difficulty, it is advisable to give up the attempt and proceed to excision, or to adopt the enucleation-resection method, to be described later. Single cysts and nodules, for example, those which have undergone recent inflammatory changes, are easily shelled out, so that the operation is soon finished. Peripherally-placed nodules are often found to have a pedicle after the gland capsule has been divided. Crushing-forceps can be readily applied to the pedicle and the removal of the nodule is thus simplified.

It is often possible to definitely arrest the hæmorrhage by including many of the bleeding points in a few ligatures, or to ligature them in a mass ; but this cannot always be done. In certain cases the bleeding may be arrested by means of a tight suture. However, it is the enucleation cases which give more trouble than the excisions, and in which the healing of the wound is more often interrupted by the formation of hæmatomata.

56. Resection of Goitre. Mikulicz has suggested resecting the diseased part of the thyroid gland, but we can only recommend the procedure for exceptional cases. Hæmorrhage is generally less easily controlled than is the case in excision, and the wound does not run such a favourable course, as large stumps of tissue are left which undergo necrosis while the ligatures occasionally become separated.

Resection is certainly rendered easier by using angiotribes, or, as we prefer to call them, histotribes (tissue crushers) (Fig. 287*a*). By means of the forceps which we have made, thick pieces of gland tissue can be so compressed and diminished in size that they can be easily included in one or more ligatures. The blades are closed upon the tissues as firmly as possible, and not until they have been removed are the ligatures applied.

This plan, however, does not succeed in every case, as the gland substance is often so brittle that the forceps cut into it, giving rise to severe bleeding, which is difficult to stop. Resection should, therefore, be restricted to the following cases :—

1. When the nodules are small and prominent and can be easily separated from the substance of the gland to a certain extent, and isolated. After raising them up they can be divided, pressure-forceps being applied behind the seat of division, after which the ligature (or even a suture) is applied, and the separation completed.

2. When we have to deal with a diffuse colloid degeneration without the formation of definite nodules, and where the firm mass presses upon both sides of the trachea and is difficult to lift out. Even in these cases a better plan would be to perform a typical unilateral excision, although it sometimes happens that the dense colloid mass on the opposite side is so firmly and widely attached to the trachea as to seriously

interfere with the healing. This also sometimes occurs where a previous unilateral excision has been done, the growth on the other side having subsequently enlarged, so that, despite free removal on one side, stenosis sometimes results.

In these circumstances preliminary ligature of the vessels on one side should be resorted to. We have also adopted this plan as a preliminary to subsequent excision in the case of diffuse colloid growths.

57. Enucleation-Resection and Enucleation-Excision of Goitre. We have introduced this combination of the preceding methods for the purpose of obviating the dangers of enucleation, and at the same time making use of its advantages. The principle of the operation consists in confining the excision to the anterior and easily accessible portion of the growth, enucleating, on the other hand, the posterior part by

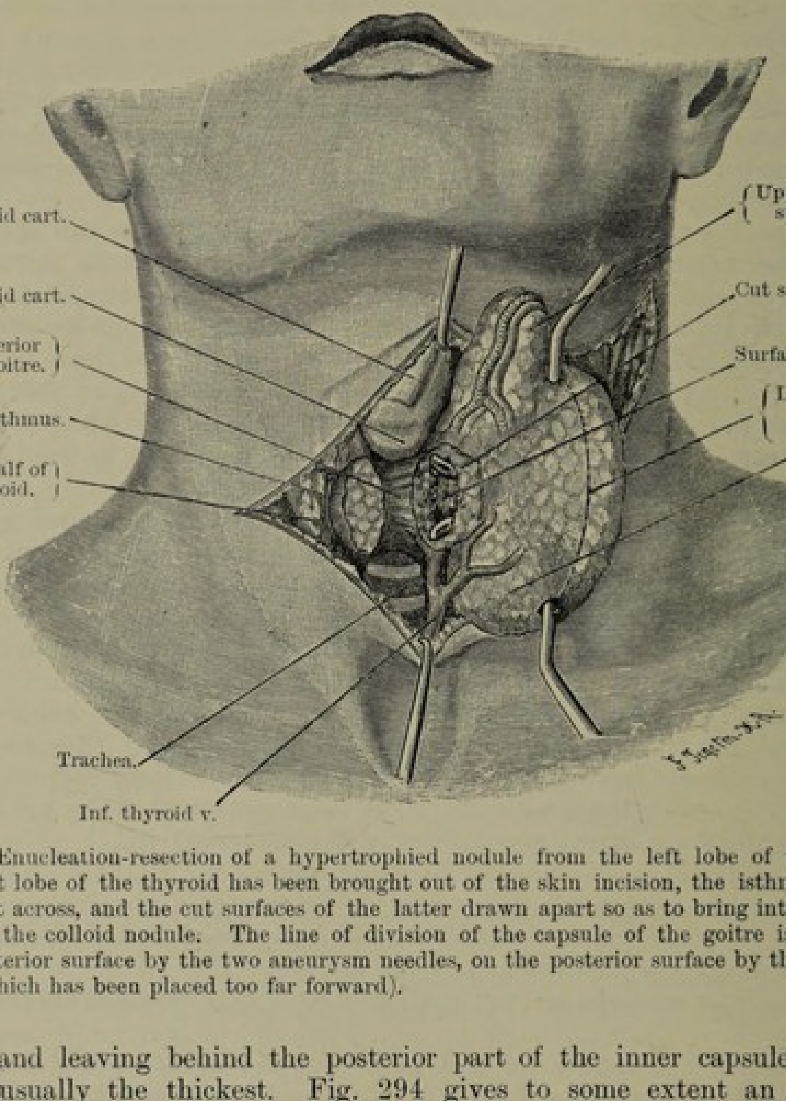


FIG. 294.—Enucleation-resection of a hypertrophied nodule from the left lobe of the thyroid. The left lobe of the thyroid has been brought out of the skin incision, the isthmus ligatured and cut across, and the cut surfaces of the latter drawn apart so as to bring into view the surface of the colloid nodule. The line of division of the capsule of the goitre is indicated on the anterior surface by the two aneurysm needles, on the posterior surface by the interrupted line (which has been placed too far forward).

resection, and leaving behind the posterior part of the inner capsule of the gland, which is usually the thickest. Fig. 294 gives to some extent an illustration of the method.

After the surface of the goitre has been fully exposed in the usual way, the isthmus, which is freed close to the tumour, is compressed, ligatured, and cut across.

In this way access is got to the tumour through an opening in the true gland capsule, as shown in Fig. 293. Into this opening a finger or blunt dissector (Kropfsonde, Fig. 295) is introduced upwards and downwards at the inner aspect of the tumour, so as to separate the gland capsule and allow of the introduction of the pressure-forceps, first in an upward, and then in a downward, direction. After the tissues have been compressed an aneurysm needle is passed under them and a ligature applied.

Under some circumstances this linear separation must be repeated in the neighbour-

hood of the upper and lower poles. By seizing the goitre and rotating it outwards, the tumour can be rapidly torn away from the inner aspect of the posterior part of the true capsule, which then constitutes the only connection the tumour has with the trachea.

The posterior wall of the capsule cannot be divided in a vertical direction without fear of injuring the recurrent laryngeal nerve, as one is working at some distance from the trachea. Bleeding may be prevented either by the careful application of artery forceps, or simply by the application of the clamp (histotribe), followed by a ligature. The dotted line in Fig. 294 is intended to represent the posterior incision through the detached inner capsule, which is to be left behind. It should have been drawn much nearer the trachea, and it is meant to be vertical.

Fig. 295. Goitre dissector.

The method has the advantage of reducing considerably the bleeding which proves so troublesome in enucleation and resection. Moreover, by leaving a well-nourished piece of gland tissue posteriorly, and the parathyroids, it does away with all anxiety regarding the opposite lobe. It also avoids any injury to the recurrent laryngeal nerve. It is obvious that the main vessels must not be ligatured before they enter the gland. But even this admirable method has a more limited field than excision. It is not to be recommended in diffuse colloid degeneration in the form of very small follicular colloid foci, but is only advisable where there are one or more large colloid or cystic masses, forming spherical tumours imbedded in relatively healthy gland tissue. It should be employed in recurrent goitres where one-half of the gland has already been removed.

58. Evacuation and Fragmentation of the Goitre. This operation which was described by us and which we have frequently practised, differs from intracapsular excision and intraglandular enucleation in that neither the perithyroideum nor the epithyroideum, *i.e.* gland tissue, is removed, as the nodule is simply incised and taken away by reducing or breaking it up, the method being analogous to "evidement" as practised for foci in bone or to "morcellement" in vogue for fibroma uteri.

The operation is chiefly indicated in large-sized cystic goitres, in order to avoid the necessity of making too large an incision in the thyroid tissue. The cyst is cut into, its wall grasped with forceps and pulled out, the surrounding tissues at the same time being pushed back.

In colloid tumours this procedure is almost forced upon the operator in those cases where a nodule with softened contents has, as the result of a periglandular adhesive inflammation, become adherent to the capsule and the surrounding tissues. Excision would here be too serious a matter.

We have seen excellent examples of this condition in nodules which had undergone degeneration after hæmorrhage. Removal of a thyroid tumour may become necessary on account of the rapid increase in its size from hæmorrhage into it, accompanied by slight inflammation. Excision in such a case is unfavourable on account of the inflammatory adhesions with the surrounding tissues, the severe bleeding, and the danger to the recurrent laryngeal nerve.

The tumour is therefore cut into with a knife, the vessels in the line of the incision being doubly ligatured. The bleeding edges of the wound are then firmly seized with artery forceps, as in enucleation, and, after rapidly clearing out the disintegrated colloid masses and clot, which form the chief contents, the soft colloid masses which remain are easily shelled out from the inner surface of the cyst with the finger. A curved needle is passed under the bleeding vessels, which are then ligatured, the cyst wall being at the same time folded. The hæmorrhage is far less than in enucleation, and the operation can be performed very rapidly. Moreover, it is almost painless, as

the gland capsule is not injured. One of our patients, who had a large, rapidly-growing hæmorrhagic colloid goitre, expressed her astonishment at the close of the operation, which was performed under cocainisation of the skin, that she had felt absolutely no pain.

The method is very suitable in those cases where one has to deal with multiple colloid nodules in both lobes which are movable and embedded in loose tissue. The nodule is grasped at its base between two fingers, raised up, and split with a knife in its entire length, by which means the capsule is stretched and a better pedicle obtained. Without relaxing our grasp we apply a pair of our pressure forceps below the fingers. The pedicle, which is thus compressed, is then ligatured with strong silk, the forceps removed, and the nodule cut away without bleeding.

In some circumstances, when the nodules are malignant and softened, and when excision is rendered impossible on account of the firm adhesions, this method of "exenteration" is very useful, as it gives immediate, though temporary, relief. In a case published some years ago, we obtained a permanent cure by the introduction into the cavity of a chloride of zinc tampon. We recently treated in this way a soft papilloma, the capsule of which was thick and firmly adherent. This procedure may often be employed in these cases instead of tracheotomy, as the latter is a very unpleasant last resource in malignant goitre.

But it is of the greatest service: (1) in nodules of large size whose contents are breaking down and softening, and which are adherent to the surrounding parts; (2) in multiple small softened tumours which can be sufficiently pulled forward to be cut into and evacuated, and where the relatively small amount of hæmorrhage can be controlled by ligature or suture; (3) especially (on account of the rapidity with which it can be done) when there is a danger of asphyxia, and when the pressure on the trachea must be quickly relieved during the operation. This is nowhere so well seen as in deeply seated nodules, and in intrathoracic goitres. Hence exenteration is often a *sine qua non* in enabling us to complete the operation in the neck.

The procedure has been erroneously ascribed to Porta, an Italian surgeon, whose method is identical with our enucleation.

59. Operation for Intrathoracic Goitre. Unfortunately the presence of an intrathoracic goitre is sometimes either overlooked altogether, or the diagnosis is made too late. An extremely sad picture is presented by a person, who has been treated for asthma, dying from this disease which is supposed to be a mediastinal tumour. If operation is delayed too long in intrathoracic goitre the outlook is certainly ominous, as asphyxia may suddenly supervene. The lungs and heart may become involved, the innominate veins and their tributaries (subclavian and internal jugular veins) have their lumen narrowed to half the proper size by the pressure of the tumour, and thrombi may form in the distended parts of the veins above. In one of our cases, after the wound had healed by first intention, and while the patient was indulging in free movement, a thrombus in the common jugular vein became loose and caused immediate death from embolism of both pulmonary arteries.

It therefore follows that timely operation should be undertaken. Cases will be found to be operable in which the tumour at first sight seemed to be quite inaccessible. We once operated on a man with marked symptoms of tracheal stenosis (but whose general health was satisfactory) and in whom a skiagram showed a large tumour which appeared to be quite beyond removal. After having satisfied ourselves, however, that the tumour moved on coughing, we ventured to make the attempt, with the result that after ten days the dyspnœa had entirely disappeared, and the patient since then has enjoyed excellent health.

The operation is difficult, and requires both skill and experience. The incision, which must be placed low down, should, as a rule, be the collar incision, as it is often difficult to tell with which side an intrathoracic tumour is connected. It is of the utmost importance that the tumour, or the healthy gland, be exposed on the side in which the nodule is situated, where it is accessible in the neck. The vessels at the upper pole of the gland, as well as the lateral accessory veins, are double ligatured and the isthmus is exposed, crushed, and divided between two ligatures. In this way

the connections of the tumour in the neck are thoroughly freed, and the gland (healthy or diseased) can then be used as a handle by which the intrathoracic growth may be pulled upwards. One must proceed very carefully and step by step expose the vessels (especially veins) which enter and leave the surface of the tumour and divide them as low down as possible between two ligatures. If necessary, the sternal portion of the sterno-mastoid should be divided, while the muscles proceeding from the sternum to the larynx should be thoroughly separated in the middle line up to their upper attachments and then widely retracted. The critical moment then comes when the tumour must be seized with the forceps (Fig. 296) we have specially devised for the purpose and dragged forcibly upwards. All the vessels entering the surface

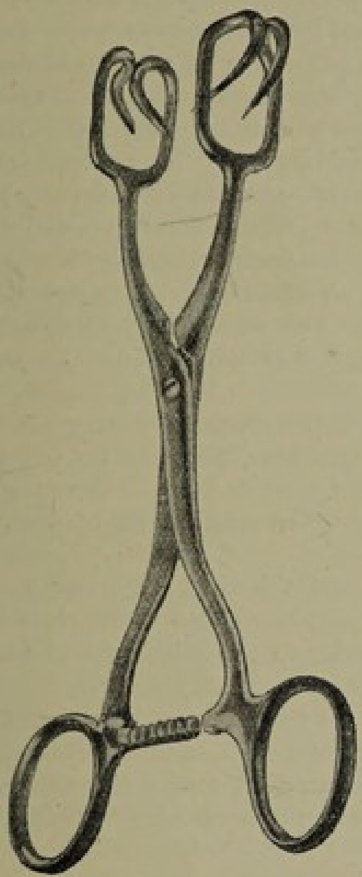


Fig. 296.—Goitre-forceps. The ring-shaped blades cause no hæmorrhage, while the recurved hooks prevent them from slipping.

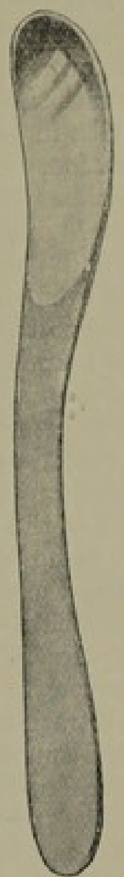


Fig. 297.—Goitre-spoon for releasing intrathoracic goitres.

of the goitre should be divided between two ligatures, as otherwise they are liable to give way.

The goitre cannot always be pulled out from its deep attachments with forceps. Occasionally it is necessary to introduce a long, broad, blunt elevator, or an instrument like a spoon (Fig. 297), underneath the tumour so as to raise it up.

Lastly, in the most difficult cases, as in the one quoted above, the tumour may be too large to allow of its being delivered through the aperture of the thorax. In cystic conditions the procedure is simple: the tumour is incised, and the cyst wall is drawn forcibly upwards. Fortunately intrathoracic goitres are generally softened and cystic. In colloid and malignant tumours, on the other hand, one must decide to diminish the size of the growth by exenteration, by forcibly inserting a finger into it, and tearing out the colloid material piecemeal as in "morcellement." The bleeding is so severe that the tumour, after being diminished in size, must be drawn as quickly as possible

to the surface in order that the vessels may be tied, and also because the dyspnœa is often very aggravated at this stage. If it has not been possible to tie the inferior thyroid artery previously, this must now be done, and therefore the tumour must not be pulled out too suddenly. If, in spite of every care, the artery is torn, the bleeding may be stopped by firm pressure with the finger downwards and outwards until the vessel can be caught, which must invariably be done. Packing the wound to arrest hæmorrhage is a bad procedure.

The after-treatment, if asepsis has been attained, is conducted on the same lines as in ordinary goitre. The patient should be well enough to leave his bed in eight days, just as after other operations on the thyroid.

60. Excision of the Thyroid when Resection of the Sternum and Ribs is necessary. Whenever an intrathoracic goitre attains dimensions so large that it can no longer be completely exposed from above and its size reduced, one must abandon the attempt to excise it from the neck. If the patient is so distressed that he would take any risk rather than continue in suffering, one must decide on a resection of the sternum and ribs in order to alleviate the danger of the condition.

This operation, in which both pleural cavities may be opened, must not be undertaken without steps being taken to prevent collapse of the lungs, *i.e.* by the use of a low or high-pressure chamber. Owing to the difficult conditions attending the operation and the enormous venous distension that exists, both pleuræ may be incised or torn even in resecting the sternum, especially as one is forced to proceed hurriedly owing to the bleeding that may occur and which is very difficult to arrest, from the large branches of the internal mammary vein perforating the inner ends of the intercostal spaces.

One must therefore attempt to gain access to the thoracic cavity on one side by resecting the second and if necessary the third and fourth ribs as far out as a distance of 10 to 15 cm. (4 to 6 inches) from the edge of the sternum. If the lung is displaced and both layers of the pleura are in contact, the latter are shut off by a circular row of sutures before being opened.

The veins on the exposed capsule of the goitre are then tied, care being taken to avoid the innominate veins which are displaced outwards, and which descend alongside of the tumour, after which the tumour is exposed, and if necessary incised. It is then thoroughly broken up and drawn upwards into the neck.

Before an intrathoracic tumour is broken up, it must always be thoroughly exposed in the neck, and subsequently drawn up through the inlet of the thorax.

The hæmorrhage is not excessive during this process, and a tumour as large as a man's head may easily be shelled out of its capsule, because the thin pedicle is so compressed that the vascularity of the tumour is diminished.

61. Operation for Recurrence of the Goitre (Struma Recidiva). In the operation for recurrent tumours we have a special problem to deal with. If a goitre has been excised on one side by our normal process, it rarely happens in nodular goitres that the other lobe of the thyroid develops to such an extent as to cause trouble.[1] It occurs most commonly in diffuse follicular colloid tumours. The reasons are obvious why recurrence should occur more frequently after enucleation than after excision.[2] But if the advancing disease in the half of the thyroid which has been left behind once gives rise to dyspnœa, one must be prepared for difficulties in the operation. We have to deal, on the one hand, with growths of very large size, and, on the other hand, with those which, as a result of the previous operation, are very adherent and may extend deeply. Such growths, especially if they are very closely applied to the trachea, give rise to trouble in spite of the possibility of the displacement of the cervical viscera towards the operated side, because one cannot again perform a simple excision. It is not easy, therefore, to find an appropriate method of dealing with such diffuse colloid goitres.

We recommend the following procedure :—The tumour is thoroughly freed in the

[1] A. Kocher has considered this matter in connection with our cases.

[2] Brunner has shown that of 18 per cent of recurrences after thyroid operations the majority follow enucleation.

neighbourhood of the isthmus and of the lower pole, where the pressure is greatest, and after ligaturing the inferior thyroid artery, is dislocated in the usual manner. The arteries and veins proceeding to the upper pole need not be ligatured. A piece of the thyroid gland is left *in situ* connected with them, and, after crushing its connection with the rest of the gland, with our goitre crushing-forceps, the crushed part may be ligatured, and the remainder of the tumour excised.

If the upper pole is entirely diseased, and if the dislocation cannot be effected without ligature of the superior thyroid vessels, they should first be tied. The goitre is then dislocated and the large thyroidea ima veins ligatured at the lower pole, after which the tumour is raised (as far as possible without hæmorrhage) from the trachea and turned outwards. Without ligaturing the inferior thyroid artery, the vessels which are seen running upwards deeply in the neighbourhood of the trachea to the surface of the tumour are caught with forceps, and the goitre tissue is incised vertically close to the isthmus. In this way a posterior capsule is formed from which the colloid matter is to be removed by blunt dissection as completely as possible and the vessels tied. The dissection is to be continued laterally beneath the capsule until a flat mass of goitre tissue is separated from the posterior part of the thyroid sufficient to maintain the thyroid function. The portion thus separated is then completely severed from the part to be removed and the vessels tied.

Excision of a residual goitre is also rendered more difficult on account of the cicatrices of the previous operation. These cicatrices, which are situated on the surface of the tumour, cause adhesion to the surrounding parts, including the muscles and the capsule, so that the goitre can only be rendered movable by working from the lateral or mesial aspect under the muscles, and dividing the latter transversely where they are adherent, thus leaving the entire cicatrix attached to the goitre. No time should be wasted in separating cicatrical adhesions from its anterior surface, but the deep surface of the growth must be exposed as soon as possible where there are no adhesions.

62. Excision of Exophthalmic Goitre (Basedow's Goitre). To the present time we have operated on 200 cases of Basedow's disease (including 10 cases of struma vasculosa and 60 of a mild type) with a mortality of 4·5 per cent, this mortality being higher than in other forms of goitre. We have, however, learned how to overcome the operative risks, which are almost entirely dependent on the condition of the heart, *i.e.* toxic myocarditis.

Excision should not be undertaken when the disease is advanced, *i.e.* when the pulse, besides being rapid, is also small and irregular, or when the heart is dilated and œdema is present. If there is severe thyro-intoxication, the slightest excitement causing acceleration of the heart's action (180 beats or more per minute) with an increase in the dilatation, it is advisable to begin by ligaturing one, or possibly two, arteries, and to postpone the excision till the patient's condition shows distinct improvement.

Even then the operation is attended with considerable responsibility and requires the utmost caution. The large vessels are very readily torn, and the goitre is exceedingly vascular, even the external capsule bleeding freely, while it is often firmly adherent. Operation is thus a matter of greater difficulty, and attended with greater hæmorrhage than is the case even in malignant goitres. The result, therefore, really depends for success on the most careful arrest of hæmorrhage.

All antiseptics and anæsthetics are a source of danger owing to the toxic conditions present in these cases. The success of operative treatment in Basedow's disease depends on the patient's being seen by the surgeon at an early stage, as with early operation brilliant results can be obtained.

The angled incision is, as a rule, preferable and every vessel must be ligatured, without, however, losing time in extirpating the goitre. The separation of the outer capsule is often attended by so much bleeding that one has to dislocate the goitre rapidly and secure the main vessels. No practitioner, unless he has had considerable experience in goitre operations, should venture on an excision for Basedow's disease.

63. Ligature of the Thyroid Arteries. Ligature of the thyroid arteries is best

considered here as it is most frequently indicated in vascular goitres, and in Basedow's disease. According to Volker,[1] it was originally suggested by Muys for the treatment of ordinary goitre, while Blizzard attempted it first without success. The first successful case was performed by Walther in 1817. Porta extended the operation to the ligature of all four arteries in 1850, a suggestion which has recently been adopted by Wölfler.

Ligature of the thyroid arteries has never come into general use for ordinary goitre, for the reason that if one goes so far as to tie the main arteries, one may just as well make sure of a permanent result by removing the tumour, especially as both are effected through the same incision. Further, when the goitre is a large one, the operation is not only difficult but often unreliable.

In simple goitres, therefore, ligature is only to be considered when the vessels are greatly enlarged, and then it is sufficient to tie only the superior thyroid arteries, this procedure frequently making the subsequent removal of the goitre much less dangerous.

We regularly perform preliminary ligature of the arteries in Basedow's disease tying them in sequence in the course of eight to fourteen days. The anæmia and partial arrest of function causes in many cases such a marked improvement that excision may be subsequently undertaken.

Even without excising the gland, we can get very good results in Basedow's disease by simple ligature of three arteries. We do not consider it permissible to tie all four arteries as has been done by Wölfler and also, according to Enochin[2] by Rydygier and Rasumowsky, as the patient is then exposed to the risks of tetany and "cachexia strumipriva" from acute and chronic changes in the thyroid and parathyroids. Even should no acute necrosis of the thyroid occur (as is proved by Wölfler) the patient is exposed to the dangers consequent on the gland secretion being arrested. We ventured on one occasion to tie all four arteries with the result that severe tetany followed.

On the other hand, we may combine excision on one side with ligature of one artery on the other side, a method which we have often employed.

The technique of ligature of the thyroid arteries has been described in the section on the surgery of the vascular system (see pp. 97 and 103). The superior thyroid artery is much more easily tied than the inferior thyroid, and ligature of the former is always preferable when there is a choice. Ligature of the inferior thyroid artery may be attended with so much difficulty, *e.g.* in Basedow's disease, that one must abandon the attempt and proceed to excision. When the capsule is adherent the artery is difficult to find and the bleeding is profuse.

Unilateral ligature is best carried out through the collar incision over the middle of the thyroid (in thyroidectomy), the gland being first of all dislocated. After the vessel has been tied, the thyroid is replaced and the wound closed, no drainage being required as no cavity is left.

64. Excision of Inflamed Goitres. It is specially in large hæmorrhagic soft colloid goitres, which have become chronically inflamed and the external capsule of which is thickened and adherent, that most trouble is experienced by surgeons who have had little experience of goitre operations. Repeated hæmorrhages are probably sufficient to produce this chronic indurative type of inflammation, the character of which may cause one to suspect that the tumour is malignant, *i.e.* the capsule is thickened, and firmly adherent to the overlying muscles, while the latter are often indurated as well.

The thickening and adhesions may interfere greatly with the freeing of the goitre, especially if the great vessels of the neck are adherent. The internal jugular vein is often found to be flattened and closely connected with the coverings of the tumour, while the same is true of the superior thyroid, the thyroideæ imæ, and the accessory veins.

Unless one is very careful, bleeding of a most troublesome nature may occur if the veins are injured, because owing to the density and hardness of the adhesions it

[1] v. Volker (in v. Bramann's Dissertation), Halle, 1904.
[2] Enochin, *Arch. f. klin. Chir.* Bd. 80.

is often difficult to control it with certainty or even impossible to control it at all, by simple ligature. The prolonged administration of iodine, either internally or locally, gives rise also to a chronic inflammatory condition of the thyroid and perithyroid tissues, which very often makes the dislocation of the tumour exceedingly difficult owing to the density of the adhesions. Large and apparently movable goitrous nodules met with in old people often show similar periglandular changes.

In all these cases no attempt should be made to force a way between the outer capsule and the tumour from the front, as the adhesions are often far too firm. On the other hand, the proper interval can frequently be found much more easily from behind, *e.g.* once the superior thyroid vessels have been isolated and ligatured, by exposing the posterior surface of the tumour from above.

It is not practicable to excise the capsule along with the goitre, because of the intimate connection of the large vessels. Not infrequently its anterior wall must be left on the tumour along with the covering muscles, *i.e.* it must be cut round, although occasionally it may be separated by forcible blunt dissection.

When it is impossible to separate the capsule even posteriorly, enucleation or "exenteration" of the nodules must be resorted to. This may often be found surprisingly easy, while the bleeding may be inconsiderable, as the vessels are in many instances partially obliterated by the inflammatory process. Abscesses and inflamed cysts are generally best dealt with by simple incision.

Any existing fistulæ should be cauterised with the thermo-cautery and closely stitched, after which the adherent soft tissues on the anterior surface of the goitre should be cut round in the manner already described.

65. Excision of Malignant Tumours of the Thyroid. It is difficult to tabulate definite rules for the excision of malignant goitres. When the cancerous or sarcomatous nodules are still circumscribed and limited to the tissue of the thyroid gland, the operation does not really differ from that required in the case of colloid goitres. On the other hand, certain forms of scirrhus cancer are less vascular than colloid goitres and even less so than struma vasculosa. Sarcomata, however, may be very vascular, soft, and even pulsating.

When the disease is extensive and has invaded the greater part of the thyroid gland, the same rules hold good as for adherent goitres (previous chapter). No attempt should be made to separate the outer capsule, muscles, or adherent tissues from the goitre mass. These must be cut round and left in contact with the goitre, *i.e.* excised along with the tumour, the line of division being through healthy tissues.

In regard to the skin incision, the one that gives the best access must always be selected, *i.e.* the angled incision. For this the skin must be freely divided. It is very important to tie every vessel at an early stage, and if possible at a distance from the gland so that all the adherent tissues as well as the adjacent glands can be removed in one mass. Not only is the perithyroideum adherent to the muscles, but often to the great vessels of the neck as well, especially the veins; while smaller veins may be full of cancerous thrombi, and even the trachea and œsophagus may be so involved that it may be necessary for a portion of them to be excised. In the case of the œsophagus the smooth and movable mucosa can occasionally be left intact, a method which has the great advantage of protecting the wound from contamination with mucus from the pharynx.

The infected lymph glands are situated beneath and behind the sterno-mastoid in both its upper and lower parts. When a malignant new growth extends into the thoracic inlet as an intrathoracic malignant goitre, no attempt must be made to remove it if it is fixed at its lower end.

66. Transplantation of the Thyroid Gland. Transplantation of the thyroid gland in individuals with deficient thyroid secretion gives permanent results in comparatively few cases. Schiff performed the first intraperitoneal operation, while we originally transplanted thyroid gland-tissue in man under the skin of the neck in the autumn of 1883, since which date Bircher and Horsley have made a special study of the subject.

One of the most interesting transplantations of recent times, which has been

verified by numerous experiments, is Payr's transplantation into the spleen. We have selected numerous sites, *e.g.* the subcutaneous tissues, both surfaces of the peritoneum, and also the capsule of the thyroid and large veins and arteries. The subserous layer of the peritoneum and the spleen seem to be the best sites in which the transplanted piece of thyroid gland-tissue will grow and act as a substitute for the absent function. Recently we have followed up the suggestion made by Albert Kocher, and have transplanted thyroid tissue into the medullary cavity of the tibia.

(e) Surgery of the Thymus

67. Excision of the Thymus Gland. Excision of the thymus may be suitably considered here, as the operative procedure is very similar to that in intrathoracic goitre. Very few surgeons have had any experience in the surgery of the thymus. Rehn of Frankfurt, who is the most competent authority, delivered an address on the subject at the Surgical Congress in Berlin in 1906, referring to 28 post mortem findings and to 5 cases on which he had operated, in all of which there was undoubted pressure on the trachea.

The thymus is placed between the sternum and the trachea above, and between the sternum and great vessels or pericardium lower down. Above, it is bounded laterally by the great vessels; the phrenic nerves are in contact with its capsule, and on the left side also the vagus and recurrent laryngeal nerve as well.

The amount of pressure exerted depends not so much on the actual size as on the consistence and the antero-posterior thickness of the gland. According to Kocher, sudden attacks of dyspnœa may be produced on forcible flexion of the vertebræ, and specially by sudden swelling of the thymus of a congestive or infective nature.

It is thus seen that the conditions resulting from enlargement of the thymus are very similar to those of an intrathoracic goitre, the former occurring not infrequently in small children. The stenosis produced by enlargement of the thymus gland gives rise to dyspnœa with inspiratory stridor, sinking of the episternal fossa, with cyanosis, which may either increase gradually or take the form of transient attacks. During expiration, or more especially coughing, a swelling may project into the lower part of the neck.

The first successful thymectomy was performed in 1896 by Rehn, while the operative results were equally good in König's two cases, and in the cases reported by Ehrhardt and Purruker. The dyspnœa disappears, thus proving that in thymic asthma and in thymus-death, a mechanical interference is present. Every case must therefore be carefully considered in regard to the advisability of operative interference, especially as the operation is a simple one, and is not attended with the difficulties of an intrathoracic goitre in which the vascularity is incomparably greater.

The operation has hitherto been performed through a longitudinal incision (without a general anæsthetic). The question may be asked whether our low collar incision is not preferable as it provides more room and causes no more injury. After division of the skin (platysma) and fascia, the gland is found enclosed in a capsule which is fairly closely connected with the great vessels and pericardium.

Intracapsular removal must always be adopted, the capsule being simply pulled forwards or held up with stitches. In his first case Rehn only fixed the gland forward with stitches, while others have resected it. Ehrhardt shelled it out completely with comparative ease. The bleeding is insignificant.

Ehrhardt[1] has shown by means of experiments on animals that the gland can be quite well done without, as our experience in the case of goitre would lead us to expect. The flattening of the trachea soon recovers: if not, Kocher's dilatation suture might be employed.

[1] *Arch. f. klin. Chir.* Bd. 78.

Treatment of Intrathoracic Dermoids

The treatment of intrathoracic or mediastinal dermoids is closely allied to that of intrathoracic goitre. Surgical interference is not to be considered when a tumour is adherent in the mediastinum. Diagnosis in the early stages still leaves much to be desired, while treatment is adopted too late and the favourable time for operation is allowed to elapse. This applies, as we have seen, in the case of intrathoracic goitre as well. We have shown in a series of cases how relatively enormous intrathoracic thyroid tumours may still be successfully removed provided they are movable,—a point which can be determined clinically by means of radiography.

Dermoids and teratomata are exceptions to the rule not to attempt the removal of an adherent tumour in the mediastinum. They exhibit a pronounced tendency to contract adhesions, and may even perforate into neighbouring structures.[1] They yield very well to treatment by drainage, and in one case, where there was a tumour in the thorax, as large as a man's head, we obtained a very satisfactory result by the unusual course of opening it in the episternal fossa (jugulum). As a rule, however, it is generally necessary to undertake a resection of ribs, in order to be able to carry out drainage.[2] We shall publish our case in detail elsewhere.

C. SURGERY OF THE THORAX [3]

(a) Surgery of the Thoracic Wall

68. Amputation of the Mamma. The removal of the mamma alone is a very simple operation, and may be effected by means of a curved incision with the concavity upwards along the lower border of the gland, and fully 1 cm. below it, the gland being shelled out subcutaneously by separating it from the fascia covering the pectoralis major up to its upper border, and then dissecting it off from the skin. We have often performed the operation in this way in diffuse adenoma and multilocular adeno-cystoma (*maladie cystique*). In lipoma, circumscribed adenoma, and fibroma situated in the deeper part of the mamma, the latter may be thrown upwards, and the tumour shelled out from its under surface without removing any of the healthy gland along with it. The minimum of disfigurement is obtained, as the cicatrix is hidden in the submammary fold. When the tumour is situated superficially a simple radial incision is preferable, the skin, superficial fascia, and a thin layer of gland tissue being divided and the tumour shelled out.

69. Operation for Cancer of the Breast. Descriptions of the operation of excision of the mamma, as well as post-operative statistics, afford conclusive proof that success in the treatment of cancer of the breast depends on the removal of all the diseased lymph vessels and glands. One cannot be too thorough in the removal of the disease itself and of the lymphatic territories which it affects. The brilliant works of Halsted, Rotter, and others show the excellent results that are obtained by a radical operation.

At the same time we must not lose sight of the fact that the improvement in the results of mammary cancer refers only to the prevention of local recurrence, and that a number of these "cures" still succumb to metastases. Grossmann estimates recurrence after the lapse of three years as still about 10 per cent.

[1] A collection of 35 cases by Shaw and Williams, *Lancet*, Nov. 1905; *vide* also Morris, *Med. News*, Sept. 1905, with 57 cases collected from literature.

[2] *Vide* Morris, *Med. News*, Sept. 1905.

[3] The latest important works on the subject which should be read are: (1) Bryant, *Transact. of the Amer. Surg. Assoc.*, vol. 13; (2) Garrè and Quincke, *Grundriss der Lungenchirurgie*, 1903; (3) "Voies et moyens d'accès dans le thorax," Congrès de Chirurgie, Paris, 1906, von Willems et Loisin; (4) Gerulanos, *Deutsche Zeitschr. f. Chir.* Bd. 49; (5) Gross, *Beitr. z. klin. Chir.* Bd. 24; (6) Amburger, *Beitr. z. klin. Chir.* Bd. 30.

Meanwhile, as is the case in carcinoma of the tongue and larynx, the most satisfactory results are obtained by surgeons who are in the habit of operating early. Of 91 of our cases collected by Dr. Meyer, the subjects of which died within a period of twenty years after operation, local recurrence happened in only 25·2 per cent, the others dying of metastatic growths, while of 8 cases dealt with at an early stage, in which only an incomplete operation was performed, two showed recurrence within three years, and six (75 per cent) appear to be permanently cured.[1]

As with cancer of other organs, it is the time at which the operation is carried out rather than the actual method employed that chiefly influences the ultimate prognosis in carcinoma of the breast. While this is the case, we still maintain that when operation is undertaken, in most instances it should be radical in the modern

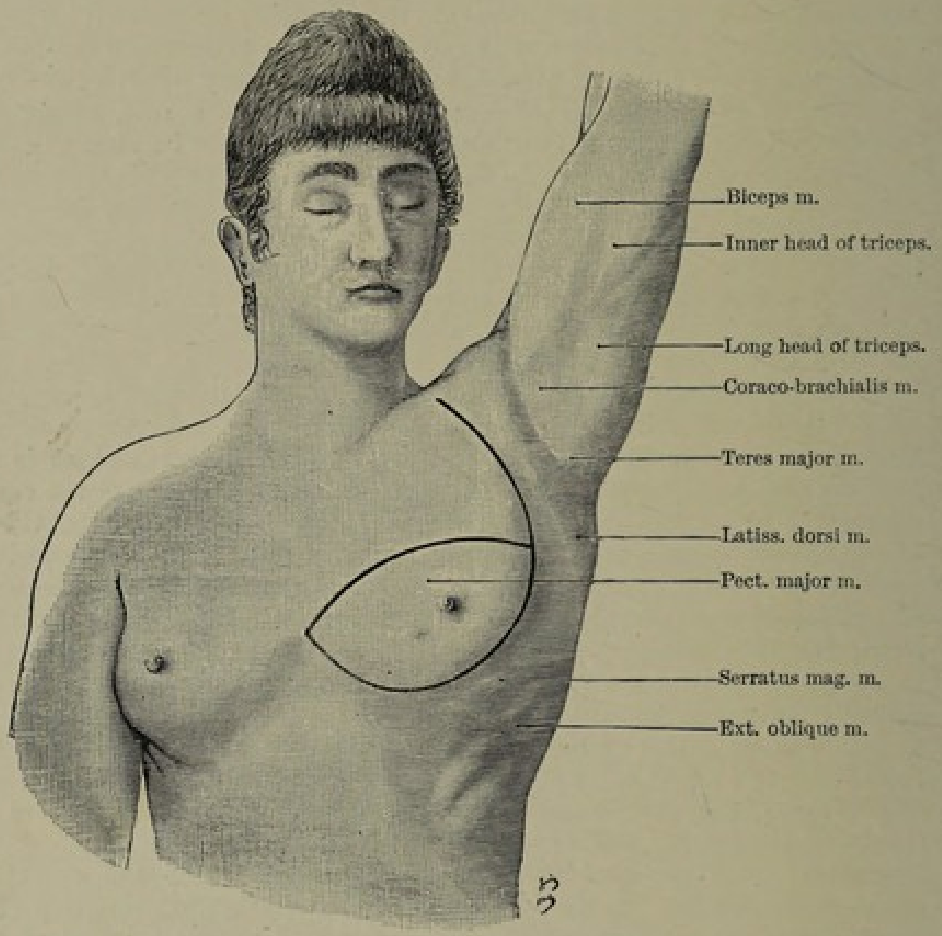


Fig. 298.—Skin incision for removal of a carcinomatous breast.

sense of the term. On the other hand, we are acquainted with individual cases of women, still enjoying the best of health, who could only be persuaded to submit to early operation on condition that we did not remove the whole breast but only excised the diseased portion.

70. Radical Operation for Cancer of the Breast (Figs. 298-302). As a rule (and the surgeon should invariably advise this), we must not be content with simply excising the gland itself, but we must simultaneously remove all those parts where cancer cells have wandered secondarily, and which are often only discovered at the operation. There are four recent researches which have very thoroughly shown in what directions cancer of the breast tends especially to spread, and which have

[1] Crile reports 80 per cent of cures in favourable cases where the mamma alone was dealt with (cf. also Schröder (Rostock), *Beitr. z. klin. Chir.*).

demonstrated the course of the local recurrences, formerly so frequent. The first paper is by L. Heidenhain,[1] the second by Harold J. Stiles,[2] the third by Grossmann,[3] and the fourth by Rotter. On the basis of a very large number of anatomical researches these authors have shown (as formerly did Gussenbauer, Waldeyer, and Langhans) that lymphatics full of cancer cells can frequently be demonstrated in the gland tissue of a carcinomatous breast, both in the immediate neighbourhood of, and also far removed from, the primary focus. The authors are all unanimous in stating that the chief direction in which the cancerous infiltration spreads is along the retro-mammary lymphatics. Moreover, cancerous emboli are to be found in the suspensory ligaments (ligaments of Cooper), in the corium, in the peri-mammary fat, as well as in the connective tissue-septa between the lobules. The efferent lymphatics open into lymphatics lying in the fascia covering the pectoral muscles. The latter drain partly into the superficial and deep pectoral glands which are situated along the free border of the pectoralis major and on its deep surface, and thence accompany the blood-vessels on their way to join the axillary glands. Only the lymphatics from the inner part of the breast follow the branches of the internal mammary to the sternal glands.

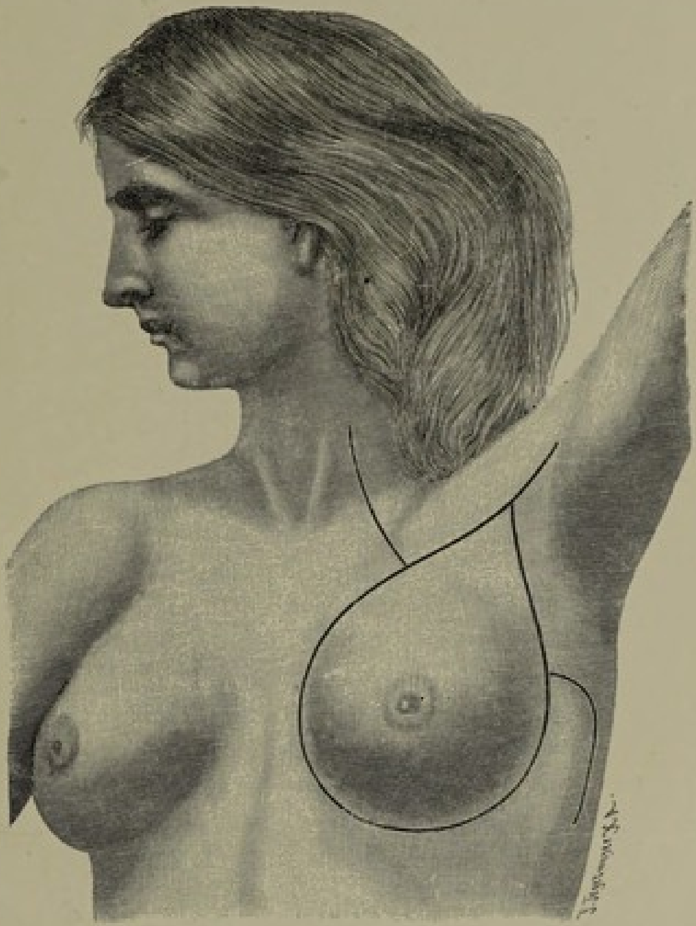


Fig. 299.—To illustrate the incision employed by Collins Warren, in the radical operation for cancer of the breast. It closely resembles that used by Willy Meyer, and the flaps are so cut that the operation is really plastic.

The excellent work and statistics of Halsted, Rotter,[4] and Joerss[5] have clearly demonstrated that the modern operation for cancer of the breast has given very much better results by keeping in mind this wide regional dissemination of the cancer cells. In the twenty years previous to 1896 we have obtained relatively good results in the 212 cases which Dr. Meyer has tabulated, 31 per cent of the cases being free from recurrence after a period of at least three years. But lately still better results have been obtained as regards both local recurrence and permanent cure.

Joerss, from a table of the results obtained by Halsted, Rotter, Cheyne, and Helferich, reckons that 42 per cent of the cases are free from recurrence after three years. Lennander has published the statistics of 74 cases operated on by Dahlgren (1887-1897); he found that 53 per cent of the cases were free from recurrence after more than three years. M'Williams, however, denies that the result of the modern "heroic" operations are better than formerly. In 100 cases, of which 66 could be traced, he only found 17 survivors (25 per cent).

[1] Langenbeck's *Archiv*, Bd. 39.
[2] *Edinburgh Medical Journal*, 1892.
[3] *Gekrönte Preisschrift*, Berlin, 1896.
[4] *Berliner klinische Wochenschrift*, 1896.
[5] *Deutsche Zeitschrift für Chirurgie*, Bd. xliv.

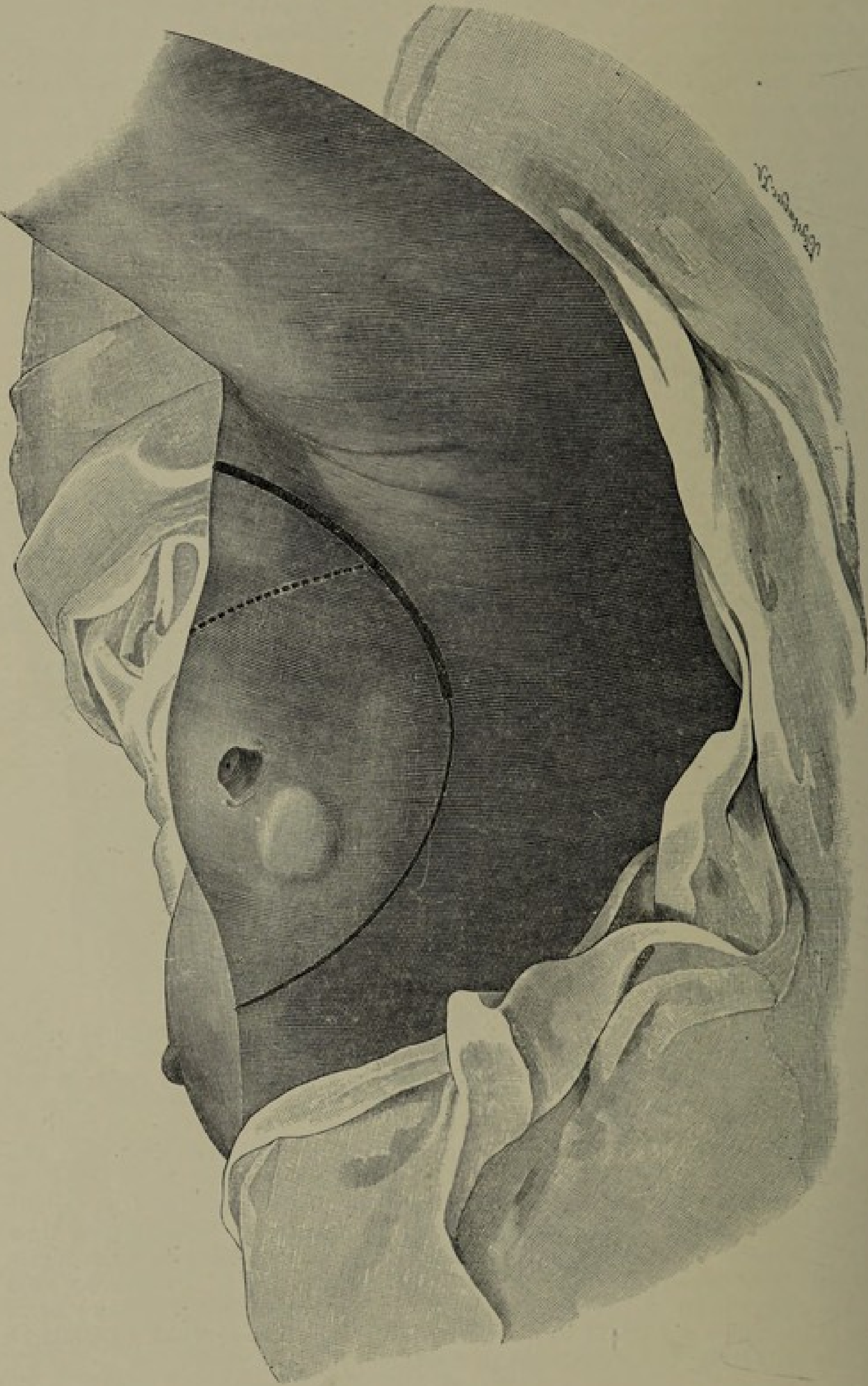


FIG. 300.—Position of the patient. The order in which the incisions are made is indicated by the different thickness of the lines.

Formerly it was the practice to excise the breast alone, and when glandular recurrence became manifest, the glands were dissected out singly by an incision in the axilla. Removal of the pectoral fascia was then practised by Volkmann, following which, superficial layers of the pectoral muscle were excised by Heidenhain. A portion of the pectoral muscle was next removed by Rotter, and subsequently a more extensive clearance of the axilla was adopted by Willy Meyer. The climax has now been reached in Halsted's operation, which consists in the complete removal of all the perimammary

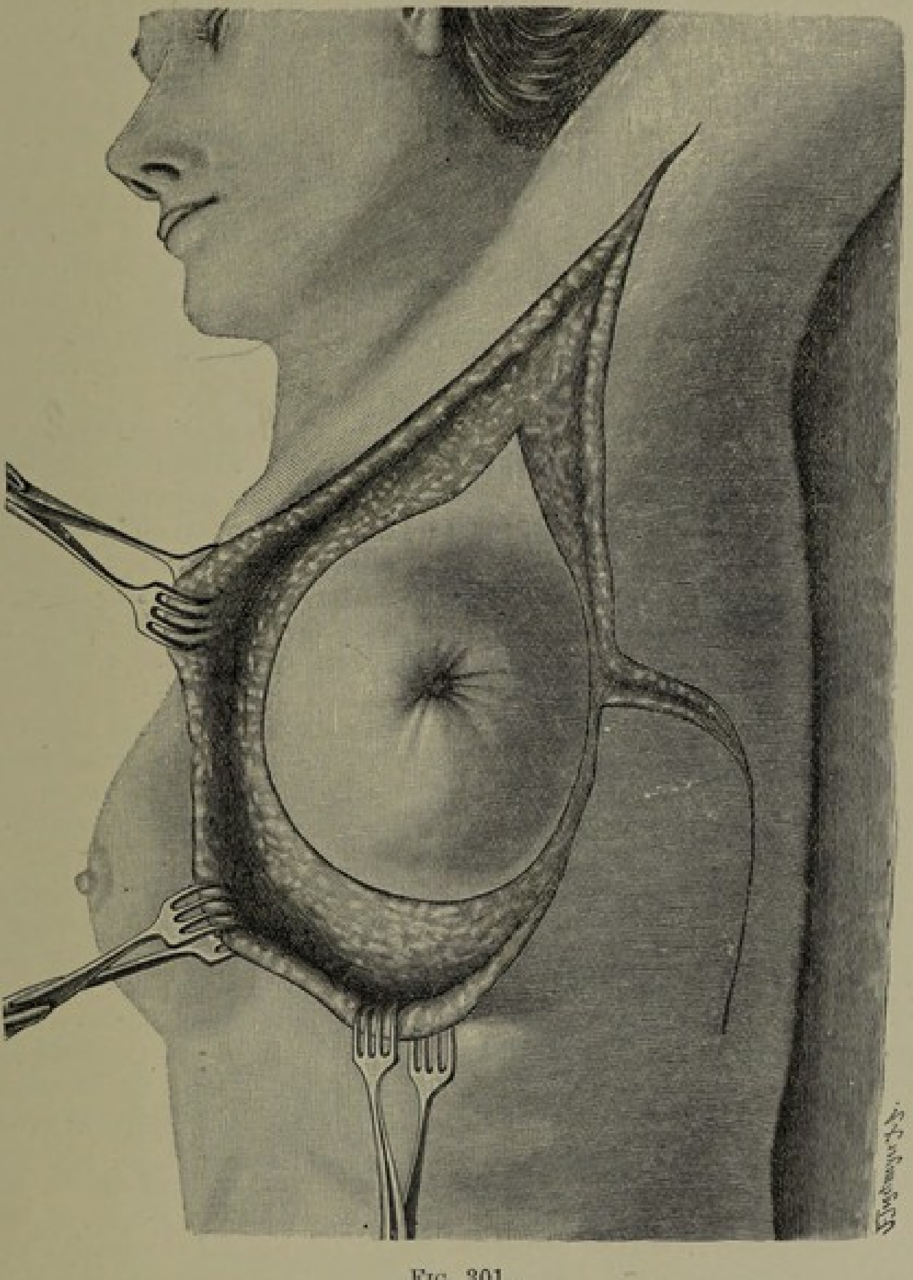


FIG. 301.

fat, clearance of the axilla and axillary fat, division and removal of the pectoral muscles from the arm, scapula and clavicle, and finally the sawing through of the clavicle and clearing out of the supraclavicular fossa. It is this very extensive operation which, according to reported cases, permits of a guarantee against local recurrence. Owing to asepsis and sure methods of arrest of hæmorrhage its risk is quite trivial.

The first part of the incision, which divides skin and fascia, begins above on the clavicle (*vide* Fig. 300) at a point slightly internal to the groove between the deltoid

and pectoralis major, and is carried downwards over the edge of the pectoralis major, across the axilla as far as its posterior fold. A superficial gland lying on the clavicle may often be found infected.

A dissector, or finger, is now passed underneath the exposed pectoralis major muscle, about two fingers'-breadth from its insertion, and the muscle is divided, while two or three vessels may have to be secured. The latissimus dorsi and teres major muscles, forming the posterior fold of the axilla, are exposed as far as the origin of the former muscle from the thoracic wall. The fascia covering the teres major, together with the fat, connective-tissue and pectoral glands, is stripped upwards by means of gauze dissection, and the subscapular nerves lying in the furrow between the latissimus dorsi and the subscapularis, as well as the posterior thoracic nerve, are exposed.

The axillary fat and the whole bunch of glands, together with the fascia covering the anterior surface of the subscapularis and serratus magnus, are reflected upwards as far as the axillary vein. The pectoralis major and its fascia are then turned down and a search is made for glands lying between it and the pectoralis minor, the pectoralis minor being then freed with the finger at the coracoid process and cut across, thus exposing the great vessels as far up as the clavicle. This division of the pectoralis minor and exposure of the axillary vessels put the pectoral branches of the axillary vessels on the stretch, and when these are secured and divided, access is obtained to the glands lying immediately below the clavicle, which must be dissected off the axillary vessels with special care.

When a gland is firmly adherent to the wall of the axillary vein, the vein must be ligatured above and below and the portion resected. If the glands behind the clavicle cannot be satisfactorily removed from below, the method employed by Halsted and Madelung should be adopted, the clavicle being sawn across obliquely from above downwards and outwards and the two halves pulled apart. For this, our incision is prolonged upwards and the superficial and deep cervical glands[1] occupying the supraclavicular fossa, are dissected out, including the gland which lies in the angle between the subclavian and jugular veins (glandula angularis). In excising this gland the thoracic duct is liable to be injured.[2]

The clavicle need not be divided if the infraclavicular glands can be satisfactorily removed from below. If there is no involvement of the infraclavicular glands, or of the glands in the costo-coracoid membrane, there is no necessity to clear the supraclavicular fossa. Certain surgeons (*e.g.* Halsted, Cushing) clear the supraclavicular fossa on principle.

Following the same principle as we have adopted in our method of complete extirpation of the tongue, we find it is only when the glands have been cleared out in one mass, and the majority of vessels supplying the primary focus have been tied, that the surgeon should proceed to the amputation of the mamma itself, together with its fat, the pectoral muscles and skin.[3] The incision is now prolonged downwards below the mamma to the sternum. The fascia and fat are stripped off the latissimus dorsi and serratus magnus, and the costal origins of the pectoralis minor are exposed. These are detached, and the perforating branches of the intercostal vessels are secured with forceps.

Passing over the ribs towards the middle line under the pectoralis major, we reach the thick sternal origin of the latter muscle and the origin of the rectus abdominis. The pectoral muscle is divided at its origin, and along with the breast is separated from the ribs and intercostal muscles. Some perforating branches of the intercostal artery are cut.

The incision is now made through the skin above the breast, and a skin flap is dissected from the subcutaneous fat as high up as the clavicle, when the clavicular

[1] Schwarz from Von Hacker's clinic has published a large body of statistics. In this excellent compilation he only records four permanent cures out of thirty-three such operations with removal of supraclavicular glands, in spite of the very radical procedure introduced by Rotter, Halsted and Kocher.

[2] Cushing has on two occasions had experience of this accident, and once was able to repair the duct by suture.

[3] Handley (*Lancet*, 1905) lays special stress on carrying the incision through the fascia two fingers'-breadth below the ensiform process in order to obviate "epigastric infection."

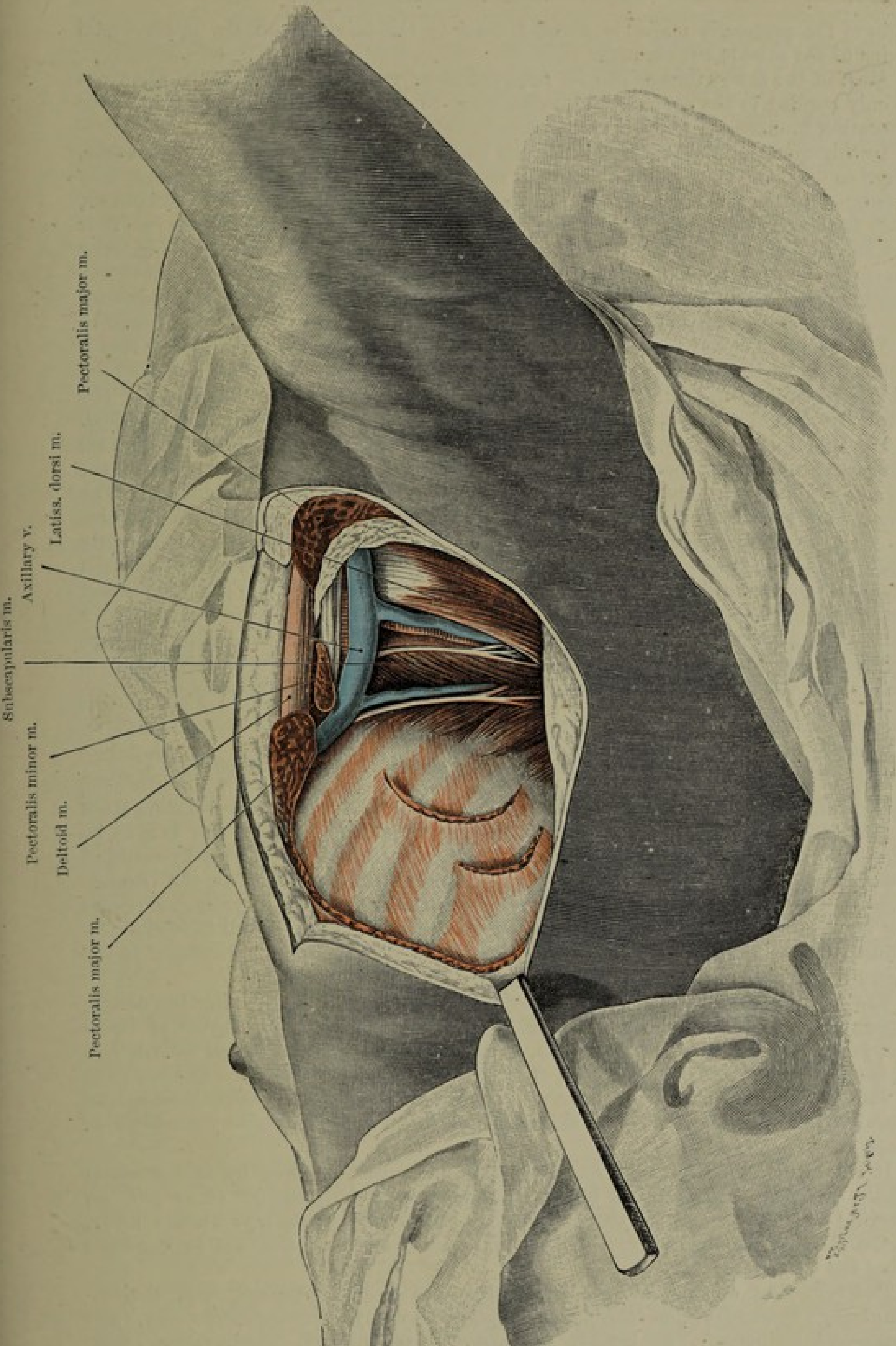


FIG. 302.—Radical operation for cancer of the breast. The mamma has been removed and the contents of the axilla have been cleared out. The axillary vein (above which is seen the axillary artery and the cords of the brachial plexus) has been cleared up to the clavicle, while, in addition, the subscapular vessels, the long thoracic vessels, and the corresponding nerves are exposed. The figure further shows the divided pectoral muscles, the ribs, and the serratus magnus, subscapularis, latissimus dorsi and teres major muscles.

origin of the pectoralis major is divided close to the clavicle and the upper costal origins of the muscle cut through.

Most of the artery forceps can be removed after twisting the vessels. Ligatures are only applied to the arteries and veins close to the main vessels, and also to the perforating branches of the intercostal vessels.

In this operation the axillary glands, the pectoral fascia, and both pectoral muscles, as well as the mamma and skin covering it, are removed in one piece. We attach special importance to the direction of our incision, because it at once exposes the muscles, which form the boundaries of the axilla, and enables one to strip the fascia, as if it were an envelope containing the contents of the axilla, in one mass from the anterior aspect of the scapula (subscapularis muscle) and the outer aspect of the thorax (serratus magnus and intercostals). It further preserves the subscapular and posterior thoracic nerves, and enables us to divide the vessels which go to supply the breast.

The wound is closed by bringing together the flap so that the axilla at any rate is completely covered. A single drainage tube is inserted at the posterior axillary fold, and should pass up between the scapula and the chest wall as far as the clavicle. The part of the wound which cannot be closed can be at once grafted by Thiersch's method.

The functional disturbances which follow such an extensive operation and removal of muscles are not so severe as one would expect, because the anterior fibres of the deltoid are able to pull the arm forwards, and the latissimus dorsi to abduct it. The movement of the arm is freer than after partial removal of the muscles. To diminish the consequent disfigurement, Collins Warren only cuts through and subsequently reunites the pectoralis minor instead of excising it, as its removal is not so essential as that of the pectoralis major. The complete removal of glands is a more important matter, and the obstruction to the flow of lymph, especially if the main vein has been ligatured, is a more serious complication. In this case a solid œdema develops, with elephantiasis of the arm, which may last for months or years, and which interferes much more with the function of the arm than does removal of the muscles.

(b) Advances in the Surgery of the Thoracic Organs

The surgery of the thoracic organs has undergone so complete a revolution since the last (4th) edition was prepared that the chapter dealing with it has had to be entirely rewritten. Hitherto operations on the chest have been practically confined to the excision of ribs and the evacuation of fluid, especially of pus, in the thoracic cavity (not so long ago abdominal surgery was similarly restricted); but surgeons have now learnt to a certain point how to overcome the risks, which have till now nullified the advantages of aseptic wound-treatment that are so well displayed in the surgery of the abdomen.

The essential feature of advance in late years consists in overcoming the danger of pneumothorax, a complication which hitherto has barred the progress of intra-thoracic surgery. A result due, however, to the enterprise of Mikulicz and Sauerbruch, and the energy of Braun and Petersen of Heidelberg, surgeons have come to appreciate the value of simple well-known measures which, when employed even without special apparatus (air chambers), can in skilled hands achieve a satisfactory measure of success.

It would almost seem that surgeons have been carried away by this sense of security and have been careless in carrying out the great principle of asepsis, as, according to recent statistics, the majority of deaths after operations on the lungs, heart, and other thoracic viscera, are attributable to infection and not to accidents during the operation.

The following operations may be distinguished—thoraco-parietotomy, thoraco-pleurotomy, thoraco-pneumotomy, thoraco-pericardiotomy, thoraco-cardiotomy, and thoraco-mediastinotomy, or briefly, thoracotomy, pleurotomy, pneumotomy, pericardiotomy, cardiotomy, and mediastinotomy, the latter including three varieties, viz. anterior, posterior and thoracic œsophagotomy.

Besides the above operations, which are undertaken either for the removal of disease in the chest-wall or to give access to intrathoracic organs, there is another category of operations in which thoracotomy is performed in order to reach, through the pleura—or as has even been suggested through the pericardium—other organs (œsophagus), and especially some abdominal viscera. These may be briefly grouped as transpleural[1] (transpericardial). At present they are principally employed for opening subphrenic abscesses or collections of fluid in the liver, and also for getting access to the stomach (*e.g.* in œsophago-gastrostomy). The œsophagus can also be approached directly through the mediastinum by the transpleural route, Jaboulay even advocating the transpericardial route.

The surgery of the thoracic wall has changed least of all, but before considering it, we find it advisable to deal with the question of the prevention and treatment of traumatic pneumothorax, as, especially in the case of new growths of the chest-wall, the surgeon must be prepared for wounding the pleura, and be ready to cope with the danger of acute pneumothorax. Otherwise, he will be hampered in the correct performance of the operation by anxiety, and will desist from a radical operation which would obviate a fatal result.

(c) Prevention and Treatment of Traumatic Pneumothorax

From experimental and clinical evidence it is well known that acute pneumothorax is a serious menace to life. No operation on the thoracic viscera, necessitating an extensive opening up of the chest-wall, can be undertaken without incurring risk. In regard to the pericardium, however, it is different. Gerulanos has shown that there is more danger in opening the right pleural cavity than the left, on account of the greater size of the right lung and its close relation with the great venous trunks and the right auricle.

The cause of the dangerous collapse that occurs in a sudden pneumothorax has been made the subject of considerable investigation. Earlier observers attributed it to displacement of the heart and great vessels; but in a series of interesting experiments, Murphy has shown that it is due to a displacement of the sagittal mesial plane of the thorax, which is caused by the sudden inrush of atmospheric air during the act of inspiration when the intrapulmonary pressure of the sound side is reduced. The mediastinum bulges into the sound half of the thorax and impedes the entrance of air into the lung on that side, while expiration is equally impeded by the mediastinum being pushed towards the side of the pneumothorax. Murphy also states that by causing traction on the mediastinum, either directly or indirectly, by pulling forward the lung, the dyspnœa and cardiac collapse are averted.

It is also a well-known clinical fact that grave symptoms result from pressure on the mediastinum; and in rapidly-increasing effusions of blood or fluid in the pleural cavity, where the displacement of the mediastinum can be demonstrated by percussion, a high degree of dyspnœa is invariably present. Considerable displacement of the heart and pressure on the great vessels may be caused by an effusion which exerts a constant pressure, but with an open pneumothorax the mediastinum swings to and fro on inspiration and expiration.

Authorities are agreed that loss of respiratory function in one lung is not sufficient to account for the dyspnœa, and Sauerbruch has proved that the respiratory volume may fall to one-tenth of the normal without serious disturbance of respiration, the same observer having also shown that the respiration of one lung may be completely shut off without producing dyspnœa, if it be previously inflated.

According to Sauerbruch's researches, the view held by Garré that the dyspnœa is the direct result of mechanical pressure on the mediastinum, which interferes with the efficiency of the sound lung, does not sufficiently explain the intensity of the respiratory disturbance; as, according to his observations, the increased rate and force of the breathing maintains the respiratory volume almost unchanged. He believes

[1] The expression "perpleural" would probably be more correct.

that the explanation lies in the fact that by the falling together of the lungs, the pressure on the thin intrapulmonary vessels is removed, and a hyperæmia results, while the normal stimulation from the vagus termination is altered, with consequent loss of tone and irregularity in breathing. The hyperæmia of the one lung produces anæmia and defective arterialization of the other, with consequent dyspnœa and rise of blood-pressure. It follows, therefore, that both pleural cavities may be opened without producing dyspnœa, provided that collapse of the lungs is at once prevented, and further, that the dyspnœa can be removed by expanding the empty lung.

Further experiments must be undertaken to determine to what extent dyspnœa is produced by displacement of the heart and great vessels, pressure on the large veins of the right heart (Gerulanos), and reflex pleural stimulation. Suffice it to say that the danger can be immediately removed by pulling on the collapsed lung and bringing it up to the thoracic wall, which has been proved by Murphy's experiments, by W. Müller, and later by Bayer, who first put it into practice intentionally. We have thus a certain and simple means of preventing the immediate danger of pneumothorax when an extensive opening in the pleural cavity has to be effected.

Delagenière and other surgeons, experienced in pulmonary operations, rely absolutely on this simple measure.

It is further gratifying to the surgeon, as well as to the patient, to know that an incomplete pneumothorax does not produce the same danger as a total pneumothorax. Garré has drawn special attention to the fact that respiration occurs again in the lung whenever the opening in the pleura is smaller than the aperture of the glottis, as in that case a certain amount of expansion takes place on inspiration, owing to the fact that the negative pressure in the pleural cavity is satisfied less rapidly than that in the lung.

Sauerbruch also showed by experiments with his air chamber that respiration can be maintained so long as even a relatively small portion of lung is in contact with the chest-wall, the intercostal muscles and diaphragm being intact.

There is a great difference between a pneumothorax that occurs rapidly and one that occurs slowly. The latter may give rise to no serious symptoms, and it seems to us that the explanation of this is to be found in the fact that the pneumothorax in the latter case is not so complete. According to Murphy's theory, on the other hand, which Garré accepts, it is maintained that the sound side has time to make up for the deficiency in inspiration by a more effective range of respiratory movement. Sauerbruch's experiments, however, prove that the absence of sudden disturbing reflexes on the part of the pleura, and the adaptation of vagus reflexes and of the heart and vessels to the new conditions, are by no means matters of indifference.

We do not attach so little importance to the simultaneous respiration in the retracted lung, as is done, for instance, by Garré, as it follows that with an open pneumothorax the respiration of the lung is obviously reversed. On expiration it is inflated by the sound lung and collapses on inspiration. This inflation with air that has been already breathed, and the respiration of the same air in the sound lung are likely to prove more harmful than beneficial. The pulmonary circulation is chiefly affected, and this, according to Sauerbruch, is the critical point. In the methods employed by Murphy, Müller and Bayer, the partial expansion of the lung is, according to Sauerbruch's theory, of more significance than simple traction on the mediastinum.

In cases where the pleura has been opened either by intention or accident, it is well to remember the great difference in danger between a complete and partial, sudden or slow-produced pneumothorax, as it is by this that the treatment is influenced.

(1) In carrying out an operation which necessitates opening the pleural cavity, the primary incision into it should be small; and, as the opening is enlarged, the rapid onset of diffuse pneumothorax is prevented by packing with warm gauze compresses (Krause). In this way the cooler air is prevented from coming in contact with a large surface of exposed pleura, and the dyspnœa from reflex stimulation is avoided.

(2) All accidental wounds of the pleura should be immediately packed with gauze

so that air may enter slowly, sudden contraction of the lung (by its own elasticity) being thus prevented.

(3) When a more extensive opening of the pleura is desired, *e.g.* in palpating the lung, after it has been examined and the nature of the lesion determined, the lung itself should be immediately seized (preferably with Kocher's artery forceps), pulled into the wound and temporarily sutured to one edge of the wound (Pneumopexy). Quénu and Longet have shown that these sutures should include the intercostal muscle (possibly even rib) as well as the parietal pleura, lung tissue, and the visceral pleura.

(4) When the nature and situation of a lesion in the lung demand an extensive opening in the pleura it is of the utmost importance that a preliminary pneumopexy should be performed, to prevent collapse of the lung while the development of pneumothorax is rendered impossible by passing deep supporting-sutures through the underlying lung, prior to incising the pleura, and by shutting off the pleural cavity from the area of lung, on which the operation is to be performed, by Roux's "continuous circular suture."

(5) A similar suture is adopted for "pleuroparietopexy,"—a preliminary to transpleural operations, a circular area of parietal pleura being sutured to the diaphragmatic layer before the pleural cavity is incised.

(6) When the situation of the lesion or tumour in the lung has not been determined, and it is necessary to insert the whole hand into the pleural cavity, this limiting suture, the use of which we owe to Delagenière, is out of the question for the purpose. In such cases we may either at once pull forward the lung and fix it to the wound as described above, or we may follow Dollinger's plan, and slowly and carefully produce an artificial pneumothorax, either at the operation or a day or two previously. The advantage of this is, that when the operation is performed, the danger of sudden circulatory and respiratory changes is compensated, while, further, it furnishes clear proof of the comparative safety of a partial pneumothorax.

The method here recommended for avoiding the danger of pneumothorax can be easily adopted by any practical surgeon, and should encourage him to take active measures in certain conditions and in cases of urgency, *e.g.* in injury to the lung with dangerous bleeding.

The favourable results obtained by Müller, Bayer, Keen, Delagenière, Garré and others, justify the adoption of such measures. We are undoubtedly indebted to the untiring efforts of Quénu and Longet, Tuffier and Hallion, Fell-O'Droyer, Brauer, and, above all, Mikulicz and Sauerbruch, that an operation which necessitates an extensive opening of the pleura has now become a comparatively safe procedure, provided the necessary apparatus is at hand.

We are at present engaged in testing the practical value of Kronecker's apparatus for artificial respiration, the simplest method of which, however, is that recommended by Quénu and Longet, Tuffier and Hallion, and Fell, the next being the "over-pressure method" of Brauer, Petersen, Engelken, and also of Quénu and Longet. Sauerbruch's method entails the most complicated apparatus. Nevertheless, Sauerbruch has supplied the most satisfactory proofs of the reliability of his procedure. We shall afterwards refer to this subject.

The method recommended by Loisin is simple in technique, but is difficult to accomplish. It consists in plugging through a bronchoscope, the bronchus on the side to be operated on by means of an indiarubber ball. When the lung is inflated, collapse is prevented, and the respiration of the other lung is not interfered with.

In all operations in which the pleura has to be extensively opened special attention must be paid to the position of the patient. The natural inclination is to lay the patient on the sound side, but this position is always to be avoided, as it impedes the movements of the sound side, and entails additional risk, when the pleura is full of fluid or when there is a pneumothorax. It is highly probable that the position the patient occupies may explain the want of agreement that exists amongst different observers as to the severity of the dyspnœa in cases where the pleura has been freely opened.

Besides the restriction of respiratory movements, the displacement of the mediastinal septum, or, on the other hand, of the heart and lung, by an accumulation of fluid, must not be forgotten. Garré has shown that the dyspnœa can be diminished by placing the patient on the affected side, which is made to project well over the edge of the table. In pleurotomy, it should be the rule to place the patient on his back, or possibly even on his abdomen.

(d) The question of Drainage of the Thoracic Cavity

It is worth while considering the circumstances in which drainage should be used after opening the thorax, either to remove collections of fluid, or after operations which admit of primary union. As the thorax is a rigid-walled cavity, it cannot be regarded in the same light as a cavity with soft walls or as an open wound. The indications, as we shall see subsequently, for draining the peritoneal cavity are of a different nature.

At the last surgical congress in Paris, Willems and Soison communicated two excellent articles (entitled, "Voies et Moyens d'accès dans le thorax") in which the question of drainage from the point of view of excluding sepsis was considered, especially by Willems.

All experimental attempts at producing artificial adhesions in the pleura have shown that adhesions do not easily form on account of the constant movements of the lung, while the lung, if it is separated from the chest-wall, has a tendency to retract as soon as a positive pressure is established in the pleural cavity by the entrance of atmospheric air.

There is no reason, therefore, for inserting a drainage tube into an open pleural cavity unless the end of the tube is immersed in the fluid to be evacuated, or care is taken by some other means to shut off the cavity to be drained.

In the case of aseptic operations air should be hermetically excluded by inserting several layers of firmly-tied sutures. More care, however, must be paid to asepsis in the case of the pleura than, for instance, the peritoneum, because in the former a localized infection is not so easily shut off by adhesions.

Before hermetically closing the wound, the lung must be brought in contact with the chest-wall, as there is no positive pressure to keep it there analogous to that produced inside the abdomen by the viscera.

When the lung cannot be fixed to the chest-wall by pneumopexy, the pneumothorax must be removed by aspiration, or Witzel's method may be adopted. The latter consists in displacing the air in the pleura with weak boracic lotion or normal saline[1] and then removing the fluid by aspiration. The method is complicated but thorough, and should be employed whenever the pleura has been contaminated during the operation, or when blood has escaped into it. In the latter case, however, it is not necessary to insist upon entirely displacing the air by Witzel's method. According to Sauerbruch, washing the pleural cavity with warm sterile salt-solution is sufficient for cleansing purposes.

On the other hand, drainage of the pleural cavity must be employed for the removal of infective fluids. Quénu and Longet, and also Delagenière and Willems, have justly emphasised this procedure, and recommend, at the same time, continuous aspiration with a suction apparatus, the latter taking either the form of a large cupping glass (Mikulicz), or an actual aspiration apparatus connected with a water pump (Perthes, Seidel). Stork employs a simple method, in which a suction flask (breast pump) is exhausted by means of a column of water flowing from one vessel into another.

Aspiration can also be combined with simultaneous plugging, as the pleural cavity can be satisfactorily closed by means of firm packing. This has been demonstrated by Krause, who found that, by packing gauze round a tube for the arrest of hæmorrhage, air was excluded from the pleura. The gauze, however, should contain a good permanent antiseptic such as xeroform, vioform, or iodoform.

[1] Bardenheuer has demonstrated the advantage of salt-solution.

Sauerbruch, who has had great experience of pulmonary injuries, has shown that no danger of pneumothorax follows the use of a small drainage tube, while there is still less risk by employment of a "cigarette-drain" (a cylinder of gauze or wick rolled in rubber tissue), as is used with great success in the abdomen in peritonitis by M'Cosh. Garré also confirms this statement.

Hoffmann's secondary drainage, which we have suggested chiefly when secondary sutures are employed, must also be mentioned. This consists in the introduction of a gauze drain wrung out of 5 per cent carbolic lotion covered with a protective antiseptic dressing. Only the superficial layers of this are changed. After a few days,

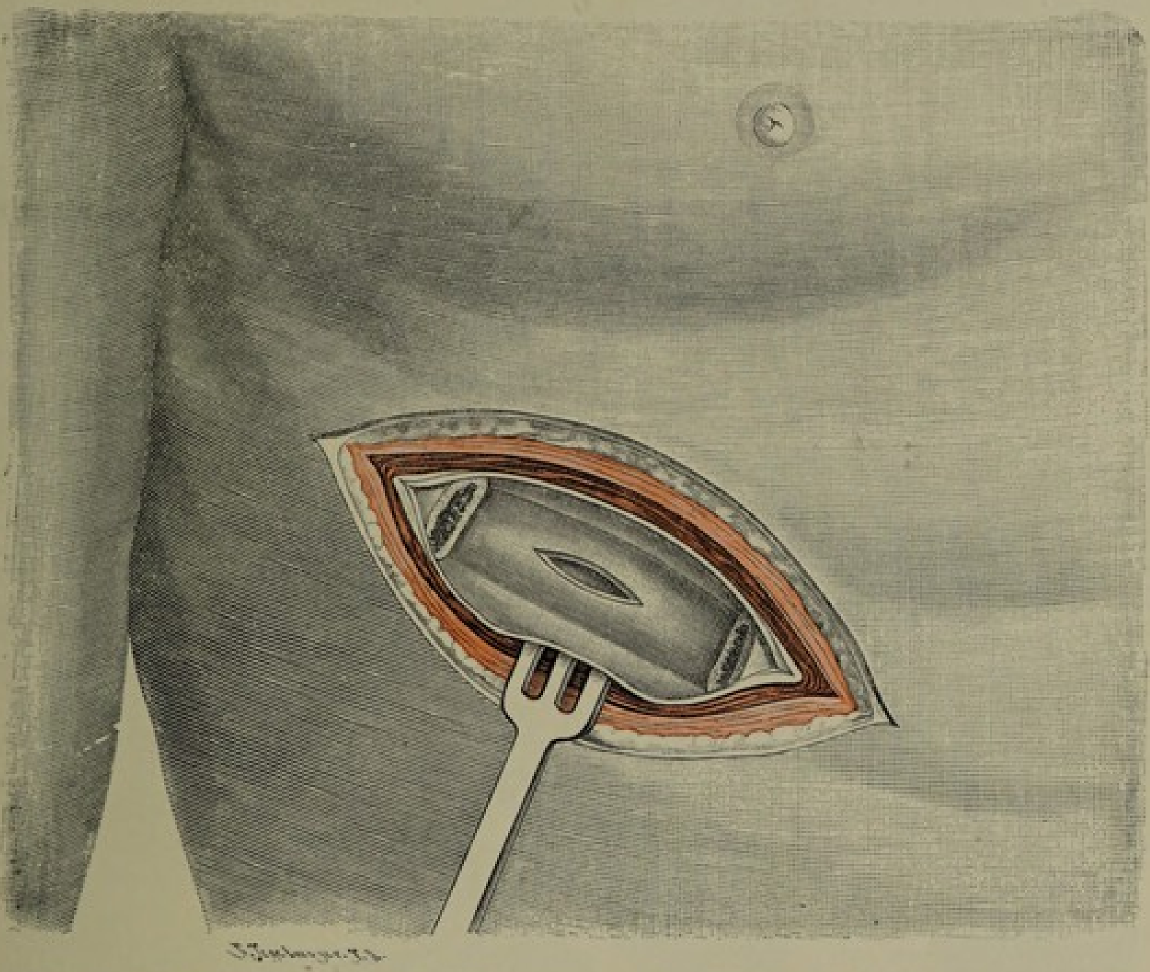


FIG. 303.—Simple resection of rib, to open the pleural cavity. 3 cm. of a rib has been removed. The periosteum covering it anteriorly has been detached, and the pleura opened through an incision in the posterior layer of periosteum.

when the lung has once more expanded, a short drainage tube is inserted, a method commended by Willems and Payr.

(e) Surgery of the Thoracic Wall

71. Resection of Ribs (Figs. 303 and 304). In a large number of cases, resection of the ribs has to be performed as a preliminary to further operative procedures, but it is also employed *per se* in the treatment of disease of the ribs. In tuberculous cases especially, excision, when performed opportunely, affords excellent results, so that we entirely disagree with the statements promulgated in text-books as to the "intractable nature" of this disease.

Other inflammatory conditions (*e.g.* typhoid, staphylococci) are of minor importance.

New growths of the ribs, chiefly primary, but occasionally secondary, are a not uncommon indication for excision, and in this connection it is necessary to be fully acquainted with the precautionary measures for opening the pleural cavity described in paragraph (*c*) of this section.

Resection of healthy ribs is frequently called for in order to restore the mobility

Fig. 304.—Resection of ribs to expose the surface of the liver. A portion of two ribs has been removed, the intercostal tissues being ligatured and excised. The costal and diaphragmatic pleura, along with the diaphragm and peritoneum have been incised, exposing the upper surface of the liver.

of the chest-wall in the case of a rigid empyema cavity, and again, to admit of full access for operations on the viscera. In the latter case an osteoplastic resection is performed. Finally, an osteoplastic transplantation of portions of the costal cartilages and ribs is occasionally indicated for the purpose of repairing parts of the larynx, trachea, clavicle, etc.

Technique.—The operation, which is a simple one if the removal of a large number of ribs is unnecessary, can be performed very satisfactorily under local anæsthesia. After anæsthetizing and dividing the skin, a 1 per cent solution of novocain with

adrenalin is injected into the muscles, and afterwards between the intercostal muscles along the upper and lower border of the rib, although Schleich uses a considerably weaker solution for more extensive operations.

An incision is carried through skin and muscle down to the bone, midway between the upper and lower borders of the rib, no large vessels or nerves being divided. The periosteum is incised and carefully separated with an elevator from the outer and inner surfaces of the rib, and the exposed portion is removed by means of a suitable pair of bone-forceps.

In children it is advisable to divide the rib first in front, as it can then be raised, and easily fractured posteriorly if an extensive portion has to be removed.

In detaching the intercostal muscles from the upper and lower borders of the rib, special care must be taken to keep close to the bone. The ends of the divided rib should be rounded off, as otherwise the vessels and nerves may be injured.

Behind the periosteum is the pleura, from which it is separated by the very thin intrathoracic fascia. These three layers are freely incised in the direction of the rib—in inflammatory cases, the presence of the exudate being previously ascertained by an exploratory puncture.

An incision in the groove from which the rib has been removed is absolutely safe and greatly facilitates the operation.

Very often resection of one rib is not sufficient. In this case a portion of the adjacent rib is removed through the same incision by drawing the skin edges well apart, the pleura being opened in the same axis as before to the resected bone. A threaded aneurysm needle is now introduced, first at the anterior and then at the posterior extremity of the lower opening, and is passed each time beneath the intervening tissues of the intercostal space and out again at the extremities of the upper pleural opening, so as to apply two ligatures to the vessels along with the pleura and muscles. The two pleural openings are now united by a vertical incision between the ligatures by excising the ligatured piece, thus making a horizontal I-shaped opening. The ligatures must be firmly applied if the bleeding from the intercostal arteries is to be thoroughly controlled. In this way the operation is performed without any hæmorrhage and is free from danger. Extensive portions of three or four ribs can be removed through the same skin incision.

72. Resection of Ribs for Tuberculosis. In the case of a tubercular rib, the disease may be completely eradicated by excision of the affected rib, provided that the abscess in connection with it is still of small extent and has a firm wall.

The soft parts and muscles are carefully separated from the thick abscess wall (under novocain anæsthesia), while the periosteum is incised in the direction of the rib and is detached along with the intercostal muscles. The rib is then divided with cutting-forceps. The periosteum on the deep surface of the rib must be separated with care on account of the close proximity of the pleura. The intercostal muscles are then detached above and below the abscess wall, and the diseased portion of rib, together with the unopened abscess, is removed like a tumour, after which the wound is sutured. A small caseous focus in the rib is often found communicating with the thick contents of the abscess.

This treatment should be regularly adopted when the disease is in an early stage, when the wound, after excision of the abscess along with the primary focus, will be healed in the course of a week. But when there is a large abscess, or when the abscess has burst and a sinus has formed, the procedure is much more complicated, because the sinuses often burrow along the intercostal spaces and give rise to peri-pleural abscesses, which render a complete removal of all the tuberculous tissues impossible. We have then to rely on thorough exposure of the disease, removal of the primary focus, as well as the carious bone, cauterization with strong alcoholic carbolic acid (10 per cent), and secondary suture after packing with iodoform gauze.

When the disease involves the costal cartilages, complete excision of the diseased cartilage, together with a piece of the sternum, is generally the only means of obtaining a cure.

73. Resection of Ribs for Tumour. The technique in excision of tumours of

the ribs differs from that of tuberculosis only as regards the extent of the operation. A long incision is made parallel to the ribs, if possible over the tumour, and the soft parts are dissected off. A flap incision with the base above and behind is, as a rule, only indicated when the tumour is adherent.

One has first to make sure of the rib with which the tumour is connected, and it will often be found that the attachment, even of a large tumour, is quite circumscribed, while most of the growth is unconnected with the ribs. The ribs that are adherent to the tumour, or that cannot be easily separated from it, are then removed as in tuberculosis, the rib or ribs being freed subperiosteally and divided in front and behind. The soft parts round the tumour are removed until a healthy rib is reached.

At this stage the essential difference between tuberculosis and new growths of the ribs becomes apparent, namely, the frequent involvement of the pleura, and one must be fully prepared for the possible dangers of a pneumothorax. If the apparatus for maintaining artificial respiration (high or low pressure) is not at hand, a preliminary pneumopexy may be performed, or the method which Keen successfully adopted in one case may be followed.[1] The chest-wall is rapidly divided with scissors (the ribs having been previously cut) and along with the tumour is removed in one piece, while the lung is immediately seized (the Murphy-Müller grip), pulled up and sutured round the wound with deep sutures.

When this has been accomplished, the rest of the pneumothorax can be removed by aspiration with Potain's apparatus, before the soft parts are replaced, and the wound closed. One or two drainage tubes are placed between the outer surface of the sutured lung and the overlying soft parts, but the pleural cavity need not be drained, for any bleeding from the cut edges of the thoracic wall is controlled by the sutures which fix the lung *in situ*. If necessary, however, a continuous suture may be inserted.

The method of opening the posterior mediastinum by the removal of a portion of the rib and its transverse process (costo-transversectomy) will be dealt with in the chapter on posterior mediastinotomy. The method of turning up an osteoplastic flap of the costal arch (Marwedel) will be considered under surgery of the stomach.

74. Resection of the Sternum. The results of this operation, as shown by the statistics collected by Rouillès[2] in 1888, are relatively satisfactory. Including Otis' statistics, Rouillès was able to collect 115 cases of resection of the sternum with 28 deaths, 42 complete and 45 partial recoveries. In 4 cases where complete resection was performed there was only 1 death. The following accidents were recorded :— injury of the internal mammary artery in 4 cases, of the jugular vein once, opening of the pericardium once, and opening of the pleura in only 2 cases. In König's case, moreover, where immediate plugging was adopted, no evil consequences resulted.

It must not be forgotten that these statistics include subperiosteal resections as well as those for which the prognosis is entirely different. When undertaken merely to evacuate an abscess behind the sternum or to remove a diseased portion of bone, the operation is not serious if the periosteum on the posterior surface can be preserved and only a limited resection performed.

On the other hand, it is a much more serious matter when large portions of the sternum have to be excised, either for chondroma, sarcoma and carcinoma, or when an osteoplastic resection has to be performed in order to remove a substernal tumour. The dangers are, firstly, bleeding from the internal mammary artery and its branches, as, for example, in new growths of the sternum where severe bleeding may occur from some of the greatly dilated veins, and secondly, the risk of injuring the pleuræ of both sides. The relations of the pleura to the sternum are well shown in Fig. 307.

Under normal conditions the pleura can be easily pushed aside, but when the anatomical relations are altered by adhesions, it is a somewhat difficult process, and in every case one must be prepared to immediately pack the opening in the pleura (with subsequent closure by suture) as described in Section C.

[1] *Therapeutic Gazette*, June 1901.
[2] Rouillès, *Thèse de Paris unter Leitung von Laboulbène and Le Dentu.*

Resection of the body and the lower half of the sternum is a relatively easy matter. It is pointed out in describing the method of exposing the pericardium that, when the ribs on one side have been excised, the soft tissues and the pleural reflexion can be easily separated from the posterior surface of the sternum. By dividing the sternum transversely above and below and fracturing the costal cartilages, the operator can turn it over to one or other side as an osteoplastic flap, in this way exposing the auricles and their great vessels. The method of making an osteoplastic flap of the sternum by means of a median section will be dealt with again in connection with anterior mediastinotomy.

A special description of resection of the manubrium sternum is, however, necessary, as the manubrium is not infrequently the primary seat of acute inflammatory processes (lower down the source of infection is generally from the ribs) and also of new growths. It is further a favourite site for metastatic deposits in malignant disease of the thyroid gland.

Gravitation abscesses are met with in the upper part of the anterior mediastinum as a sequel to inflammatory conditions of the thyroid or cervical glands, while tumours of the thyroid and thymus, dermoid cysts, aneurysm, and malignant tumours of lymphatic glands are also encountered in this region. We have shown in a series of successful operations that even the largest masses of tuberculous glands in the upper part of the thorax can be removed from the neck, without resection of the manubrium, provided they are movable.

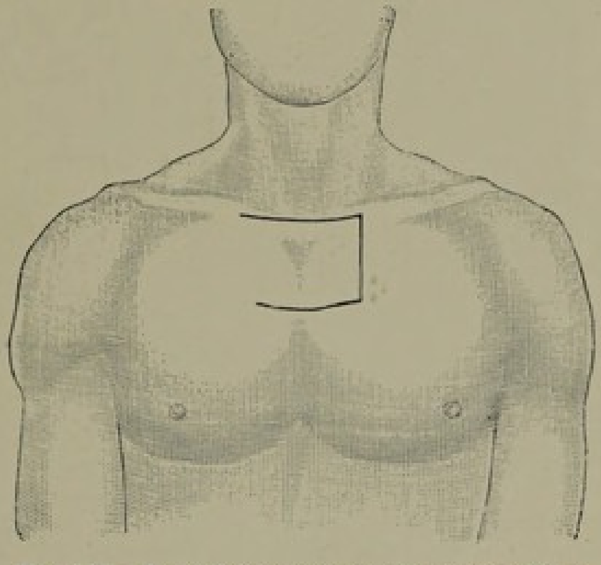


Fig. 305.—Incision for osteoplastic resection of the manubrium sterni.

From the results published to date, we may conclude that the manubrium, or even the whole sternum, can be removed subperiosteally without any great functional disturbance, and above all without embarrassment to respiration. No permanent inconvenience is reported either by Bardenheuer, who has had a comparatively large experience of the operation, or by Routizki or Rizzoli. The removal of the sternal ends of the clavicles along with the manubrium seems an advantage. The skin incision is shown in Fig. 305, and in Fig. 306 the manubrium is seen turned over to the right as an osteoplastic flap.

The upper part of the incision crosses the suprasternal notch transversely and is carried down to the bone, avoiding the communicating branch between the two anterior jugular veins, after which the periosteum on the anterior surface of the manubrium is stripped off the bone along with the capsular ligaments of both sterno-clavicular joints and the origins of both sterno-mastoid muscles. Posteriorly, the attachment of the cervical fascia and the origins of the sterno-hyoid and sterno-thyroid muscles are detached along with the periosteum, and the left sterno-clavicular articulation is freely opened by an incision down to the first costal cartilage. By incising the periosteum at the lateral margin of the manubrium the cartilage of the second rib is exposed, isolated and divided with bone-forceps, after which the perichondrium of the first rib is detached, the latter cut across, and the whole of the posterior attachment of the capsule exposed.

The manubrium can now be raised with a sharp hook so as to expose its posterior surface, and is sawn across at a level corresponding to the lower border of the second rib. By still further dragging the manubrium forwards, and carefully detaching the soft tissues, the costal cartilages on the right side are broken across and the manubrium is turned completely over to the right side. Fig. 306 shows the anterior mediastinum

exposed. On the right are seen the superior vena cava, innominate veins, internal mammary vein, ascending aorta and internal mammary artery, and on the left is observed the reflexion of the pleura.

This operation corresponds in most points with that described by Giordano and Auvray.

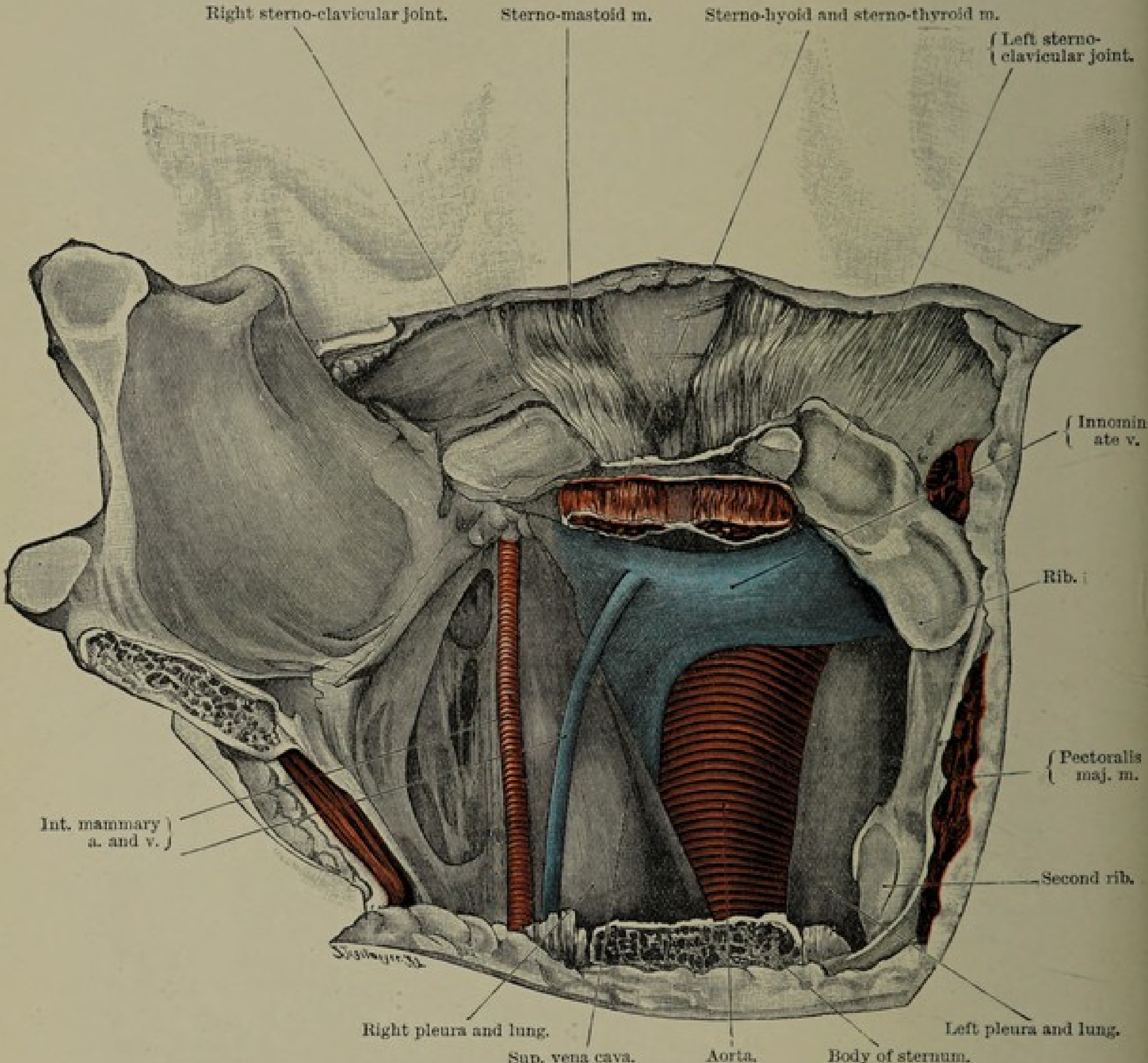


FIG. 306.—Osteoplastic resection of manubrium sterni. The sternum is turned over to the right side. The depressors of the larynx are seen detached from the back of the manubrium. The right and left pleuræ and lungs are exposed bounding the anterior mediastinum.

(f) Mediastinotomy

75. Anterior Mediastinotomy. Partial excision of the sternum has often been performed for the purpose of securing access to the anterior mediastinum and of exposing the innominate artery or the bronchi (Rushmore and Ricard after Loisin).

Access may be got to the upper part of the mediastinum by reflecting subperiosteally the manubrium, as described in paragraph 74 (osteoplastic resection of the manubrium). Poirier reaches the upper mediastinum by dividing the sternum transversely and

turning down the upper half as a flap. It would appear of more advantage to turn it upwards, after dividing it transversely below and cutting through the costal cartilages, as the attachments of the capsular ligaments to the clavicles would be partly preserved.

The lower half of the mediastinum can be exposed by the method described under pericardiotomy (*vide* the surgery of the circulatory system, page 83).

If it is desired to expose the anterior mediastinum in its entire length, Milton's method may be employed, in which the sternum is divided vertically in the middle line with a saw and bone-forceps. The ensiform cartilage must be removed. An interval 5 to 6 cm. (2 to $2\frac{1}{2}$ inches) broad is thus obtained, through which the reflexion of the pleura can be pushed aside, and the right auricle with its large veins exposed by splitting the pericardium. Milton has performed this operation with complete success in a case of tubercular disease in the mediastinum.

76. Posterior Mediastinotomy. Enderlen[1] has published a reliable and descriptive paper on posterior mediastinotomy in relation to disease of the œsophagus, but since the introduction of the œsophagoscope, it is seldom necessary to expose the œsophagus through the posterior mediastinum for the extraction of foreign bodies, while v. Hacker's method of continuous dilatation has still further restricted its use in the treatment of stricture. In the case of diverticula and new growths of the œsophagus, posterior mediastinotomy should be attempted as a radical excision is only possible when there are no adhesions present. Mediastinal abscesses, however, arising either from the œsophagus, glands, or the vertebræ are readily reached through the posterior mediastinum.

Stoganov (March 1899) collected fifteen cases of posterior mediastinotomy. The operation was performed twelve times for abscesses or spinal disease, twice to divide a stricture of the œsophagus and to excise a carcinoma of the œsophagus, and once for tuberculosis. In addition to this, Forgue performed it once for the removal of a foreign body from the œsophagus, and Leobet once for division of a stricture.

Stoganov describes the history of the operation, and ascribes its origin to Nassilow. Nassilow in 1880, after studying the surgical anatomy of the region on the cadaver, described the technique of the operation for exposing the œsophagus for foreign bodies and tumours. Quénu and Hartmann adopted his method in 1891. Obalinski opened a tuberculous abscess in the mediastinum after Böckel had previously recommended and described the operation; and Vincent, Auffret, and Schöffer had performed the same operation for spinal tuberculosis. Ziembicki advocated the operation in 1895. In 1897 we excised a mediastinal carcinoma of the œsophagus on the cadaver, and Rehn performed the same operation on the living subject.

Potarca published important studies on the technique in 1898. Nassilow recommended entrance on the left side for the upper part of the œsophagus and on the right side for the lower part. Potarca, in spite of the fact that the pleura dips deeper behind the œsophagus on the right side, preferred the right side only, because the aorta is too much in the way on the left.

Rehn followed Potarca's advice and went in on the right side, because the aorta greatly increased the difficulty on the left side. The incision is made vertically, midway between the spines of the vertebræ and the inner border of the scapula, and is carried down to the ribs. A few centimetres of the ends of three ribs (two to four according to Potarca) are resected subperiosteally. After dividing the intercostal muscles the intercostal vessels and nerves are isolated, the former being divided between two ligatures.

In passing down over the lateral aspects of the bodies of the vertebræ, great care must be taken to avoid the cord of the sympathetic. The azygos vein, which, together with the vagus, lies along the right side of the œsophagus, must be either pulled aside or ligatured. The œsophagus, which can now be pulled into the wound, may be incised when there is a foreign body or a stricture; if a neoplasm or a diverticulum exists a resection may be performed. Both ends must be drained, and the lower one, of course, used for feeding.

[1] *Deutsche Zeitschr. f. Chir.* Bd. 61.

Heidenhain (Langenbeck's *Arch.* Bd. lix.), as opposed to Quénu, Hartmann, and Rehn, prefers to reach the posterior mediastinum through a longitudinal skin incision close to the middle line (a transverse incision being made through the muscles), and to at once resect one or more transverse processes, together with the heads of the ribs. The removal of only one transverse process is sufficient in adults to allow of free access to the mediastinum. The soft parts are separated from the lateral and anterior aspects of the bodies of the vertebræ. Injury to the pleura is not a matter to cause anxiety.

If a periœsophageal abscess in the upper part of the mediastinum does not reach farther down than the third dorsal vertebra, it can easily be reached from the neck.

An incision is made over the clavicle, and the surgeon either passes down between the two heads of the sterno-mastoid, or, what is better, divides that muscle transversely immediately above the clavicle. The dissection is then continued to the left of the posterior aspect of the sterno-clavicular articulation, along the outer side of the common carotid and the internal jugular vein. In operating on the right side we pass down between these two vessels. By operating from above and from behind, Heidenhain succeeded in freeing the œsophagus as far as its middle. He, like Cavazzani, cured a periœsophageal abscess in this manner. Rasumowsky, by a similar procedure, cured an acute posterior mediastinitis.

In the dead subject we have exposed an œsophageal carcinoma situated immediately opposite the division of the trachea. We consider it necessary as a rule to resect more than four ribs—the second to the seventh, or the fourth to the ninth, according to the situation of the disease. The incision is made vertically over the angles of the ribs, a hand's-breadth from the middle line, through skin, trapezius, rhomboids, latissimus dorsi, and serratus posticus. The tendinous attachments of the iliocostalis and longissimus dorsi are divided and the muscles retracted inwards, and about 4 ins. of six ribs are carefully resected subperiosteally. The intercostal arteries and nerves are clearly exposed, the latter being divided between two ligatures.

The pleura, which is now exposed, can be readily separated as far as the anterior surface of the vertebral column. The œsophagus, along with the tumour, can now be felt to the right of the aorta, and, provided there are no adhesions to neighbouring organs, it can be pulled out. To separate an adherent tumour from the aorta seems rather a daring undertaking, although Farabœuf states that the aortic wall is very resistant. Bryant,[1] following Nassilow, only attacks the œsophagus from the left side, above the arch of the aorta; below this point he exposes it from the right side, while below the ninth dorsal vertebra he considers it altogether too difficult to reach. In the case of a foreign body in either bronchus, or in the œsophagus, Bryant forms a rectangular flap, with its base over the spines, and resects only one rib, but divides and retracts the neighbouring ribs above and below. He determined, in two adults, that the distance from the upper incisor teeth to the spine of the first dorsal vertebra was 203 mm. (8 ins.), to the second 219 mm. ($8\frac{3}{4}$ ins.), to the third 238 mm. ($9\frac{3}{4}$ ins.), to the fourth 257 mm. ($10\frac{1}{4}$ ins.), to the fifth 279 mm. (11 ins.), to the tenth 381 mm. ($15\frac{1}{2}$ ins.).

A review of the operative procedures which have up to the present time been adopted in dealing with diseases of the posterior mediastinum shows that a distinction must be drawn between cervical and dorsal mediastinotomy. Hacker has clearly defined this difference, and Ziembicki has shown that under certain circumstances it may be advantageous to combine the two methods, as has been done in a few cases.

(1) *Cervical mediastinotomy* has been performed by Ziembicki, Obalinski, Heidenhain, Rasumowsky, Lürmann, and Hacker. Heidenhain's advice on the method to be pursued has been given above. Hacker has published some interesting points regarding his cases. On one occasion he was able, by means of the Röntgen rays, after injecting iodoform emulsion through a rubber tube, to define the lower border of the abscess at the body of the fifth dorsal vertebra. Redness and the presence of gas

[1] *Transactions of the American Surgical Association*, 1895.

could be detected above one clavicle when the head was inclined downwards. Heidenhain also met with this sign. In the after-treatment Hacker placed the body on an incline, and in order to feed the patient properly (the œsophagus being perforated) he performed gastrostomy.

Hacker, unlike Heidenhain, made his dissection to the inner side of the large vessels. The position of the abscess in the neck should determine the route to be followed.

We have found that the cervical route is the easiest and least dangerous method of exposing the upper part of the posterior mediastinum for inflammatory affections, and these are practically the more important cases. The acute inflammatory affections which occur here are generally consequent upon œsophageal perforation (foreign bodies), and in these cases the surgeon can hardly decide on an operation too soon if the patient's life is to be saved.

(2) In *dorsal mediastinotomy* the credit of having shown how to avoid the chief danger, namely, injury to the pleura, belongs to Heidenhain. This accident has often occurred, and has caused death by secondary infection of the pleura. Heidenhain makes his incision close to the middle line of the back, and pushes the soft parts outwards from the laminæ till the transverse processes are exposed. The latter, along with the ends of the ribs, are resected. The deeper parts (to a depth of 4 ins.) can be reached with very little risk of injury by keeping to the lateral aspect of the bodies of the vertebræ. The pleura, along with the thin subpleural fascia, can be pushed to one side. The removal of only one transverse process is sufficient, according to Heidenhain, to enable the mediastinum to be reached, a point of special value in the case of abscesses.

For a detailed description of the method of dealing with abscesses in the posterior mediastinum, or if necessary of exposing the œsophagus, see paragraph 77, as well as the surgery of the thoracic portion of the œsophagus (page 503).

77. Costo-Transversectomy. This operation was described by Ménard in 1894, although it had been previously recommended and performed by Heidenhain. It may be employed with advantage in cases of spinal caries with abscess formation in the anterior or lateral regions of the bodies of the dorsal vertebræ. It gives excellent access, and allows of the abscess being opened with least injury to surrounding structures.

In describing the method of opening the pleural cavity, we emphasised the importance of cutting directly down on to a rib, removing a portion subperiosteally, and incising the pleura in the line of the rib, instead of in the intercostal space as was the former method, because the intercostal vessels and nerves are thus avoided and the only structures divided are the periosteum, pleura and endo-thoracic fascia. In exposing the posterior mediastinum it is equally advantageous to avoid the point of exit of the intercostal arteries and nerves, and to obtain access by removing the transverse process and the head and neck of the rib as far as the tubercle.

The incision, which we prefer to that used by Heidenhain, is begun over the most prominent dorsal spine, and is carried obliquely downwards and outwards along the rib which is to be resected. It must be remembered in excising the rib that the most diseased vertebra is the higher of the two with which the rib articulates. This, however, is easily determined by means of a radiograph.

After division of the skin and fascia, the latissimus dorsi and the long muscles of the back are divided in the same direction. No bad results follow the division of these muscles as they are richly supplied with nerves, and, moreover, the bleeding is much less than in Heidenhain's method, where the muscles are separated from their attachment to the spines and laminæ of the vertebræ. The smaller muscles of the back are then divided, and after the transverse process of the vertebra and its rib have been exposed, the former is divided at its root with bone-forceps. The periosteum is then peeled off the rib and the rib is divided just outside its tubercle. After carefully dividing the anterior surface of the periosteum of the rib, a finger can be passed into the posterior mediastinum, and if the diagnosis is correct, the abscess will be opened.

In a case on which we recently operated, where, in the absence of local indications,

the presence of an abscess was inferred from the late onset of paraplegic symptoms, we were able to remove a sequestrum from the body of the vertebra without difficulty. In cases of caries of the bodies of the vertebræ, it will be noticed that an abscess which emerges through the intervertebral foramen and compresses the nerve roots and the cord, can be much more satisfactorily drained by this method than by laminectomy, which is more troublesome to perform, and which exposes the posterior aspect of the cord rather than the real site of disease.

In our case the disease was completely cured, but the motor paralysis did not disappear, a result owing, no doubt, to pressure on the cord by the back of the body of the vertebra. Further treatment was refused.

This method can also be employed in the treatment of other abscesses in the posterior mediastinum, and if further space is required, more than one transverse process and rib may be excised.

(g) Pleurotomy

78. Indications for Pleurotomy. Fig. 308, after Spalteholz and Pansch, illustrates the relations of the lungs and pleura, showing where the pleura may be opened without injuring the lung, and also the formation of the pleural sinus by the reflection of the costal and diaphragmatic pleura.

Pleurotomy is performed as a preliminary step in pneumotomy, and we have already alluded to its efficacy in other operations connected with the treatment of pleural effusions. Its latest use, according to Murphy and Ratl, is to produce a therapeutic pneumothorax.

We have also pointed out in the introduction how the operative treatment of pleural effusions has been lately developed, and that now drainage of the pleural cavity is always combined with aspiration.

The same principle has, however, existed for a long time in the use of Potain's and Dieulafoy's aspirator. Revillod was one of the first to combine aspiration with permanent drainage, while Bülau demonstrated its practical use in cases where a single or repeated puncture was insufficient. Effusions of blood, lymph or serum, can be cured by a single aspiration, unless the presence of virulent organisms or new growths causes a return of the fluid.

On the other hand, when the condition is due to a progressive infective process, *e.g.* tuberculous effusion or empyema, drainage with aspiration must be continued till the infective source is either removed or destroyed.

79. Pleurotomy for Empyema. The following is the method most commonly employed in opening the pleura for the removal of purulent effusions. Having ascertained the presence of pus by exploratory puncture with Pravaz's syringe, we make an incision, 4 to 6 cm. in length, along a rib in the area of dullness, a method we have adopted under local anæsthesia even on children with very little discomfort.

The patient's skin is first prepared as for all other aseptic operations, while the usual precautions are taken against sepsis.

The edges of the incision are swabbed with an alcoholic solution of carbolic acid, and iodoform powder is rubbed into them in order to prevent infection of the freshly-cut surface. The periosteum is then carefully reflected and $1\frac{1}{2}$ to 2 in. of the rib is removed with Liston's or Lüer's forceps. The pleural cavity is then opened by incising the periosteum for a distance of $\frac{1}{2}$ in. and is thoroughly washed out with warm saline solution, after which a drain is inserted and antiseptic dressings are applied.

Empyemata, secondary to pneumonia, or following a traumatic pleurisy where suppuration has occurred in the effused blood, can be readily cured by this method, and with complete restoration of the pulmonary function ; while the lung, owing to the suction action of the chest-wall, comes to the surface again, and the discharge disappears. There can be no doubt that the majority of physicians now advocate the early and complete evacuation of purulent exudates in the pleura.

It cannot be denied, however, that immediate healing does not occur in certain cases, owing to incomplete evacuation of the exudate, either because the opening in the pleura is too small or because it has not been suitably placed.

When the opening has been too small, much benefit will be derived from Bülau's method of syphon drainage or from permanent aspiration. In the former method a

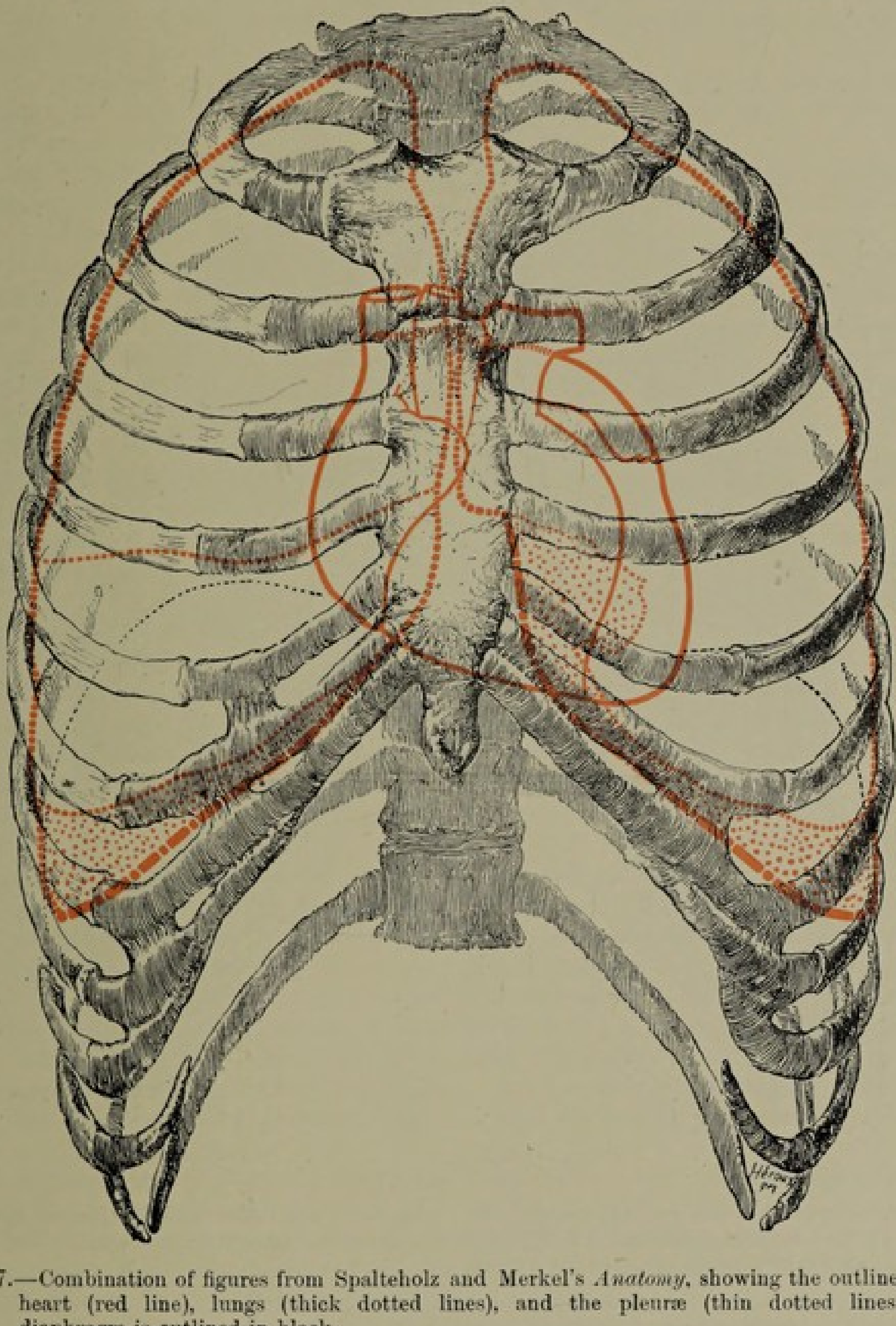


FIG. 307.—Combination of figures from Spalteholz and Merkel's *Anatomy*, showing the outlines of the heart (red line), lungs (thick dotted lines), and the pleuræ (thin dotted lines). The diaphragm is outlined in black.

rubber drainage tube is inserted down to the bottom of the cavity, a special opening through a rib being sometimes made for this purpose, and the contents are syphoned by bringing the tube over the bed and immersing its end in a vessel containing water (carbolic or sublimate solution). Or, as an equivalent, an aspiration apparatus may be applied similar to that used in producing congestion. In the first case, care must be taken to make the wound air-tight by packing antiseptic dressings all round the

drainage tube; but in the latter the aspiration apparatus secures sufficient closing of the wound. In either case the importance of preventing mixed infection cannot be overestimated. There is often a tendency to carelessness in dealing with suppurative cases, and we place more importance on ensuring a good outflow and avoiding mixed infection than on the production of hyperæmia. In our clinic we have for long emphasised the harmfulness from this point of view of large incisions, and believe

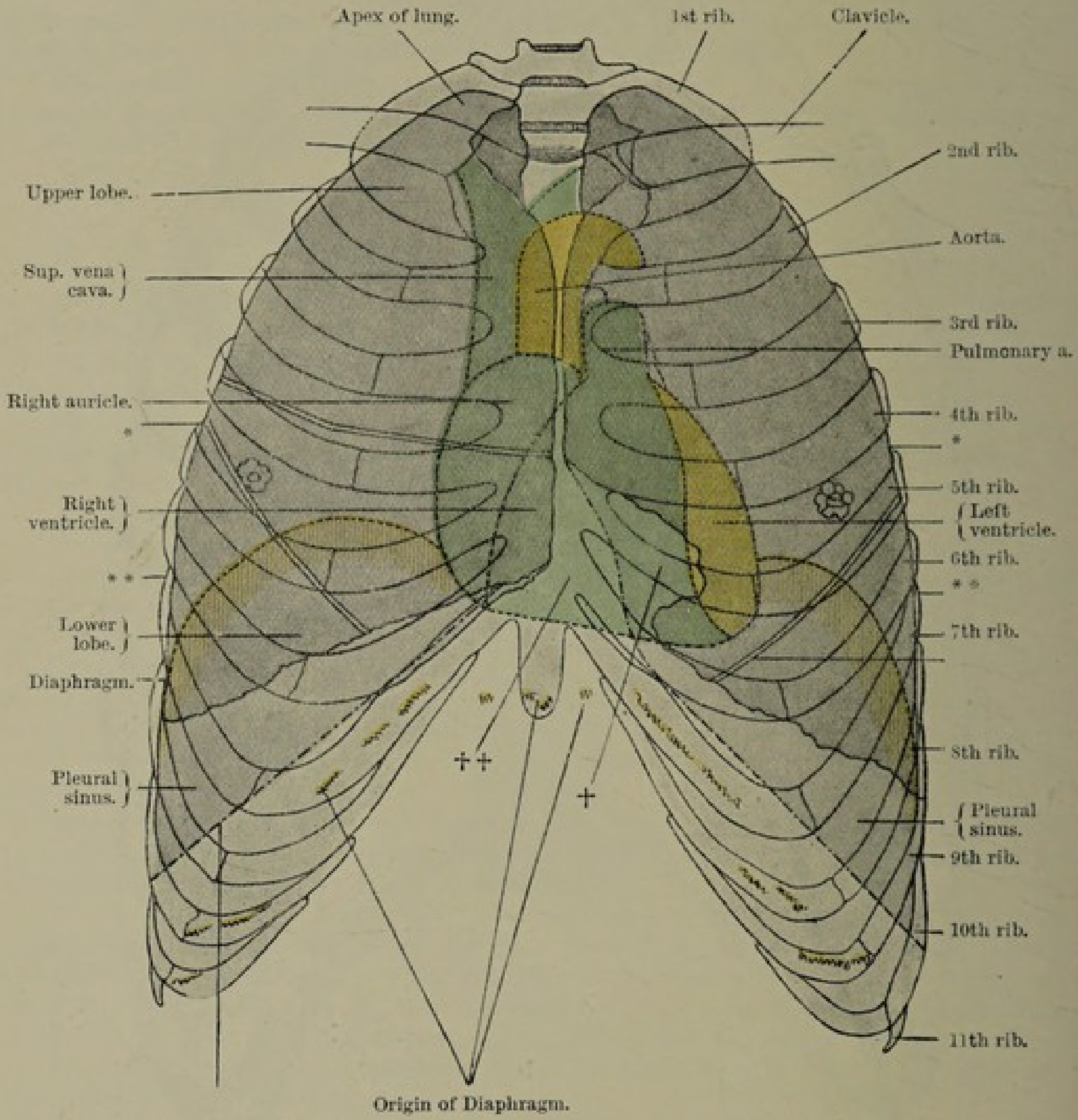


FIG. 308.—Relations of the thoracic viscera. The lungs are shaded dark and the pleuræ light grey. † The incisura cardiaca. †† The area of pericardium in direct contact with the chest-wall (no pleura intervening). (After Pansch.)

that Bier has rendered much greater service in teaching the profession how to make use of small incisions, than in making them think that treatment by hyperæmia is a cure for every evil.

It often happens, however, that the case is seen too late for the application of proper treatment, and mixed infection has been produced by lack of aseptic precautions in opening the pleura, in which neglected cases one must rely on free incision and open treatment of the wound.

80. Treatment of Neglected Empyema. Chronic empyemata need not be con-

sidered separately as they come under the category of neglected empyemata, *i.e.* they have not been opened at the proper time. There are cases, however, which, although not of old standing, have as a result of careless operation become chronic. Simple aspiration, or aspiration combined with drainage, is here quite insufficient, as such cases must be treated by an open wound. Chronic empyema, further, should no longer occur, as the majority of physicians and surgeons now realise that recovery can only be guaranteed by thorough evacuation at the proper time, in which case there is considerably less risk of an unfavourable result.

It is a common enough failing amongst practitioners to regard the opening of a recent empyema as a slight, or even trivial, proceeding, and from lack of proper care mixed infection occurs.

In order that the infective exudate may be thoroughly drained, the opening must be sufficiently large, and must be made at the most dependent part of the pleural cavity. This is effected by Walter, by means of posterior pleurotomy, and by Delagenière, by drainage of the costo-diaphragmatic sinus.

As Fig. 308 shows, the pleural cavity is opened by removing the cartilage of the sixth rib; in the lateral region the right pleura will still be opened by removing the ninth rib, and the left by removing the tenth rib; posteriorly in the scapular line (on both sides) by removing the twelfth rib. A preliminary puncture should never be made at these lowest limits, because the diaphragm may be immediately subjacent to the wall of the chest. It is better, as stated above, in the first instance to open the pleural cavity in the region where one is quite certain of finding fluid, *i.e.* where its presence has previously been ascertained by puncture, or by aspiration with an exploring syringe. After a free opening has been made, a probe or the finger is introduced to ascertain the deepest part of the cavity, over which a second opening may then be made by resecting a piece of rib. In this way provision is made for efficient drainage and for syringing out the cavity through two openings.

Schede is right in stating that the subsequent expansion of lung takes place best when the thorax is opened at its deepest and most posterior part. He advises resection of 6 cm. ($2\frac{1}{4}$ ins.) of the ninth and tenth ribs in the scapular line, thereby differing from König, who resects a portion of the sixth rib in the axillary line, but does not obtain such rapid healing. By following Schede's procedure the cavity may be at once washed out, a short and wide T-shaped tube being used to allow of the free escape of the fluid.

Repeated washing out of the cavity is, as a rule, to be avoided, as, according to Schede, it interferes with the adhesion of the pleura. Fœtid empyemata, however, should be washed out, and retention of pus must be prevented by efficient drainage.

We have never found any harm result from continued irrigation, and if sterile salt solution only is used and all aseptic precautions are taken, much benefit will be derived. The chief disadvantage is that it interferes with the antiseptic dressings, which consist chiefly of iodoform gauze and sublimated woodwool wrung out of carbolic. According to Schede's statistics, both as regards mortality and definite recoveries in neglected empyemata, resection of a rib is a far superior method to that of drainage with aspiration.

81. Treatment of Chronic Empyema (Fig. 309). We have already stated that all chronic empyemata may be classed as neglected, but it does not follow that all neglected cases are necessarily chronic. Owing to the long duration of the latter cases and the consequent changes in the parts, the surrounding tissues become so modified that it is impossible for the lung to expand and resume contact with the thoracic wall. The parietal, or visceral pleura, or both, become hard and indurated, and shrinkage of the abscess cavity is prevented or indefinitely retarded. The only advantage is, however, that the danger of a sudden displacement of the mediastinum and collapse of the lung is removed.

In these cases mobilization of the chest-wall or of the lung is of benefit, and may be accomplished in a variety of ways—by simply dividing and separating the indurated tissues from the ribs (Quénu), or by a more extensive resection of ribs, an operation first introduced by Simon, and developed by de Cerenville, but brought to

perfection by Estlander, whose name it bears, or finally by Delorme's operation, in which the indurated tissues are dissected off the lung.

Estlander, who further developed the procedure which Simon and Küster had previously adopted, makes a vertical incision, dissects back the soft parts, and resects a number of ribs subperiosteally: the skin is replaced, and the oval area of the chest-wall, no longer supported by the ribs, is able subsequently to sink in. Schede introduced a much more thorough and extensive operation. He makes a large curved incision which commences posteriorly between the vertebral column and the scapula, and is continued downwards to the lower border of the pleura. It is then curved forwards and upwards to the anterior axillary fold, ending immediately below the pectoralis major. The soft parts are reflected off the chest-wall and turned upwards, and all the ribs from the second downwards are then freed subperiosteally and divided at their costal cartilages and posteriorly. The intervening intercostal muscles with the thickened pleura are then removed, the latter being previously thoroughly opened. The visceral pleura is scraped with a sharp spoon, and the external soft parts are then replaced over it.

Schede's method, which placed the operative treatment of old-standing empyemata with contraction of the lung on a sound basis, has been improved by Depage, who, after merely dividing the ribs through the incision, turns the entire area of the chest-wall upwards as a flap, and then resects the ribs subperiosteally as far as necessary from the inner surface. This certainly is a far less severe method than that of Schede. For its success, however, it is essential that the pleura should not have become so inelastic as to prevent its coming into contact with the shrunken lung after the ribs have been removed.

Delorme has lately suggested a method (pneumoplasty) for bringing about the closure of old empyema cavities, a method which, when available, is better than the above operations. After opening the pleura he separates extensively its adhesions to the lung, and then performs, as far as is necessary, a decortication of the cicatrised tissue from the surface of the lung. Lardy and others have proved that this is the best means of causing the lungs to expand so that they may come in contact with the inner wall of the chest. On the other hand, Voswinkel affirms that the operation is more difficult to perform and the hæmorrhage is more severe.

The following is the procedure we adopt for old-standing large empyema cavities which will not heal on account of adhesions:—In order to ascertain the extent of the cavity one or two ribs are excised in the situation of the sinus. If there be no fistula, or if it be in a position unsuitable for exploration, an exploratory puncture is made in the axillary line to determine the lowest limit of the cavity, and one or two ribs are here resected.

An oblique incision is carried from the opening through the soft parts in an upward and backward direction between the scapula and the spine, as far up as the preliminary exploration has shown that the cavity extends. The ribs and intercostal spaces are divided seriatim along this incision, the periosteum of each rib being reflected, and 1 to 2 cm. of bone removed. The soft tissues of the intercostal spaces should be divided as far forward as possible, as the artery can be more easily ligatured in that situation. If the cavity reaches as high as the first rib it also must be resected.

The incision is then prolonged in a forward direction along the rib corresponding to the lower border of the cavity. This rib is resected subperiosteally, and the periosteum and indurated tissues are divided along the whole length of the wound. Lastly, the incision is continued upwards.

The anterior limits of the cavity are followed with the finger, and the skin, the soft parts of the intercostal spaces, and ribs (or the costal cartilages) are divided along this line. The flap so formed, consisting of the whole thickness of the chest-wall, can now be gradually thrown upwards *in toto*, and the position of the lung and state of the visceral pleura examined.

If, on dividing the pleural adhesions, it is found that the lung is still capable of expansion, and that the adhesions can be peeled off, nothing further requires to be

done, provided the lung expands to fill up the cavity. But if the lung does not expand sufficiently then Depage's operation must be resorted to, as many ribs as necessary being resected from the pleural surface of the raised flap, commencing with the lowest one. In order to make the flap thoroughly movable it may be necessary to resect even the first rib, but this is no easy matter. Owing to the firm adhesions

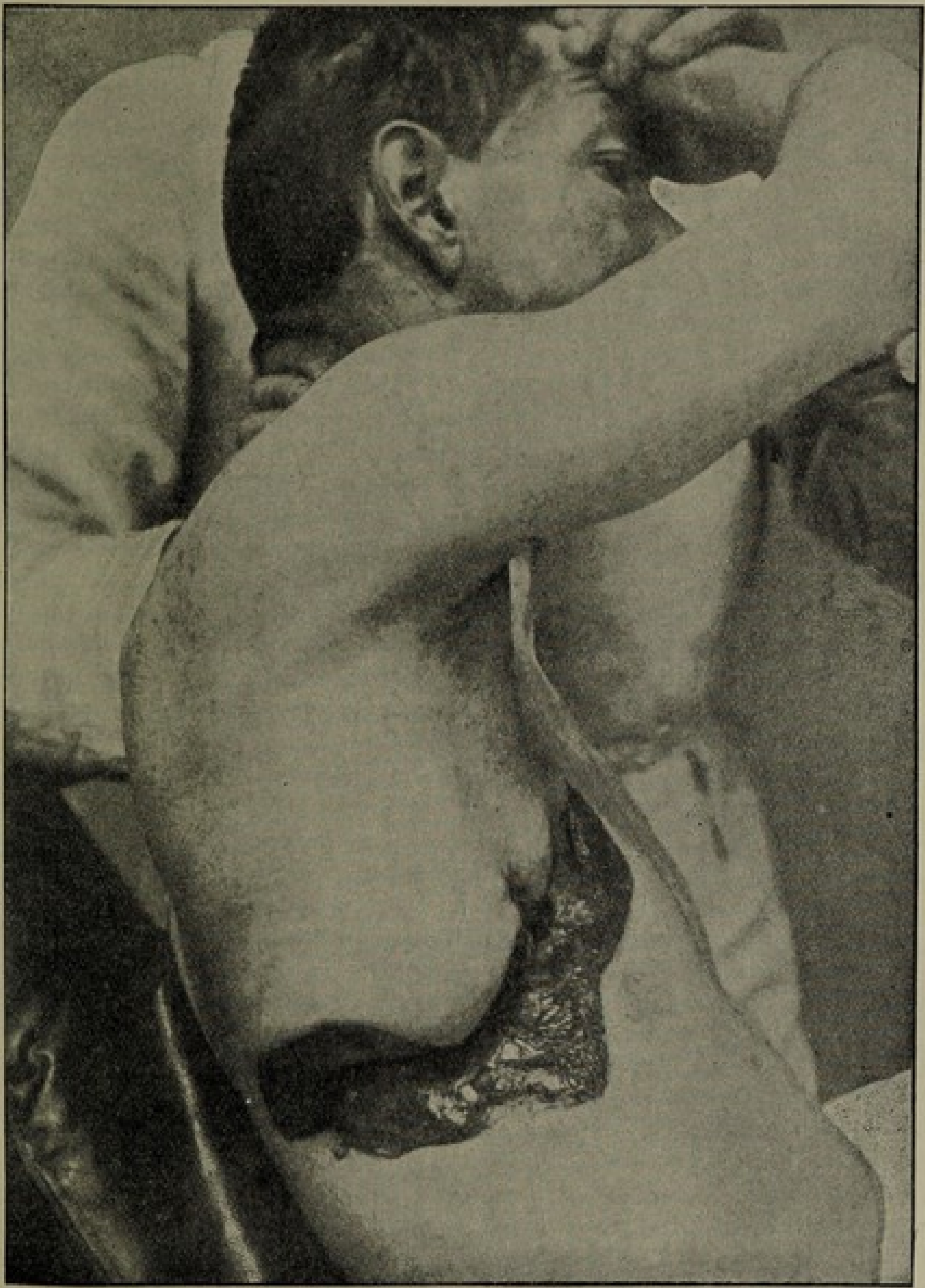


FIG. 309.—Thoracotomy with division of 9 ribs (3rd-11th) for fistula after empyema.

the subclavian vein may be torn, as happened to us recently notwithstanding every precaution. Stuffing and subsequent suture of the vein prevented any evil results.

If, after Depage's operation, it is found that the costal pleura is so dense that it is impossible for the chest-wall to fall in sufficiently to come in contact with the shrunken lung, the requisite area of thickened pleura must be removed from the inner surface of the flap.

When one has to deal with a more limited cavity, the flap methods of Schede, Keen, and Depage are not necessary. The ordinary Estlander operation is all that is

required, the portion of the ribs covering the cavity being resected subperiosteally by means of a simple longitudinal incision. But it must be borne in mind that frequently a large cavity is divided into two portions by a dense septum, so that the obliteration of only one of the cavities will not bring about a cure of the condition.

Fig. 309 shows the extent of the incision and the procedure to be adopted for a limited empyema.

If it be desired to perform an osteoplastic operation according to Delorme's method, *i.e.* to replace the flap that has been reflected, a small piece of each rib which overlies the posterior limit of the cavity may be resected through separate small incisions. The ribs having been already divided anteriorly, a portion of the thoracic wall can now be folded back like a door on its hinges. If prepared the ribs can also be broken across posteriorly. The dense and thickened visceral pleura covering the collapsed lung is incised and stripped forward and backward off the lung until it once more expands.

In advocating resection of the scapula, Sudeck has made a notable advance in the radical cure of large rigid empyema cavities, as the scapular muscles can be utilised to obliterate the hollow of the empty pleura. Ringel (1) has reported three severe cases in Kümmel's wards which were cured by this method. The difficulty connected with resecting the first and second ribs is avoided, as the flaps thus obtained are so thick. The subsequent limitation of movement of the arm is comparatively little.

Sudeck resects the ribs *seriatim* through parallel incisions, while on the other hand Ringel adopts Schede's U-shaped incision. Where the costal pleura is greatly indurated, and especially in tuberculous empyemata, besides the clearing out of the intercostal spaces, all the thickened adherent tissues should be dissected off the lung. If the U-shaped incision is made, it should overlap the edges of the cavity all round. Even the largest tuberculous empyemata may be cured by this operation, provided that the other lung is in a healthy condition.

Ssubbotin, following Ringel's suggestion, introduced in 1888 a wedge-shaped resection of ribs. Simon, Küster, and Estlander have exploited a complete subperiosteal operation, while Schede has gone so far as to remove the whole chest-wall in some cases where the adhesions were excessively rigid.

(h) Pneumotomy

The method of securing access to the lungs, and at the same time avoiding the dangers of pneumothorax and infection, has been described in detail in a previous part of this chapter. The treatment of special diseases will now be considered.

82. The Treatment of Pulmonary Suppuration. Although the surgery of the lung is no longer limited to the treatment of abscesses, it is in the latter condition that operative interference is most commonly required.

With the patient lying on his back or abdomen, not on the sound side, an incision is carried, under local anæsthesia, along the rib corresponding to the lowest limit of the abscess. The rib is exposed and resected subperiosteally, and by retracting the skin upwards all the other ribs in relation to the abscess are similarly exposed and resected. Garré advises caution in the region of the heart on account of subsequent adhesions of the pericardium. The lung is then fixed to the thoracic wall (Korte) by means of Roux's circular stitch already described. Garré states that in about 87 per cent of cases this is unnecessary as the lung over the abscess is already adherent, but it is often difficult to know this beforehand. The pleura is then incised, and if there is much dense cicatricial tissue covering the lung it should be divided with the knife and removed. After having localised the abscess by means of an exploring needle, the superficial part of the lung is opened with the thermo-cautery and the opening enlarged and deepened with a blunt instrument. In dealing with an acute abscess nothing more need be done, but in cases of chronic suppuration with induration of the surrounding lung tissue, Garré removes the thickened tissues, resecting still more ribs if necessary.

The abscess cavity is then stuffed with iodoform or xeroform gauze, and antiseptic dressings are applied. Abscesses of the lung should never be washed out for fear of spreading infection to other bronchi. In suitable cases, instead of employing packing, a drain may be inserted through a special opening in the skin, after which the wound is completely closed and a suction apparatus applied. This form of treatment, however, requires more supervision. The cavity closes by contraction of the adjacent lung tissue, and Garré states that bronchi as thick as a quill will close by cicatrisation.

Of four hundred cases operated on for suppurative conditions of the lung, including abscesses, gangrene, and bronchiectasis, Garré states that 75 per cent of cures was obtained.

83. Surgical Treatment of Tuberculosis and Actinomycosis of the Lung and their Sequelæ. Surgical treatment of tuberculous lesions in the lung, as elsewhere, does more harm than good if an incomplete operation is performed. Success can only be obtained by a complete removal of the diseased tissues. Tuffier and Lawson have extirpated tuberculous foci with success.

Simple incision only leads to mixed infection with staphylo- and streptococci, and consequent chronic suppuration.

The excision of a tuberculous focus in the lung is at the present time liable to failure, owing to the fact that in the first place it is not easy to diagnose an isolated focus with certainty at a sufficiently early stage, and secondly because it is even more difficult to determine whether the disease has not extended farther.

At present the surgical treatment of pulmonary phthisis can only effect the complete removal of localised foci by providing sufficient access, *i.e.* by resecting the ribs.

Resection of the ribs enables us to insert a needle into the lung without danger and to aspirate and examine the contents of cavities and caseous foci, while if mixed infection is present, with decomposition of the contents, fever, and other symptoms of chronic sepsis, it permits of a thorough opening being made and of appropriate cleansing with carbolic alcohol and plugging with iodoform gauze.

Even when a circumscribed cavity cannot be discovered, resection is still serviceable, for it provides an opportunity of injecting small quantities of carbolic and iodoform in glycerine to stimulate the cicatricial contraction of the focus.[1]

Garré also draws attention to the statement made by Freund and Schmorl, that in apical phthisis the first costal cartilage is frequently found to be shortened, and points out that the tuberculous process often originates in this portion of the lung, which has never become inflated. Just as Nature, according to Freund's observations, leads to a complete cure of a tuberculous focus by the formation of a false joint in the first costal cartilage, so similar results are possible from artificial increase of pressure.

Access is got by an incision along the first intercostal space, dividing the skin, fascia, pectoralis major and intercostal muscles, at the same time avoiding injury to the internal mammary artery and the axillary vein. The periosteum and perichondrium are incised along the lower border of the first rib, carefully reflected upwards, with the lower two-thirds of the rib and cartilage resected. The upper third protects the axillary vessels but may be subsequently divided if mobility is required.

By freeing the parietal pleura, according to Tuffier's method, sufficient room is secured to enable one to palpate the lung, but if necessary the second costal cartilage may be resected. If on exploratory puncture pus is found, a small incision is carried into the lung and the opening enlarged with forceps until the cavity is completely emptied, when it is packed with gauze.

In actinomycosis of the lung, when the disease has spread directly from the chest-wall to the lung and pleura, the localisation of the operation is much more definite. Garré has reported four cases which were cured by surgical interference. From our experience of actinomycosis of the superficial tissues—a disease which is by no means rare in Bern—it is not necessary, as Garré advises, "to cut out the whole disease

[1] We only mention in passing Murphy's research on the influence on pulmonary tubercle of "therapeutic pneumothorax" produced by introducing nitrogen into the pleural cavity. Lemke and Braun recommend the method. The results are far from convincing.

regardless of the tissues," for in the case of the lung as elsewhere, there is a risk of spreading the infection. But thorough opening of all sinuses and removal of masses of granulations, painting with tincture of iodine and subsequently packing every corner, and above all the administration at the same time of 60 to 90 grains of potassium iodide daily, are advisable.

Intractable sinuses, which fail to heal on account of the retraction and rigidity of the surrounding tissues, or which are more frequently associated with bronchiectasis from the traction of the cicatricial tissue, are amongst the most common sequelæ of pulmonary abscess.

In these cases, therefore, as soon as the primary condition has been cured, the mobility of the surrounding tissues should be restored by resecting the ribs, freeing the parietal pleura and dividing or excising all fibrous adherent cicatricial tissue in the manner already described for the treatment of chronic empyemata.

Garré believes that healing is accelerated by suturing healthy lung over the open bronchus after removing the fibrous and indurated tissues, and then closing the wound in the overlying soft parts. It is a condition which certainly calls for energetic treatment. To suture the lung and pleura securely, in one case Garré had to free the greater part of the lower lobe of the lung to such an extent that it could easily be pulled into the opening in the thoracic wall.

84. Surgery of Tumours of the Lung. In connection with tumours of the lung, the diagnosis is the most difficult problem the surgeon has to decide. Apart from hydatids, the treatment of new growths of the lung has achieved little success in cases other than those where the tumour growth has spread from the chest-wall to the lung, *e.g.* in sarcomata. Although an extensive operation is necessarily required, Rehn, Kronlein, W. Müller, Garré, Keen and others have obtained excellent results.

In these cases the site of the growth can be accurately determined, while the portion of the lung involved is already adherent to the thoracic wall. The risk of pneumothorax is therefore well under control, for once the tumour has been detached from the chest-wall it forms a useful handle by which the lung can be pulled forward.

This is also the reason why such brilliant results are obtained in the treatment of hydatid cysts with adhesions, the result of previous inflammation. Garré estimates the mortality at 10 per cent in cases which have been submitted to operation as against 64 per cent where the disease has been allowed to run its natural course.

In the treatment of hydatids, mere incision of the cyst, not excision, is all that is required. After a limited resection of ribs the lung tissue is incised (Garré) and the cyst emptied and packed. If the cyst is small, Borrow advocates its complete closure by suture.

The technique in cases of sarcoma (carcinoma) of the lung, the result of direct invasion from the chest-wall, differs, therefore, in that, after division of the parietes round the growth, the tumour has to be excised from the lung tissue and healthy lung has to be fixed to the edges of the wound in order to prevent collapse (as described in section (*c*)), the pneumothorax being subsequently evacuated by aspiration. A further difference between the excision of malignant tumours and the treatment of adherent hydatids is the presence of blood which collects in the pleural cavity.

Gerulanos maintains that by preventing the accumulation, better results are obtained if drainage of the pleural cavity is employed. The drain should be placed at the most dependent point. Aspiration-drainage (Willems) is, however, the best means of promoting the expansion of the lung, while, in addition, it diminishes the risk of secondary infection from without.

On the other hand, Rehn, who is one of the pioneers of thoracic surgery, closes the wound at once to avoid this risk and only employs drainage when necessary.

Tumours which are non-adherent to the chest-wall (certain forms of hydatids, dermoids, sarcoma, and carcinoma of the bronchi), are dealt with on the general lines laid down for the prevention of total pneumothorax. If the growth be localised by X-rays, and is superficial and not multiple, the opening in the pleura must be large enough to allow of the lung being palpated, pulled forward and sutured, while warm compresses may be used to prevent the entrance of air (Krause).

The thorax is thus simply opened to enable one to inspect and palpate thoroughly the lung. Sufficient space is obtained by resecting the greater part of one rib and incising freely the deep layer of periosteum (Mikulicz's intercostal incision does more injury to the parts), or by making an osteoplastic flap, as Posada advises for non-adherent hydatids (Garré). An extensive resection of the chest-wall is quite unnecessary.

After the tumour has been excised and the lung sutured [1] or stitched to the wound, the pleura should be aspirated, and if fluid tends to collect in it, it should also be drained.

Extensive resections, as are made, for example, in chronic empyema, are only necessary for excision of part of the lung, *e.g.* in Helferich's operation of pneumotomy. Helferich has gone so far as to excise the middle and lower lobes, ligaturing the vessels and larger bronchi, and afterwards covering the stump with the remaining lung tissue. In such a case, provision must be made for dealing with the large cavity, which cannot be immediately filled.

85. Surgery of Injuries of the Lung. Subcutaneous as well as penetrating wounds of the lung, even when complicated by severe hæmothorax or pneumothorax, generally heal without intervention, provided, firstly, that there are no abnormal conditions present to interfere with the arrest of hæmorrhage or to give rise to late hæmorrhage; secondly, that the large vessels at the root of the lung are not wounded, and finally, that septic infection is absent.

When there is no external wound, or if it is only a very small one, surgical interference for the arrest of hæmorrhage with suture or packing is only exceptionally indicated, according to Garré, *i.e.* when the hæmorrhage is profuse and repeated. It is often very difficult, however, to come to a decision regarding the severity of the bleeding. Garré also advises operation in cases of valvular pneumothorax, when air is being constantly sucked in and its exit prevented. In the latter case repeated aspiration may, however, be employed.

It is quite different when there is a large gaping wound in the thoracic wall. Here, the wound should be extended along an intercostal space, as Delagénière and Thiel advise, and the lung pulled up by inserting the hand into the pleural cavity. When the rent in the lung has been exposed, it must be firmly closed with deep sutures. If the hæmorrhage proceeds from the root of the lung, it is then so deeply placed that its arrest by suture or ligature is practically impossible. Garré has, however, reported three cases in which it was successfully controlled by packing.

To Rehn belongs the credit of demonstrating the advantages of immediate suture of the thoracic wound, even at the risk of having to employ secondary drainage in a few days. We much prefer to insert at once a drainage tube (cigarette) at the most dependent part of the pleural cavity, by cutting down on a pair of curved forceps pushed into the lowest intercostal space, as Sauerbruch recommends.

When the wound in the lung has to be packed, this dependent drain is indispensable. It is only when the lacerated portion of lung can be securely anchored in the region of the wound that the pleural cavity may be primarily closed (Rehn), after the air has been aspirated, and any blood-clots removed by flushing with saline solution.

In addition to hæmorrhage and valvular pneumothorax, there is another urgent indication for immediate operation, viz. bilateral pneumothorax. In such cases aspiration must be employed at once, and if it is associated with an open wound the collapsed lung must be immediately drawn up and anchored to the thoracic wall.

Injury to the diaphragm resulting in diaphragmatic hernia also calls for immediate opening of the thorax, preferably by an incision below the fifth rib or in the interspace above or below. After reduction of the hernia the tear in the diaphragm is to be closed.

Infection of the lung from a septic pleurisy is a further indication for immediate thoracotomy. This has, however, already been alluded to in a previous chapter.

Hernia of the lung is a fortunate occurrence inasmuch as it closes the wound in

[1] Tiegel found that sutures of the lung are considerably more reliable if the silk is taken directly from a solution of chloride of iron. He also employs supporting sutures.

the thoracic wall. When it persists it may be covered over by means of an osteoplastic flap obtained by division of the ribs and costal cartilage on one side in the manner recommended by Vulpius.

(i) Transpleural Operations.

Although every operation on the lung is necessarily performed through the pleura, the term "transpleural" is only applied to operations in which both layers of parietal pleura are traversed in order to reach certain structures in the abdomen or posterior mediastinum. In these circumstances it is most important to guard against the entrance into the pleural cavity of air, blood, or other secretions. The method by which the pleural cavity is shut off depends on whether the operation is performed through the costo-diaphragmatic sinus, where the parietal layers of the pleura are in contact, or through the pulmonary part where they are widely separate from one another.

86. Transpleural Laparotomy. The opening of the abdomen through the pleura and the diaphragm is chiefly performed in exposing the convex surface of the liver for the purpose of opening abscesses or hydatid cysts (transthoracic hepatotomy) (Figs. 310, 311).

The presence of an abscess having been ascertained by an exploratory puncture, an incision 4 in. long is made extending obliquely forwards from the anterior axillary line between the seventh and eighth ribs, or in the posterior axillary line between the eighth and ninth ribs. The fascia and the muscular fibres of the latissimus dorsi and external oblique are divided. The periosteum covering first the one and then the other rib is separated all round with a sharp raspatory, carefully avoiding the pleura, and at least 3 ins. of both ribs are excised. The pleura is now shut off with a continuous circular suture introduced so as to surround the area where the opening is to be made. According to Stiles, deep sutures should be introduced with a curved needle, first through the soft parts of the intercostal spaces, and then under the extremities of each of the periosteal troughs (after resecting portions of two ribs), so as to include both layers of the pleura (costal and diaphragmatic), and thus to shut off entirely the area of operation from the rest of the pleural cavity. A portion of costal pleura, at least 2 inches in diameter, can then be excised within the sutured area, and the glistening bluish upper surface of the diaphragm exposed. The diaphragm, which forms a somewhat thin layer of muscle between the pleura and peritoneum, is then incised.

If the peritoneum is not adherent to the upper surface of the liver a continuous circular suture must also be introduced between the parietal and visceral peritoneum. The liver abscess (or hydatid cyst) is then opened—with the thermo-cautery if deeply situated—and the cavity is then stuffed with iodoform gauze.

Perpleural Method of Opening Subphrenic Abscesses. Subphrenic abscess most commonly results from inflammatory processes round the cæcum. The temperature, which may have subsided as the primary exudate in the right iliac fossa undergoes resolution, either suddenly or gradually rises again and the patient's condition gets worse. There is pain in the loin and interference with respiration, while the liver dullness distinctly increases and may extend from the fifth rib above to several fingers'-breadths below the costal margin. There is also tenderness on pressure in the loin and along the costal margin, with increased resistance, while there may be a characteristic metallic resonance at the highest point of the dull area.

A long exploring-needle should be first inserted to determine whether the abscess can be reached from the costal margin. If no pus is found, portions, 2½ ins. in length, of the ninth or tenth ribs should be resected subperiosteally over the area of maximum dullness and tenderness. The needle is then inserted through the posterior layer of periosteum, pleura and diaphragm, to ascertain the proper place in which to incise the pleura.

As the patient lies on his back, the pressure of the diaphragm against the chest-wall in this position prevents the entrance of air when the pleura is opened. The

costal and diaphragmatic pleural are then sutured together with a continuous circular catgut stitch, after which the diaphragmatic pleura is divided in the centre of this area, and by separating the muscular fibres of the diaphragm the abscess is entered. It is then drained, thoroughly irrigated with saline lotion, and a warm salicylic fomentation is applied.

87. Surgery of the Thoracic Portion of the Œsophagus. The method of exposing the œsophagus and the structures adjacent to it through the posterior mediastinum has

Fig. 310.—Resection of ribs to expose the surface of the liver. A portion of two ribs has been removed, and the intercostal tissues have been ligatured and excised. The costal and diaphragmatic pleura, along with the diaphragm and peritoneum, have been incised, exposing the upper surface of the liver.

already been considered in a previous chapter, where we pointed out that posterior mediastinotomy is chiefly employed for minor conditions, such as opening a peri-œsophageal abscess, or removing a foreign body.

The extensive resection of ribs which Quénu, Hartmann and Levy have recommended for the excision of mediastinal tumours, and which has been carried out by Rehn and Faure, the latter of whom even excised the first rib, has not proved satisfactory. Better results can be secured by other methods. Jaboulay has chosen the most direct and daring line. He exposes the pericardium from the front, divides it in its

whole length, pushes the heart aside and reaches the œsophagus by incising the posterior wall of the pericardium.

Experiments, however, have shown that the transpleural route affords the best access, and we owe much to Sauerbruch for his excellent investigations on the surgery of the thoracic portion of the œsophagus. Through the kindness of Herr Sauerbruch and Professor Borchard, we had opportunities in the late v. Bergmann's clinic of witnessing operations of this nature, both under reduced pressure (10 mm. mercury) and under high pressure with Engelken's apparatus (at about 10-18 mm. water). We are convinced of the perfect applicability of the method. The anæsthetic employed was oxygen and chloroform given with the Roth-Drager apparatus.

Sauerbruch only obtained good results in resection of the œsophagus when he employed the anterior transpleural operation introduced by Mikulicz and Dombromysslow. Later, he adopted Mikulicz and Anschutz's modification, in which the line of suture comes to lie inside the abdomen, either by drawing up the œsophageal foramen

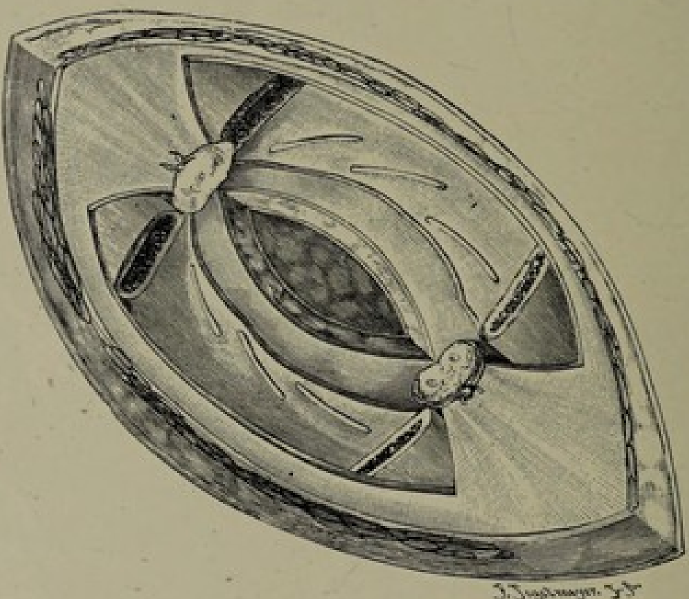


FIG. 311.—Transpleural exposure of the convex surface of the liver. The soft tissues of the intercostal space have been ligatured at the extremities of the divided ribs; the part between the ligatures has been cut away. The costal and diaphragmatic pleura are stitched together with a deep suture which shuts off the rest of the pleural cavity; the two layers of the pleura, the diaphragm, and the peritoneum have been incised, and the upper surface of the liver is exposed.

and stitching it to the cut end of the œsophagus, or by pulling up a portion of the stomach into the thorax. Lately he has used a Murphy's button with much success in performing the anastomosis. He has demonstrated by careful observations on the cadaver, which Mikulicz has confirmed on the living subject, that it is possible to isolate and preserve the vagus nerves in resecting the œsophagus, and that after division of the pleura and the peritoneum at the diaphragmatic foramen the stomach can be pulled up as far as the hilum of the lung.

He recommends his low pressure chamber manufactured by the firm of Trelenberg in Breslau. The operation is performed with a reduction of air pressure corresponding to about 7 to 9 mm. Hg., closing the wound under 14 to 15 mm. Hg. The modified high-pressure chambers by himself and Engelken are also to be recommended. For operation on animals the anæsthetic used was morphia and ether.

88. Transpleural Œsophagotomy. Sauerbruch employs an incision through the third right intercostal space exclusively, and reaches the œsophagus on the right side above the root of the lung, and as low as the azygos vein. The lower part of the œsophagus is reached through the fourth or fifth left intercostal space.

In urgent cases the intercostal incision in our opinion gives the quickest access to the pleura and pericardium in dealing with injuries of the lungs and heart, but in ordinary circumstances the subcostal incision is to be preferred. An incision of the desired length is made by sliding up the skin, and cutting firmly down on to the rib and cartilage. A portion of the rib is then excised subperiosteally, and the underlying periosteum, endothoracic fascia, triangularis sterni and pleura are incised, without appreciable bleeding, and without the risk of entering the pleural cavity too soon. When operating without an air chamber, a preliminary pneumopexy is advisable.

By forcibly separating the ribs (Mikulicz's rib-retractors being serviceable for this purpose), the lung can be pushed aside with a special spatula and the œsophagus identified by the introduction of a bougie. The pleura covering it is then incised, and the whole thickness of the œsophagus, from which the nerves and vessels have been freed, is grasped with forceps and pulled forward. Having packed off the surrounding parts with gauze, the œsophagus may then be opened in its long axis, after which the mucous membrane is seized with Kocher's forceps, so that it may be subsequently recognised and invaginated with Lembert's sutures. The muscular coat of the œsophagus is sutured with silk and the wound closed or, if necessary, drained as described in section (*d*). Sauerbruch plugs the œsophagus with a tampon, which later on is passed into the stomach.

89. Transpleural Œsophago-gastrostomy (Biondi and Sauerbruch). Sauerbruch regards this operation as suitable for short-circuiting the lower part of the œsophagus in cases of diverticulum, stricture, and possibly carcinoma.

The pleura is opened and the œsophagus exposed as described above, but the posterior layer of the parietal pleura is not divided. The diaphragm is displaced downwards and the lowest part of the œsophagus grasped with forceps and pulled up, taking care not to include the vagi. The part of the diaphragm covered by pleura and peritoneum is seen (in the dog) as a greyish-white area about 2 to 3 cm. wide. A fold of the pleura is now incised, and after the edges of the diaphragm have been grasped the incision is enlarged and the stomach pulled up.

Sauerbruch performs the anastomosis with Murphy's button in the following simple and ingenious manner: The female portion of the button is first passed down the œsophagus by means of an œsophageal bougie, and, guided by the finger and thumb, is conducted into the part of the fundus of the stomach which has been pulled up, and is there provisionally fixed.[1] The male half (plugged with gauze) is then passed from above and tied into the œsophagus. Then, without detaching the pleura, it is made to project against the anterior wall of the œsophagus while an assistant makes an opening large enough to allow it to protrude. The same method is adopted with the half in the stomach, which is closed by the finger of the operator, and the two halves are pressed into one another.[2] The fundus of the stomach is thus anastomosed with the œsophagus. The diaphragm is carefully stitched round the stomach, so that no hernia of the latter may occur.

90. Transpleural Resection of the Œsophagus (after Sauerbruch). In this operation Sauerbruch adopts one of two methods depending on whether the disease is situated high up or low down in the œsophagus. In the former case :—

(*a*) *The Invagination Method.* The œsophagus is exposed as above, but the posterior layer of pleura is divided, the œsophagus isolated, and the vagi are freed, so that they may not be invaginated with the œsophagus. The portion of the œsophagus to be excised is then raised up by passing a piece of gauze behind it.

The diaphragmatic pleura, the diaphragm and peritoneum are incised at the œsophageal opening and the fundus of the stomach is pulled up, in the manner described above. The portion of the œsophagus to be resected is now invaginated into the stomach as completely as possible (without the vagi), uniting the muscular wall of

[1] If a stricture prevents the passage of the button down the œsophagus, the button must of course be inserted through a direct incision into the stomach, where it is to be fixed with a purse-string suture.

[2] Sauerbruch smears the edges with Lugol's solution, for the same reason as Tiegel soaks his sutures in chloride of iron, viz. to produce stronger adhesions between the serous surfaces.

the former to the serous and muscular coats of the stomach with a circular suture, after which the cone of stomach is fixed all round the opening in the diaphragm, and the external wound is closed.

After ten to fourteen days the abdomen is opened, the stomach drawn out and opened, and the conical mass inside cut off with "Cooper's scissors."

(*b*) When a higher resection is required, the œsophagus is exposed, the vagi are isolated and the stomach is pulled up into the thorax as before. The œsophagus above and below the tumour is crushed with crushing-forceps, ligatured in the grooves thus produced, and the portion containing the tumour is cut away, care being taken to pack off the surrounding parts with gauze pads and to avoid injuring the vagi. The mucous membrane is cut away, and in the case of the upper end, the muscular coat of the œsophagus is stitched over the stump, while the lower end is invaginated into the stomach and a layer of sutures superimposed.

The female half of a Murphy's button is then fixed into the summit of the stomach cone, while the male portion is passed down the œsophagus and the anastomosis made at a point on the anterior wall of the œsophagus, *which is still covered by pleura*, in exactly the same way as was described in œsophago-gastrostomy.

91. Contraindications to Transpleural Œsophagectomy. Resection of the œsophagus with anastomosis to the stomach can only be performed when the part of the tube excised is situated below the hilum of the lung. Malignant disease, according to Schmid and Sauerbruch, is most frequently met with in this situation (70 per cent) and the latter author points out that in 35 per cent of these cases no metastatic growths could be discovered at the autopsy.

When a carcinoma involves the upper part of the œsophagus or the vicinity of the root of the lung, no surgical interference should be considered; at the most, posterior mediastinotomy may be performed. In the latter case, the method advocated by Quènu, Hartmann, Tuffier, and Faure gives ample room. It entails the resection of the posterior ends of the first five or six ribs.

End-to-end union of the œsophagus with sutures should never be attempted from in front as it is invariably unsuccessful. The operation of œsophagoplasty, devised by Mikulicz and Sauerbruch, is more deserving of consideration. Here, the divided ends of the œsophagus are brought to the surface some distance apart, sutured to the skin at convenient spots, and the wound is closed. When the wound is healed, two skin flaps are dissected up and turned inwards like a folding door so as to form a tube lined by epidermis. Finally the mucous membrane of each open end is freed along with a collar of skin and sutured to both ends of this newly formed œsophagus. Later on the tube can be replaced inside the mediastinum by bringing the soft parts over it. Roux has suggested an even more ingenious plan of manufacturing a new œsophagus out of a portion of intestine.[1]

D. ABDOMINAL SURGERY

(a) Laparotomy

92. Indications and Conditions necessary for Success. Operations on the abdomen have become the most brilliant field of operative surgery. There is no longer any organ in the abdomen which is not accessible to surgical treatment. Where expectant treatment in acute affections (ileus, inflammations, etc.) may be fraught with danger or result in a chronic condition, early surgical interference may save life and bring about a rapid cure. In chronic affections (adhesions, dilatation of the stomach, gall-stones, etc.), where months are required before medical treatment results in any success, an operation may immediately and permanently remove the whole trouble.

[1] *Semaine médicale*, 1907.

It is every day becoming a more pressing necessity that practitioners should recognise the almost absolute safety of opening the abdomen. We should then no longer have to complain that so many valuable lives are lost from appendicitis, that cases of ileus are recommended for operation only after ulceration of the gut has set in, and that cases of carcinoma of the stomach and intestines are not sent for surgical treatment until the presence of innumerable diseased glands renders radical operation impossible. We do not at all desire to see the practice of diagnostic exploratory laparotomies extended. At the present time, especially amongst the younger generation, there are only too many doctors who prefer to save themselves the trouble of making an exact diagnosis by opening the abdomen in order to obtain information as to the indications for, and contraindications to, operative interference.

But when it is a question of imminent danger to life, or when an apparently definite diagnosis has been arrived at (*e.g.* perforation of the stomach and intestine, acute circumscribed peritonitis and all cases of ileus), or where there is a suspicion of a malignant growth in the stomach or intestines, procrastination on the part of the practitioner is, in the present state of abdominal surgery, culpable. The patient should not be allowed to pass through months of medical treatment without showing any material improvement, or without the physician being able to hold out the assurance of a satisfactory result by non-operative treatment.

Were the advantages of early operation more fully recognised, surgeons would not be called upon to operate on so many cases in which peritonitis and sepsis have practically precluded all chance of recovery.

It is not necessary that all medical men in practice should undertake the surgical treatment required, but it is essential that they should be thoroughly acquainted with what surgery can accomplish. A proper surgical knowledge enables one to recognise the indications which call for energetic measures, and makes one feel the responsibility of inactivity. A hundred times more harm is done even now by delay than by operative faults.

To open into the peritoneal cavity was looked upon till recently as a procedure fraught with danger on account of the risk of setting up inflammation. Now, however, it has become quite evident that the peritoneum, as long as it is healthy, is possessed of a far greater tolerance of infection than the majority of the tissues. When the surgeon sees that injuries of the abdomen, attended with prolapse of coils of intestine for hours, may result in uninterrupted recovery, he loses his fear of opening into the abdominal cavity in healthy individuals, even though the procedure should involve the pulling out of the intestines. In contusions, in perforating injuries of the abdomen, and in cases of ileus, early laparotomy and examination of the viscera proves often the best and most speedy mode of bringing about recovery, provided that the principal part of the operation is performed on healthy peritoneum. Early operation in acute appendicitis has, moreover, shown how confidently recovery can be expected when inflammation is localised.

To open the peritoneal cavity exposes the patient to serious danger only when the peritoneum is the seat of a diffuse infective condition, or when other organs in the body are sympathetically involved owing to toxic influences. The surgeon even yet finds himself much too frequently forced to operate after diffuse peritonitis (which might have been avoided by earlier interference) has set in. In such cases an operation must perforce be performed, to remove, if possible, the immediate dangers, but the unsatisfactory results which follow in these cases should in no way be regarded as a measure of the success nor of the indications for laparotomy in suitable cases, but should be considered in a different category.

We must now consider a few of the secrets of success in laparotomy.

(1) Special stress must be laid on the preparation of the patient (*vide* General Introduction), and the advisability of emptying the gastro-intestinal tract two days before operation and of maintaining this condition by suitable diet (free administration of fluids and limitation of solids) is of the utmost importance. The prophylaxis of aspiration-pneumonia and the necessity of raising the blood-pressure (by stimulants or possibly saline infusion, or [according to Kümmel] by transfusion) have also to be

carefully considered. In the case of an alcoholic patient, Kümmel allows half a glass of brandy before the operation.

(2) Elevation of the pelvis. This is easily provided for in operations in the region of the hypogastrium and pelvis by means of the "Trendelenburg" position, but for operations in the mesogastrium or epigastric regions, *e.g.* stomach, gall-bladder, and kidney, local elevation of the back can be employed with advantage. It is essential that a heated table should be used to keep the body warm.[1]

(3) In all cases where it is not certain that the organ to be operated on can be as easily drawn out of the abdominal cavity as, *e.g.*, a movable appendix, an ovarian tumour, a movable tumour of the intestine, or the gall-bladder, etc., the incision must be made sufficiently large to allow of the organ being freed and delivered and the surrounding parts packed off.

(4) As soon as the abdominal cavity is opened, the healthy regions of the abdomen should be packed off from the field of operation with gauze swabs. When the disease is in an organ that can be brought out of the wound this can be easily accomplished, but it is of even greater importance to pack thoroughly all round when the disease is deeply placed. Warm sterile soft gauze compresses wrung out of ·75 per cent salt solution should be used to isolate the field of operation, as they will absorb any escaping fluid such as blood, gastric contents, bile, urine, or exudates.

(5) Avoidance of any antiseptic, and of any possibility of injury to the peritoneum by cooling and evaporation. No small praise is due to Tavel and his pupils for having demonstrated experimentally the nature of this deleterious action, and for having rendered its avoidance possible. On the basis of their researches we were probably the first to employ (chiefly in laparotomies) only physiological salt solution at the body temperature, and to keep all exposed peritoneal surfaces constantly moist and warm by the application of compresses covered with gutta-percha tissue.

(6) Thorough removal of every source of infection,[2] and drainage of infected areas, combined with their isolation by tampons in the form of gauze strips impregnated with a fixed antiseptic, as recommended by Mikulicz. As iodoform has so strong a toxic action on the peritoneum, xeroform or vioform is to be preferred. Special care should also be taken that any gauze not lifted straight from the steriliser be wrung out of carbolic lotion so as to remove any possible surface infection.

(7) Prevention of any collection of blood or effusion in the wound by careful arrest of hæmorrhage, for as long a period as is necessary, and by suture of every injured peritoneal surface. In some exceptional circumstances a raw peritoneal surface may have to be left, and this may give rise to an accumulation of blood or serum; when this occurs a tube should be passed down to the place and the fluid removed by suction. This is an important point, and it was only when attention was paid to it that the intraperitoneal treatment of a uterine stump was rendered safe.

Tietze showed by his excellent experiments that the omentum could be safely employed for covering over necrotic areas in the stomach or intestinal wall. Braun and Bennet even closed defects in the stomach with omentum only, which formed firm adhesions to the surrounding serous membrane. The inner surface of the omentum gradually becomes covered over with epithelium which grows in from the edges of the opening.

(8) Careful suture of every cut or tear in the peritoneum, and complete closure of the main wound, except where an opening is left for drainage. A "cigarette drain" keeps the opening patent, while the wrapping of rubber tissue protects the surrounding structures and the contained xeroform gauze absorbs the secretion; or a drainage tube may be employed, to which a suction apparatus, like a large cupping-glass, is attached. (*Vide* von Kelling on the "Technique of Abdominal Surgery," *Centralbl. f. Chir.* Bd. 4, 1904.)

(9) In the after-treatment of a laparotomy, free respiratory movements are to be

[1] Henle has shown by the statistics of a large number of authenticated cases how frequently pneumonia follows laparotomy, and he has come to the conclusion that a chill during the operation in the presence of a small source of infection is chiefly responsible for such a mishap.

[2] See remarks on previous page.

encouraged by breathing exercises (morphia, by reducing the pain, has a beneficial action); the passage of flatus is procured by stimulating peristalsis by means of an intestinal tube and glycerine suppositories, while the blood-pressure is sustained by subcutaneous saline injections.

93. Position of Incisions and Methods of Suture in Laparotomy.—The only incisions in the abdomen which can be regarded as normal are the median, the transverse in the upper part of the abdomen, and the oblique incision passing from above downwards and inwards in the lower part of the abdomen, because these incisions do not damage the muscles of the abdominal wall through their nerve-supply, and are in accordance with the principles which have been already laid down for all the normal incisions of the body. The above normal incisions can be very well used in combination, as, for instance, in splenectomy, or for carcinoma of the lowest part of the sigmoid flexure when to the median incision a transverse incision may be added, varying in length according to the requirements. Assmy, at Czerny's instigation, showed that the longitudinal incisions through the middle of the rectus, which are preferred by many surgeons, cause atrophy of the median portion of the rectus if its motor nerves be interfered with.[1]

Why is a substitute for the median incision constantly being sought? The chief reason is that it is regarded as pre-eminently predisposing to ventral hernia, while cosmetic considerations supply another reason. Since laparotomy is nowadays so very common (specially in gynæcological cases), a desire has manifested itself to hide the scar on the abdomen. Küstner and Pfannenstiel, in cases where a large incision is unnecessary, have endeavoured to avoid both disadvantages by the "transverse incision above the symphysis." They make the incision close to the pubis so that the scar is hidden by the hair, just as surgeons have long been accustomed to do to reach the bladder. But the chief value which Küstner, in opposition to Pfannenstiel, attaches to his procedure is that he not only divides the skin and superficial fascia transversely, but also the aponeurosis of the abdominal muscles along with the linea alba. Pfannenstiel has pointed out that below the semilunar fold of Douglas all three abdominal muscles unite in front of the rectus, and that posterior to it there is only the fascia transversalis. For this reason the aponeurosis in front of the recti, along with the linea alba, can be separated upwards in the form of a flap with lateral attachments. The abdomen can then be opened by separating the recti and dividing the fascia transversalis and peritoneum by a median longitudinal incision. The separated aponeurosis is afterwards sutured above the symphysis, thus forming a protection against hernia.

This question of ventral hernia is closely associated with asepsis and suturing. If a surgeon cannot use buried sutures without the fear of stitch abscesses (Jonnesco), then he must certainly take special precautions to give firmness to the scar when the temporary sutures are removed. Those who are not sufficiently certain of their asepsis to bring themselves to employ permanent sutures, but who rely on absorbable catgut for buried sutures, can never hope to obtain as firm a closure of a wound as can be got with a buried organic non-absorbable suture. Herein lies the secret for preventing ventral hernia. We must confess that to us it is an anachronism to hear the gynæcologist's constantly reiterated complaint of suppuration in buried sutures, and of ventral hernia from the giving way of sutures, the latter accident occurring only with catgut. Will surgeons not be influenced by Madelung's report at the last surgical Congress in Berlin on a hundred and one cases where sutures in the abdominal wall had given way, and desist from using catgut?

We always use silk for the sutures, because it gives a more durable mechanical support. This may appear to be unnecessary as far as the peritoneum is concerned, since it adheres and heals quickly and easily; and it might even be contended that permanent foreign bodies tend rather to predispose to the formation of adhesive tissue. For suturing the peritoneum alone catgut or silk may be used. Below the level of the umbilicus we do not consider it desirable to suture the peritoneum alone: the

[1] Blair has made extensive investigations with regard to the best means of sparing the abdominal nerves.

fascia transversalis should always be included with it, as it is not worth stitching the latter separately. In the region of the navel the peritoneum is so intimately blended with the linea alba and the cicatricial tissue round it that it is much better to include it along with the aponeurosis of the linea alba.

For suture of the principal aponeurosis (linea alba) a non-absorbable material is required. This aponeurosis (which forms the chief support to the abdominal wall against hernia) must be firmly united with permanent sutures—either silk or metal. To most people metal sutures left in permanently are very unpleasant, although Witzel and, following him, Goepel have even used buried meshes of silver wire to strengthen the line of suture. Even that excellent invention, aluminium bronze wire (Socin),[1] gives a very unpleasant sensation of a foreign body. Silk is therefore the only desirable material. We have no experience of the new collodion-thread introduced by Witzel and Wederhake.

We hold that absolutely sterile silk cannot be any guarantee against the subsequent formation of a stitch abscess. The difficulty is rather to keep sterilised silk sterile till the wound is healed. It is so easily infected anew by the hands, by the patient's skin, and by bacteria from the wound. The result of this is the formation of stitch abscesses, but nothing more. In the chapter on "Wound Treatment" we have explained why we always use antiseptic silk. This suture material is quite sufficient, even in an incision in the linea alba, if a carefully applied continuous suture be inserted to prevent gaping and hernia formation. The only occasion when exception may be made is when the fascia, before operation, is stretched and thin, with separation of the recti. Such cases are very suitable for overlapping the recti. The deep silver sutures, recently recommended by Küstner, may also be employed. Even though the suturing be perfect, the occurrence of suppuration renders it uncertain as to whether a ventral hernia will or will not form, but the chances are in favour of the hernia resulting.

In spite of this decided opinion—which materially simplifies the question of the best abdominal incision—we consider it justifiable to attempt to obtain increased firmness along the line of suture. A very good plan is to make the incision through the sheath of one rectus, and displace the entire muscle outwards. The rectus should not be split, as Howitz proposes, as this of necessity causes atrophy of the internal part which is cut off from its motor nerve-supply. The method which Lennander and Wolkowitsch recommend is better, namely, to divide the anterior wall of the sheath of the rectus muscle, to draw the rectus *in toto* to one side, and then to open the abdomen through the posterior wall of the sheath. This posterior wall is thin, and offers little resistance in the lower part of the abdomen. When the operation is concluded, the posterior wall of the sheath is first closed, the rectus replaced and sutured along its inner border, and then the anterior wall of the sheath is closed. This method of suturing the abdominal wall we have already recommended in gastrostomy.

We consider that Lennander's incision is specially indicated in place of the mesial incision where there is marked separation of the recti, as the latter depends entirely for its strength on the firm closure of the separated muscles.

In lateral ventral hernia Carl Beck has also employed this method of strengthening the abdominal wall by means of a plastic operation on the muscle. He divides the rectus muscle in the frontal plane and folds over the anterior layer into the gap with its nerve-supply intact.

In employing this method of displacing the rectus muscle, we have solved the difficulty of how to strengthen the scar by making use of muscular tissue whose nerve-supply is not damaged. In dealing with the choice of incisions in general, we drew attention to the progress made in this direction by non-division of the muscles, even though the skin incision be at right angles to the course of their fibres, but by simply splitting the muscular bundles and pulling them forcibly apart. In this manner injury to the nerves can be avoided with certainty, and it is unnecessary to divide the muscles in a direction opposed to the course of their fibres. It is possible to expose a large area of peritoneum by separating the muscular fibres of the

[1] Pfannenstiel declares that the "French" introduced this substance. It was Socin, in conjunction with Hägler, who introduced it into practice.

internal oblique and transversalis muscles through an incision parallel to the fibres of the external oblique. In this way, also, incisions may be carried obliquely upwards and inwards, as well as paramesially. Transverse division of the rectus need not be feared as the rectus has a metameric nerve supply in successive segments.

If Minxewitsch is right in saying that a suture which traverses the whole thickness of the abdominal wall is firmer than an "Etagenaht" (suturing in layers), then the method proposed by Pozzi, recommended by Depage, and frequently used by others, should receive some consideration. It combines the advantages of both, and should be particularly suited to the advocates of catgut. The peritoneum alone (or peritoneum and transversalis fascia) is sutured, and then silver wire or aluminium bronze sutures are passed through the whole of the remaining thickness of the abdominal wall and tied, after the aponeurosis (linea alba) has been separately united by buried sutures. Minxewitsch speaks in favour of the method we have recommended above, as he finds that the union is most satisfactory when the incision has been made in the middle line, and when silk has been used for the sutures.

With regard to incisions in the lateral regions of the abdomen, it is only rational that they should be parallel to the course of the nerves in the abdominal wall. When more room is desired, a mesial incision may be added so as to form a flap. It is sometimes necessary to incise the soft parts across the line of the nerves in order to obtain better access, and in these cases any nerves lying on the transversalis must be hooked upwards and downwards, as Blair has so clearly illustrated. For the less serious cases of appendicitis requiring operation, Lennander prefers the vertical incision through the sheath of the rectus. He draws the nerves of supply upwards and downwards, while the outer border of the rectus is drawn towards the middle line.

94. Complications after Laparotomy.—Next in importance to peritonitis, which is the most common complication of laparotomy, we must consider paralysis of the stomach and intestines, and pneumonia. Thrombosis and embolism, and hæmorrhage from the stomach or intestine, are also serious post-operative complications, but depend more on the nature of the interference with the special viscera.

Acute dilatation of the stomach is an exceedingly grave symptom, unless recognised early and relieved by passing the stomach tube. Its origin is, however, not quite clear. Kelling found, from experiments on animals, that dilatation of the stomach may follow the establishment of a gastric fistula under chloroform, and Braun produced the same condition by section of the vagus nerves. Injury to the muscular wall of the stomach seems to have an important bearing in its production, while it may also be caused by reflex disturbance of the circulation. Lastly, obstruction of the duodenum by the superior mesenteric artery must not be forgotten. Further light on the question can, however, only be obtained by experimental research. Suffice it to say that in the after-treatment of abdominal operations the possibility of the distension being due to dilatation of the stomach should always be kept in mind, and steps should at once be taken to empty the stomach.

Distension of the intestines is also frequent after laparotomy, and is generally due to the fact that flatus is not passed. According to careful observations made by Pankow (Jena), in the majority of cases no flatus is passed on the first day after operation, and only by a few on the second. This cannot be wholly explained on the ground of inflammatory reaction; further knowledge can only be gained by accurate observation and experiments.

It is also well known that interference with the circulation or injury to the nerves of the intestine may give rise to paralytic distension, but remedies applied in this direction, *e.g.* physostigmin or eserin, only produce definite results in a certain number of cases. Along with Vogel[1] we have seen remarkable results follow the administration of physostigmin or eserin in non-inflammatory cases in which all other treatment had failed.

Pankow, on the other hand, maintains that he could not prove that 1 mg. ($\frac{1}{64}$ gr.) of eserin sulphate caused any passage of flatus, but in our experience we have almost always been able to observe, in half an hour, the effect on the intestines

[1] *Deutsche Zeitschr. f. Chir.* Bd. 63, 1902.

of a decimilligramme of physostigmin ($\frac{1}{600}$ gr.) given once or twice daily. Colicy pain and definite peristalsis are produced.

While we are as yet more or less ignorant of the real primary causes of the after-effects of abdominal operations, from the practical point of view, we do know the conditions which favour so-called paralysis of the gut, and can avail ourselves of measures to prevent it.

Active decomposition of the intestinal contents further contributes to abdominal distension, but this only occurs when the contents of the bowel become stagnant. It is generally admitted that steps must be taken to prevent the possibility of decomposition occurring either before or after operation, by the use of the rectal tube, glycerine suppositories, and aperients such as magnesium sulphate.

We must remember that as an immediate consequence of diarrhœa there is an increase in the number of bacteria in the intestine, and a diminution again when the intestine is thoroughly emptied.

We agree with Pankow that it is a mistake to give an aperient the day before operation and *a fortiori* on the morning of operation, for the operation is then performed at the period when the bacterial activity of the intestine is at its height. We do not, however, like Pankow, omit preliminary purgation on this account, but we ensure evacuation of the bowel two days in advance. On the evening before operation we administer an enema, followed by frequent small doses of bismuth to diminish the production of gas by restricting the development of intestinal organisms.

We do not starve our patients, but allow solid food in the form of meat and a free supply of fluids up to the last day. Diet likely to cause flatulence is avoided.

Hæmorrhage from the stomach or intestines after laparotomy is rare, but has been observed and reported in several cases since v. Eiselsberg first drew attention to it.

The source of the bleeding in some cases, but not in all, can undoubtedly be traced to erosions or ulcerations of the mucous membrane, and v. Eiselsberg regards them as retrograde embolisms from veins, although it is still undecided how often this is the case.

To prevent the occurrence of these ulcers it is important that the circulation of the intestine should be interfered with as little as possible, by avoiding all unnecessary bruising, handling, or constriction by clamps. We regard the use of clamps as directly responsible for thrombosis and embolism, though they are convenient from other points of view. More attention than hitherto should be paid to this question in investigating the causes of post-operative hæmorrhage.

Obstructive distension, due to impairment of the heart's action caused by the operation, must also be mentioned. The extreme Trendelenburg position, so much employed by gynæcologists, must be regarded as a factor in impairing the circulation in prolonged operation, and should be avoided.

Finally there is the question of poisoning. We believe that the preliminary preparation of the patient with corrosive sublimate, which, though superfluous, many surgeons will not abandon, is really the prime agent in the production of erosions of the mucous membrane of the stomach and intestines.

Pneumonia and other pulmonary complications have already been mentioned, as post-operative sequelæ. They are very frequently met with after abdominal operations, and especially after operations on the upper part of the abdominal cavity, as in the latter breathing is more seriously interfered with, owing to the pain caused by contractions of the diaphragm.

Aspiration pneumonia is the commonest form, and is due to aspiration while under the anæsthetic, or to the fact that pain renders deep breathing or coughing impossible.

This form of pneumonia can be considerably influenced by treatment, and Kümmel and Rotter have diminished its frequency by the use of scopolamin and morphia. Morphia after the operation, according to Friedrich, has a beneficial effect on respiration. Hypostatic pneumonia is less common, and is due to disturbances of circulation resulting from the position of the patient and interference with respira-

tion. In this connection Kraske justly emphasises the disadvantages of exaggerated elevation of the pelvis.

The second variety, according to Kelling, is infective pneumonia. Payr has shown that even slight infection may readily cause the entrance of organisms into the lymphatics of the thorax. Embolism is of no less importance, and is all the more certain to give rise to inflammation if of an infective character.

Payr has drawn attention to the fact that the onset of thrombosis in the omental or mesenteric veins can occasionally be recognised even during the operation by a bluish discoloration of the intestine as well as of the omentum. Its results (bleeding from the stomach and intestines due to retrograde embolism) can be prevented by free resection.

Payr has given histological proofs that a number of these thromboses do not originate in purely mechanical causes but are due to an inflammatory infiltration round the veins, as, for example, occurs when the omentum is adherent to the appendix in cases of acute perityphlitis. Kelling believes that when there is lymphangitis of the mesentery the inflammation spreads by retroperitoneal veins, and gives rise to thrombosis and embolism in the systemic circulation. Gebele,[1] who affirms that aspiration-pneumonia occurs in 6·3 per cent of all abdominal operations, states that embolism in the liver is exceptional, owing probably to anastomoses between the portal system and the vena cava.

95. Laparotomy in Cases of Peritonitis.[2] Removal of the cause should be the first object in operating for peritonitis. The following general remarks, however, are directed specially to those cases where the cause cannot be removed or discovered, and where the peritonitis has to be treated *per se*.

Like other acute inflammatory conditions, peritonitis is at first usually localised (peritonitis circumscripta), although sometimes it originates simultaneously in more than one situation. Lennander has rightly observed that the exudate may be limited by adhesions or be free. If a localised collection of pus is not removed thoroughly or at an early stage it will extend and set up a diffuse peritonitis.

Whenever, therefore, a circumscribed exudate is diagnosed or suspected, steps should be at once taken to remove it. Acute appendicitis is always systematically treated on this principle, and the brilliant results are attributed to the removal of the diseased appendix before definite abscess formation has occurred.

How is this first rule to be satisfactorily carried out? The suppurative focus must be reached with a minimum of injury, and since Lennander's investigations on the insensibility of the intra-abdominal organs we have successfully employed local anæsthesia for this purpose. The position of the abscess having been determined by the dullness and tenderness on pressure, a small incision is made over it through skin and fascia, after which the muscles are split by M'Burney's method, and retracted. The parietal peritoneum is then picked up with forceps and a small incision, which is subsequently enlarged with a pair of artery-forceps, is made into it.

A glass tube is inserted down to the bottom of the cavity, and aspiration-drainage is established by attaching a suction apparatus to it. When aspiration is not practicable, a cigarette drain (M'Cosh), which consists of a central wick of xeroform gauze disinfected with carbolic lotion and wrapped in a cylinder of guttapercha tissue,[3] may be used after carefully washing out the cavity with normal saline solution. When the drain is removed, iodoform and glycerine should be dropped into the cavity.

What further treatment is necessary when the local process has spread and given rise to diffuse peritonitis (peritonitis diffusa)?[4] Here different types must be distinguished :—

[1] *Beitrag z. klin. Chir.* Bd. 43.

[2] See the latest publication on the treatment of peritonitis read at the International Congress of Surgeons at Brussels, 1905, with Reports from Friedrich, Krogius, Lennander, Lejars, M'Cosh, and De Isla.

[3] Similar forms of drainage may be employed, *e.g.* Lennander's thick wood-wool wick, wrapped in guttapercha, and Drensmann's glass drain. The latter has no terminal opening, but is perforated at the sides and contains a strip of gauze.

[4] The terms "diffusa" and "circumscripta," used in contradistinction to each other, are in common use and are quite intelligible.

(1) When there are numerous small foci of pus scattered throughout the abdomen but individually shut off (peritonitis diffusa saccata), the treatment is similar. Each focus must be dealt with through a separate incision and drained as described.

Whenever, in addition to general symptoms of peritonitis, a suppurative focus can be diagnosed by pain and dullness, it must be immediately opened through a small incision and drained in the manner described above.

(2) The second form is that in which there is diffuse peritonitis with a progressive effusion which extends so as to invade successive regions of the abdominal cavity (peritonitis diffusa libera). This is found, especially in pneumococcal peritonitis of children, in cases where there is infection with bacillus coli, and after rupture of certain abscesses (cholecystitis).

In these circumstances the first and most important indication is to evacuate the pus at all points where its presence can be proved. Multiple small incisions should be made, and drainage tubes inserted into the pouch of Douglas, in each lumbar region, just above Poupart's ligament, and in both the subphrenic spaces below the costal margin.

Only prompt and vigorous measures can avert disaster. We have successfully dealt with cases of acute suppurative general peritonitis following high excision of the rectum by inserting drainage tubes above both groins and below the costal margins.

It is essential to know how the different regions of the abdomen can be most advantageously drained.

In women the pouch of Douglas is best drained through the posterior fornix of the vagina. The vagina should be purified in the same way as the skin, after which the abscess is punctured, the mucous membrane incised, the opening enlarged with forceps, and a glass drain inserted. A long rubber tube is then attached to this and led into a vessel containing carbolic lotion. Syphon action is thus obtained, or an aspiration apparatus may be attached to the rubber tubes. The glass tube is kept in position by plugs of iodoform gauze.

In men the recto-vesical pouch is drained by an incision immediately above the symphysis pubis (the bladder having been emptied), and through this a glass drain is passed down to the bottom of the pouch, with aspiration drainage.

The iliac fossæ and the regions of the ascending and descending colon are drained by an incision similar to that used for typhlitis (*q.v.*), *i.e.* by an incision two fingers'-breadth above the outer part of Poupart's ligament, into which glass tubes are inserted obliquely, one towards the middle line and the other directly upwards, followed by aspiration drainage.

Drainage of the recess under the diaphragm, liver, and spleen is discussed under the treatment of subphrenic abscesses. An incision is made in the posterior axillary line, just below the costal margin, and glass tubes are inserted, one directed upwards between the liver (or spleen) and the diaphragm, and the other directed inwards above the colon under the liver and spleen. In many cases we reach a subphrenic abscess more easily from the front by an incision near the outer border of the rectus, 1 cm. from the costal margin, splitting the fibres of the external oblique and transversalis and their fasciæ.

A cigarette drain may be substituted for a glass tube if the latter is likely to prove harmful.

When there is a collection of pus in the region of the pancreas above and below the stomach, a mesial incision should be made above the umbilicus and two drainage tubes inserted one above and one below the stomach, the latter being passed through the gastro-colic omentum.

When several incisions have to be made, if the general condition of the patient is satisfactory, an injection of morphia should first be given, followed by light ether anæsthesia assisted by local anæsthesia.

(3) The third form is when the peritonitis is diffuse, but nowhere has the fluid collected in sufficient amount to be recognised clinically and evacuated.

Lennander draws special attention to the fact that the absence of all pain makes the diagnosis of "central" peritonitis very difficult. The term "peritonitis diffusa

sicca" might be applied to this form, but it is already employed in reference to a class of cases of a less serious nature.

The treatment of this variety of peritonitis is the same as that of the preceding ones (1) and (2). If drainage of the septic fluid in the abdominal cavity is not effective, the important question must be considered of relieving the toxæmia from the decomposing intestinal contents by emptying the bowel.

Enterotomy and enterostomy are new departures in the treatment of peritonitis, and are based on the theory that the distension is due to an increased bacterial activity inside the bowel associated with decomposition of the contents, the toxines of which are absorbed by the lymphatics, thereby causing infection of the peritoneum. The latter condition is often strikingly demonstrated by the occurrence of fæcal vomiting.

According to Lennander, distension of the gut is chiefly due to the action of the toxins on the plexus of Auerbach (between the longitudinal and circular coats), which paralyses the muscular coats of the bowel and permits the toxines to penetrate through the lymphatics of the serous coat.[1] Even apart from the toxic action on the nervous mechanism, it is obvious that the peristaltic action of the muscular coats must be greatly interfered with by infiltration and œdema.

Besides "primary" paralysis of the intestine, which, like peritonitis diffusa sicca, depends on the absorptive power of the serous coat, we must take note of the distension that occurs from a mechanical obstruction at a point where inflammatory exudate and adhesions have been found. This is frequently observed by post-mortem examination, and along with Mikulicz we have often seen it occur in living subjects. The distension in such cases has therefore the same origin as mechanical ileus.

Stercoræmia (the term applied by Lennander to the toxæmia due to absorption of the contents of the bowel), must be treated by thorough removal of the intestinal contents, and in frequent lavage of the stomach we have a method the value of which is not sufficiently appreciated. On several occasions we have seen serious toxic conditions disappear very rapidly after washing out the stomach. A rectal tube should also be passed, and if this fails to procure a passage of flatus, the rectum and colon should be irrigated (through a T tube) with warm saline. If there is still no result, and a kink in the large intestine is present, Lennander advises making a fæcal fistula at once in the cæcum according to Witzel's method. The opening can also be used for feeding the patient.

The timely administration of suitable aperients has already been alluded to, but they are usually given too late, and, as Heidenhain has shown, they are only of use when there is no obstruction present. All parts of the intestine which cannot be reached from the natural orifices should be emptied, either by puncture or incision.

After the abdomen has been opened, an incision, $\frac{1}{2}$ to 1 cm. in length, should be made in the transverse axis of the intestine (to avoid the blood-vessels). The edges are then grasped with Kocher's artery-forceps, while the intestine is gently "milked" between the index and middle fingers of the hand, protected by a rubber glove. The entire length of intestine may be emptied in this manner, for which purpose Dahlgren has devised a double spring roller. When the bowel is emptied the small wound in the intestine may be closed if no further accumulation is expected. In this connection it is, of course, taken for granted that no food is administered by the mouth.

This should be the routine procedure in all cases in which the abdomen has been opened for the treatment of peritonitic obstruction of the bowel. When, however, the source of the peritonitis cannot be removed, few surgeons will carry out the principle so far, in case the patient cannot bear the shock of so severe an operation.

Every surgeon has had the melancholy experience of seeing patients who have been handed over to him in a state of collapse rapidly sink after "correct" treatment, by freely opening the abdomen and removal of the original cause as well as the exudate and decomposing intestinal contents.

When "inflammatory obstruction," as it has been called by Heidenhain, occurs in a patient with advanced cardiac weakness of septic origin, a temporary enterostomy should be made instead of enterotomy, as is done in similar circumstances in mechanical ileus.

[1] For this assumption Lennander refers to statements of Askanazy, Waldeyer, and Magnus.

Enterostomy, *i.e.* the production of a fæcal fistula, can be rapidly performed in one or more places under local anæsthesia. We refer to it in the chapter on intestinal surgery.

Escher[1] was the first to demonstrate the advantage of enterostomy in severe cases of typhoid peritonitis. Haffter[2] and Heidenhain[3] have established the procedure, and Greenough[4] has collected a mass of material to illustrate its value and demonstrate its technique. That eminent surgeon Lennander advocates enterostomy in three places (above, below, and in the region of the injured gut) in all cases of extensive injury of the bowel. M'Cosh, on the other hand, holds that a temporary enterostomy is seldom beneficial. Why is there this difference of opinion? Because the same class of cases is not compared, and similar technique is not employed. Enterostomy in peritonitis has as its object the removal of the septic contents of the bowel when they cannot be removed otherwise, and is only performed when the absorption is severe and threatens life. In the worst cases evacuation of the intestines is of vital importance, and a series of recent excellent results we attribute to the combined removal of peritoneal and intestinal infection.

The question whether it is better to freely open the abdomen and perform an enterotomy with subsequent closure or drainage of the wound, or to make several small incisions in the intestine, depends firstly on the condition of the patient, and secondly on the prospect of being able to remove simultaneously the cause of the peritonitis and the peritoneal foci of infection.

Technique—The simplest method consists in making a small incision in the abdominal wall, and fixing a loop of bowel to the parietal peritoneum and fascia transversalis. After the loop has been incised a rubber tube may be inserted and xeroform gauze packed round it. By this method, however, it is difficult to avoid soiling the wound, and it is therefore better to conduct the contents away by fixing a drainage tube into the intestine, according to Witzel's method, and suturing the tube to the abdominal wall; or a glass tube may be fixed into the bowel by means of a purse-string suture, including the parietal peritoneum and deep fascia (*vide* chapter on "Fæcal Fistula," Greenough's use of the Mixter tube). For the small intestine the lumen of the tube adopted need not be greater than $2\frac{1}{2}$ to 3 mm.; for the large intestine it must be 5 mm. thicker, and stronger.

After-treatment.—All food must be withheld as long as the bowels do not act freely, and the practice of giving milk and pieces of ice is to be condemned as injurious. Water should be freely administered under the skin (2 to 4 litres per day of physiological saline: if there is much collapse, it may be given intravenously).

Nothing combats the danger of inanition, heart weakness, or toxæmia so effectively as the free administration of water, and in this connection Sahli has drawn special attention to the benefit derived from "washing out the body." Friedrich's subcutaneous feeding by injections of oil (up to 200 g.) and grape sugar (5 per cent in physiological saline) is only to be resorted to when the condition is protracted and the evacuation of the intestine is delayed. Enterostomy openings may be employed for the injection of fluid nourishment after twenty-four hours.

When the inflammatory and obstructive stages have been overcome, a severe form of diarrhœa (spreading ulceration) occasionally occurs, a condition which, according to Lennander, is best treated through the enterostomy openings.

Fowler considers that the position of the patient is of the utmost importance in the treatment of peritonitis, especially after drainage, and he advocates the adoption of a more or less sitting posture with the thighs flexed, so that the pus may gravitate to the bottom of the peritoneal pouch.

96. Laparotomy in Abdominal Tuberculosis. In opening the abdomen for the treatment of tuberculous peritonitis, our object is not merely to remove the exudate, but also to discover the organ from which the peritoneum has become secondarily infected. Indeed, the onset of tuberculous peritonitis is a favourable occurrence in that it draws attention comparatively early to the presence of a tubercular process which is limited

[1] *Grenzgebiete*, Bd. 11, 1903.
[2] Gebhard, *D. Zeitschr. f. Chir.* Bd. 74.
[3] Busch, *D. Zeitschr. f. Chir.*, 1902.
[4] Harvard University, September 1904.

to one of the abdominal organs, and affords an opportunity of removing it at the proper time.

The Fallopian tubes are the organs from which most commonly tuberculous peritonitis originates. But the primary source of infection may be found in the intestine or the vermiform appendix.

Operation, therefore, has the definite object of removing the primarily-diseased organ, even if there is uncertainty in the diagnosis as to which organ is diseased.

It takes the form of a large median exploratory incision, with evacuation of the exudate, and thorough irrigation with 0·8 per cent salt solution at the body temperature.

The abdominal organs are next examined as far as the adhesions, which are often numerous and strong, will allow, and the source of infection, be it in the Fallopian tubes, intestine, or appendix, should be removed by excision of the entire organ.

It is of the utmost importance to avoid the slightest chance of introducing sepsis, for no greater disaster can befall the patient than the occurrence of mixed infection with staphylo- or strepto-cocci. The strictest aseptic precautions must be taken, and the use of sterilized rubber gloves is absolutely indicated.

Drainage is not desirable as it may lead to secondary infection. It is occasionally necessary, however, to pack the wound after the fluid is removed, in order to prevent any oozing that may occur from accumulation, but we must be very certain that the iodoform or vioform gauze used is thoroughly disinfected (*e.g.* in 5 per cent carbolic). It should be removed as soon as possible, and the antiseptic dressings should be frequently changed to prevent infection during the period of drainage.

The cavity may with advantage be swabbed out with iodoform and glycerine (2 to 5 per cent), or it may be filled with the mixture, using 50 to 100 g. Vioform has also been found of use in promoting the disappearance of peritoneal tubercles.

Extensive cases, in which the parietal peritoneum and the intestines generally are thickly studded with tubercles, can be completely cured by laparotomy and removal of the primary focus. Lauper has successfully cured cases of this nature in our clinic.

97. Laparotomy for Peritoneal Adhesions. Lauenstein emphasised the excellent results which can often be obtained in cases of severe pain and spasms in the region of the digestive tract by opening the abdomen and simply separating adhesions which fix the viscera to some particular spot on the abdominal wall, or which link or bind them together. The importance of this condition has not been fully appreciated. The results of such an operation are often striking and immediate, and relief may be given to suffering which has been endured for years.

We recently operated on a patient who suffered from attacks of pain, attended with so much collapse that the question of perforation was considered, more especially as there was a history of previous ulceration. Laparotomy was performed, and a strong adhesion to the lateral aspect of the abdominal wall divided. The whole of the symptoms disappeared. The agony had been so intense that the patient dreaded taking food, and in consequence was very much emaciated.

No directions for operation suitable for every case can be given. The adhesions must be completely divided in order to ensure perfect freedom of movement of the viscera, and, where possible, large raw areas must be covered over with healthy peritoneum. If it is the case that silk, being a permanent foreign body, is more liable to cause adhesions, preference must be given to catgut, which is easily absorbed.

Tavel has recently described cases where troublesome symptoms, due to adhesions in the region of the colon after appendicitis, at once disappeared on dividing the adherent bands. We have frequently observed similar cases where persistent pain has been removed by dividing adhesions, which are often as thin as a thread, between the intestinal coils or between the intestines and the abdominal wall or neighbouring organs.

(b) Operations for Hernia (Herniotomy)

98. Radical Cure of Inguinal Hernia. (*a*) *Radical Operation in Uncomplicated Inguinal Hernia.* Since the last edition we have had our list of hernia operations revised and brought up to date, with the object of obtaining a correct estimate of the efficiency of our method of performing radical cure[1]; as these observations extend over a period of five years, we consider we are justified in referring to them as permanent cures.

The results are highly satisfactory. In his comprehensive work on radical cure of inguinal hernia, Pott[2] states that Kocher's method gives the best percentage of permanent cures (92·5 per cent), while of the others, Bassini's is next with 89·8 per cent. Brenner has investigated 1073 cases in which radical cure was performed and found that Kocher's method showed 92·5 per cent of cures compared with 90·1 per cent by Bassini's. Daiches, from a total of 508 cases operated on between 1895 and 1900, states that the percentage of permanent cures by the lateral transposition method is 95·5; while in our own clinic at Berne we obtained 97·7 per cent of cures in 173 cases between the years 1896-1900 with the transposition-invagination method.

These figures, which refer to the operation in the adult, are distinctly better than those obtained from other methods. The results of radical cure in children should not be regarded in the same light as those in adults, for at the present time a large number of children are submitted to early operation in order to avoid the necessary supervision and the inconvenience of a truss, although the hernia would probably be cured without operation. In children, therefore, the proportion of cures is very large, but the mortality is relatively high. Campbell calculates the mortality at about 3 per cent, while, according to Buhlmann, out of 117 radical cures in children, Tavel had eight deaths, of which only one, however, was directly due to the operation.

Our patients have been almost exclusively adults, and, unlike a number of other surgeons, we undertake the radical cure at an advanced age, *e.g.* seventy, if the patient is in other respects a healthy subject. The tendency to complications is naturally greater in elderly people, *e.g.* embolism, etc.

The high standard of our results must not be attributed to the fact that, being the originator of the method, we have devoted personal attention to the subject: indeed, the majority of the operations in our clinic are performed by temporary assistants or by practitioners who have been taught the exact technique of our method. Equally satisfactory results are obtained by surgeons elsewhere. Deanesly[3] reports 95 per cent of permanent cures after two years' observation in 142 patients at all ages by Kocher's method. Hahn[4] published the results of radical operation in 221 cases of inguinal hernia in Rydygier's clinic; 7·8 per cent of recurrences occurred after the Bassini-Postempsky method, and only 4·9 per cent after Kocher's method. Grosse,[5] in Landerer's clinic, has observed very little suppuration after Kocher's operation, and no recurrences, while a relatively large number of recurrences were noticed with Bassini's method. Even the most flattering statistics [Franz and Rotter (689 cases)] give only 95·6 per cent of radical cures by Bassini's method, while Carle (Galeazzi) out of 601 operations had 5·99 per cent of recurrences by Bassini's method and 5·02 per cent by Kocher's. Angerer and Trzebicky also publish excellent results.

On the ground, therefore, of our long personal experience and the evidence furnished by the results of others, we can justly claim for our transposition method that it gives the best results as regards permanency of cure in uncomplicated inguinal hernia, that it is easily and quickly performed and is devoid of danger.

The operation may be performed under local anæsthesia (Cushing), with or without the administration of ether.

[1] Inaugural Dissertation von P. Daiches, Leipzig, 1904.
[2] Pott, "Sammelstatistik von 23,519 Radikaloperationen," *Deutsche Zeitschr. f. Chir.* Bd. 70, 1903.
[3] *Brit. Med. Journ.*, June 1905.
[4] *Deutsch. med. Wochenschr.*, 1904, No. 8.
[5] *Deutsch. Zeitschr. f. Chir.* Bd. 57.

An incision,[1] $2\frac{1}{2}$ to 3 inches long, dividing the skin and superficial fascia, is made in the groin from a point a finger's-breadth above the centre of Poupart's ligament to a point one inch internal to the external abdominal ring. In the centre of the wound the superficial epigastric artery is divided and a vein at the inner angle of the wound is also ligatured (Fig. 312).[2]

The pillars of the ring are defined by blunt dissection, and the thin prolongation of the external oblique on to the cord, viz. the external spermatic or Cooper's fascia, is incised in a downward direction, exposing underneath it the cremasteric and the infundibuliform (transversalis) fascia.[3] The latter coverings are also incised, care being taken to avoid injuring the spermatic vessels and nerves.

When the infundibuliform fascia is divided, the hernial sac can be isolated from the constituents of the cord[4] from the external ring downwards; the fundus is then

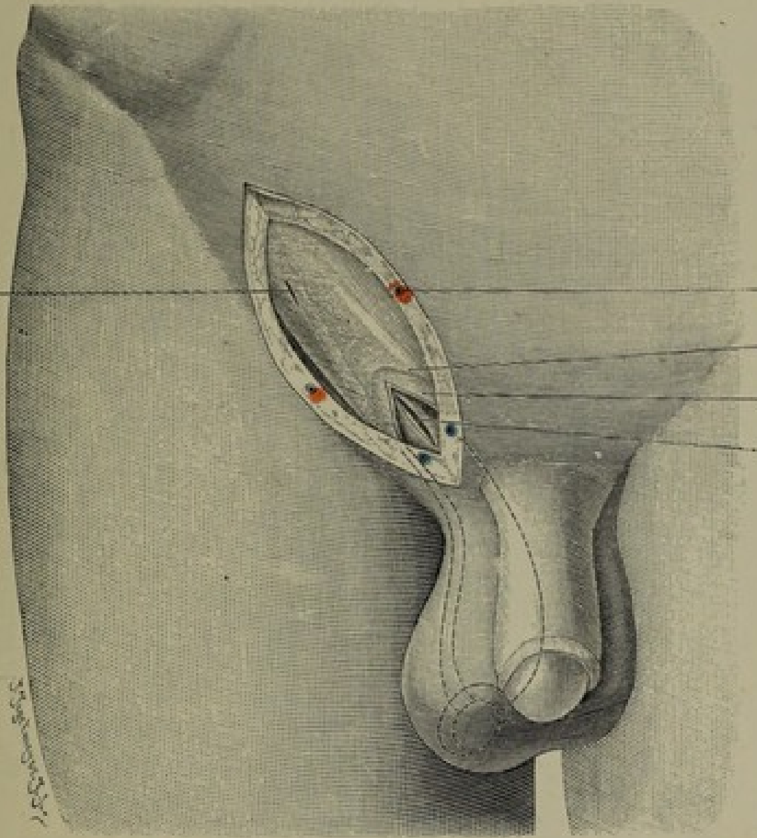


FIG. 312.—Incision over inner half of Poupart's ligament, exposing in the subcutaneous fat the divided superficial epigastric artery and a constant vein. The aponeurosis of the external oblique and the pillars of the ring are exposed, the external spermatic fascia (Cooper) has been divided, and a vertical incision has been made through the cremastric and infundibuliform fasciæ down to the spermatic cord.

grasped and forcibly pulled downwards, exposing the highest part of the sac, off which the cord is stripped with gauze dissection.[5]

[1] In previous editions we described an inguinal incision which was also used for castration and the treatment of hydrocele and varicocele, etc. Separate incisions are now described.

[2] It is quite unnecessary to prolong the incision upwards over the internal abdominal ring.

[3] If local anæsthesia by Cushing's method is employed, a second injection of novocain is now given, the needle being passed from the external ring up the inguinal canal and downwards into the coverings of the cord.

[4] By holding the cord up to the light, the sac can be easily recognized.

[5] If the funicular process is continuous with the tunica vaginalis testis, *i.e.* vaginal hernia, the sac should be ligatured and divided, the lower part being returned into the scrotum. In the female the operation is more simple: the round ligament should not be divided as in Bassini's method, but should be separated from the sac and preserved in the same way as the spermatic cord.

The next step depends on whether or no the sac can be easily invaginated into itself from below. In the former case[1] the sac is treated by transposition and invagination; in the latter[2] by simple lateral transposition. It is first necessary, however, to reduce the contents of the sac.

Transposition by Invagination.—The Transposition-Invagination Method (*vide* Figs. 313, 314, 315) is the most effective. The fundus of the sac is grasped by a pair of curved narrow dressing-forceps (with toothed ends similar to Kocher's artery-forceps) and invaginated backwards through the inguinal canal, keeping the points

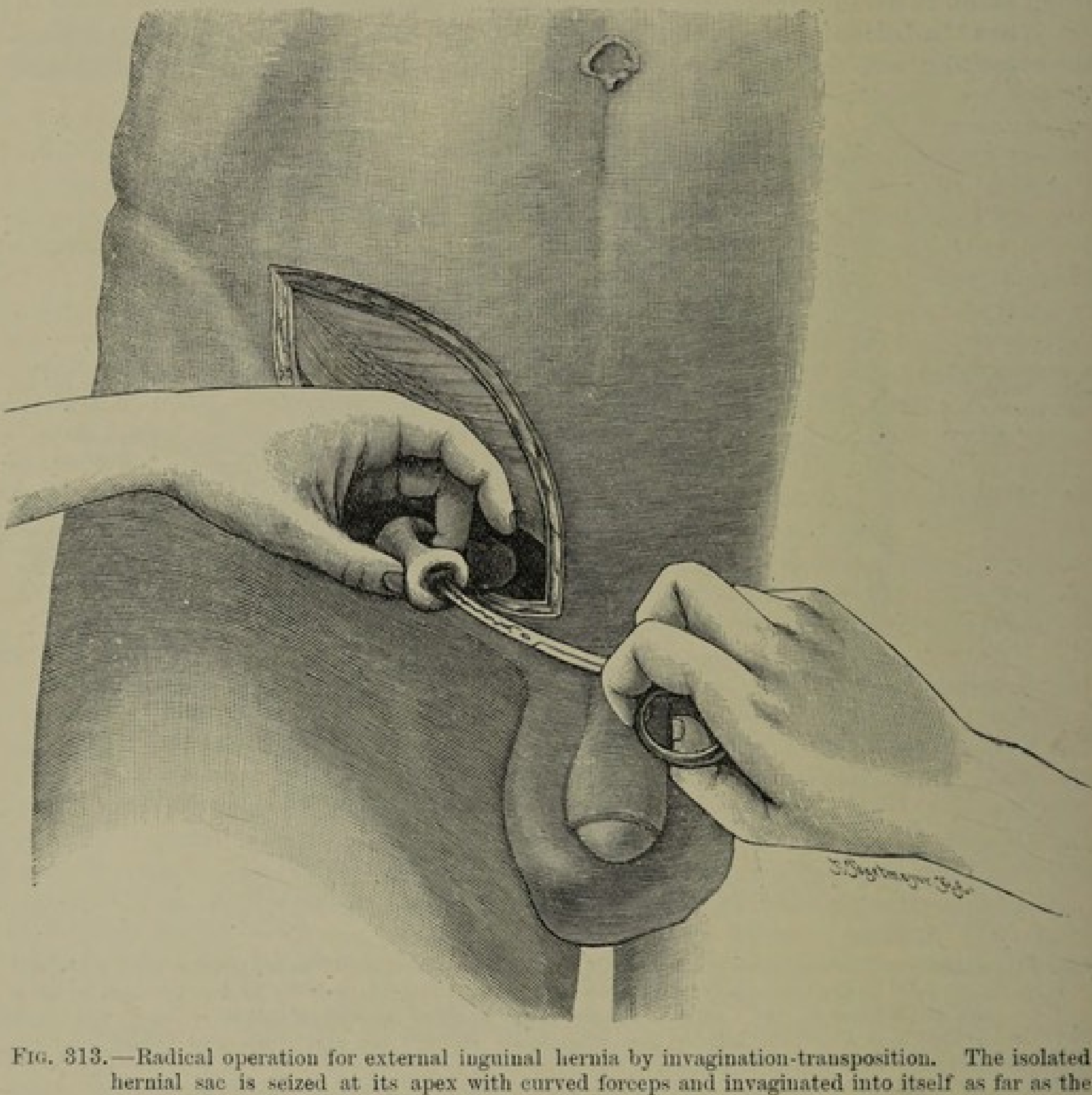


FIG. 313.—Radical operation for external inguinal hernia by invagination-transposition. The isolated hernial sac is seized at its apex with curved forceps and invaginated into itself as far as the posterior end of the inguinal canal.

of the forceps close behind the anterior wall until they reach the internal abdominal ring, where they are caused to project forwards.[3]

A small incision is made through the external oblique aponeurosis at this point and the nose of the forceps pushed through, covered by the parietal peritoneum, which is then incised, the edges being caught in artery-forceps. The apex of the

[1] In an ordinary uncomplicated adult hernia this is practically always possible.

[2] In children invagination is often difficult, as the sac is sometimes very short and thin.

[3] The most common mistake is that the forceps are not kept close enough to the anterior wall of the canal, and that they are pushed too high up towards the anterior superior spine of the ilium. It is only by a gross mistake of this sort that it is possible to injure the intestine or to nip it between the invaginated sac and the parietal peritoneum.

sac is now seized with artery-forceps and the curved dressing-forceps are loosened and withdrawn from the canal. The whole length of the inverted sac, the serous surface of which is turned outwards, is forcibly drawn up (Fig. 315), its neck

FIG. 314. FIG. 314*a*.

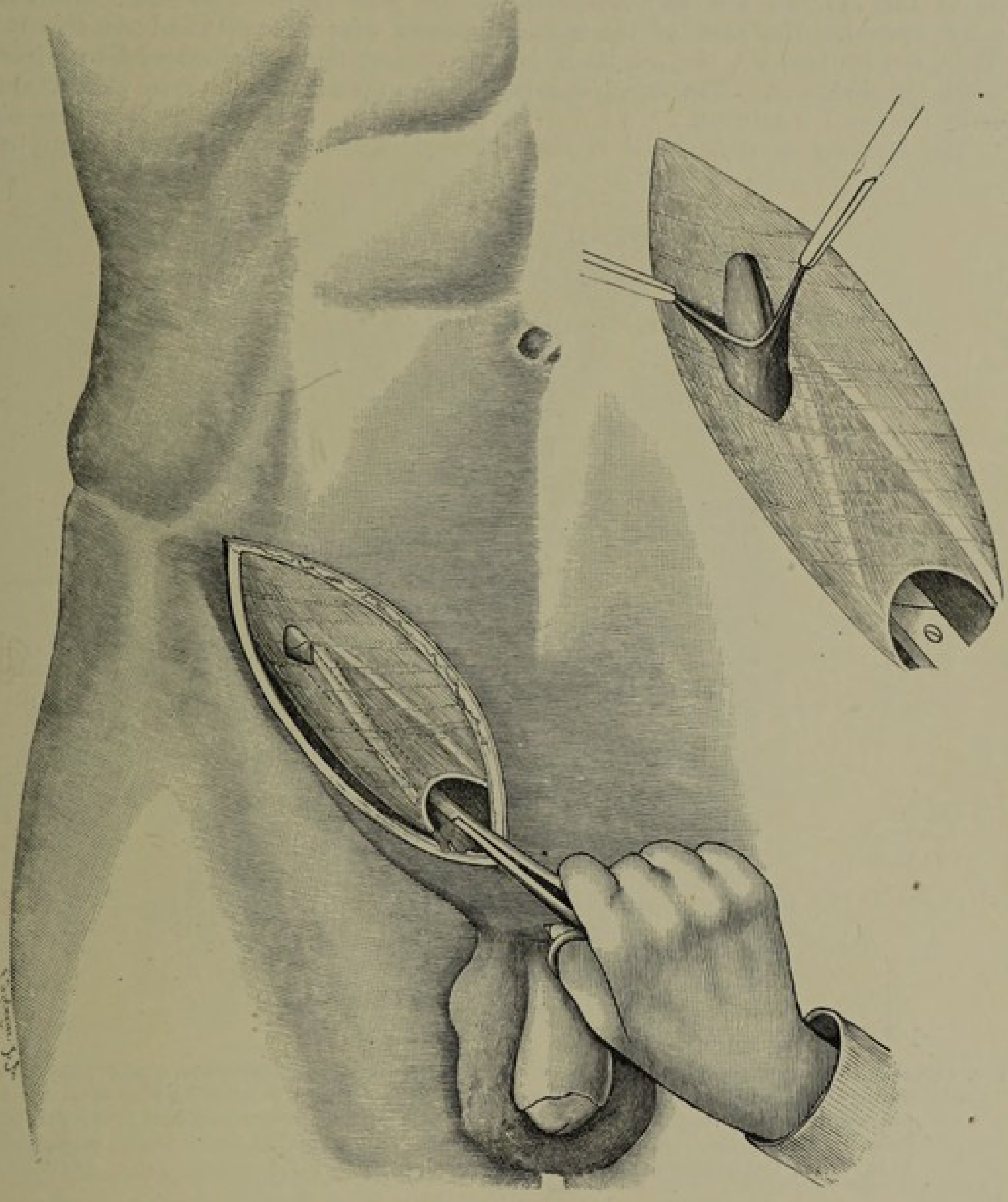


FIG. 314.—The invagination-transposition method. The point of the forceps forces the apex of the invaginated sac directly outwards from the internal inguinal ring towards the anterior abdominal wall. A small incision is made over the prominence so caused through the external oblique aponeurosis and the deep abdominal muscles.

FIG. 314*a*.—The parietal peritoneum is shown divided, its margins held apart, and the inverted hernial sac pushed through.

transfixed, and firmly ligatured at the opening in the aponeurosis and divided, the stump being allowed to slip back. The small opening in the parietal peritoneum and in the aponeurosis is then closed with a stitch and the canal sutured (*vide infra*).

Lateral Transposition.—When the sac cannot be invaginated either from its

shortness, tension, or thinness, or because it is advisable to remove it entirely, the apex of the sac is simply grasped with curved forceps and pushed up the inguinal canal immediately behind its anterior wall as far as the internal abdominal ring, where, as described above, it is protruded through a small opening in the aponeurosis and forcibly pulled out.

As the sac has not been invaginated, the parietal peritoneum in this case is not opened. The neck of the sac is ligatured with strong thread close to the slit in the aponeurosis, the sac itself is cut off, and the stump allowed to retract inside the abdomen. The small opening in the aponeurosis is then closed, and finally the canal is sutured.

The inguinal canal is closed in the following manner:—A series of interrupted

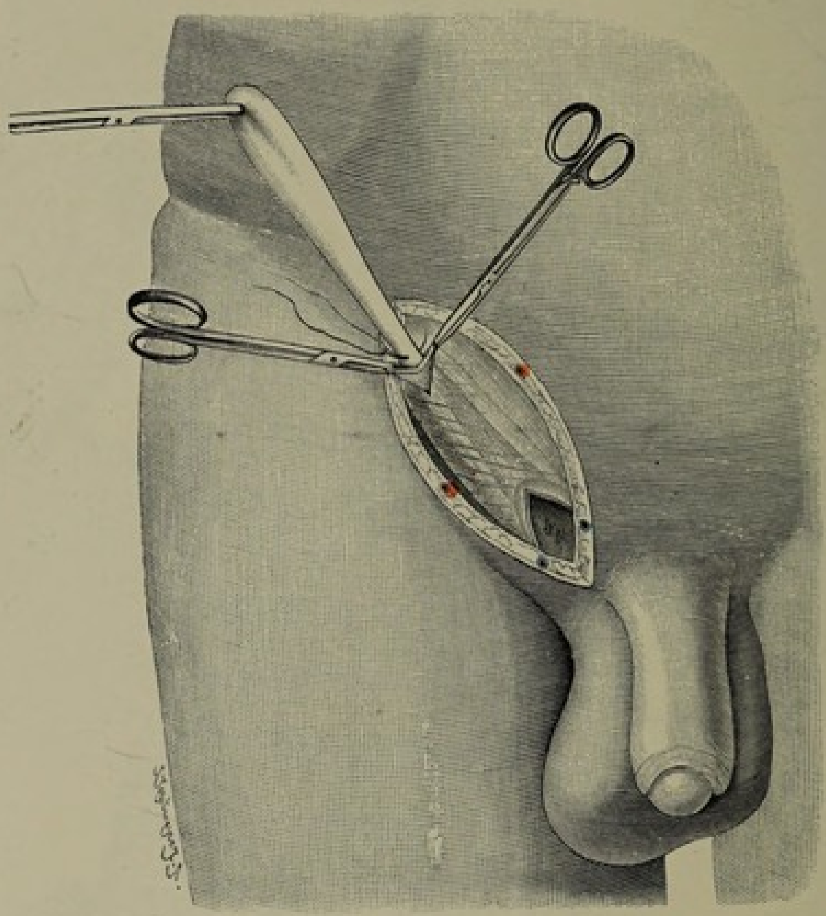


FIG. 315.—The transposition-invagination method. The sac has been invaginated and pulled out through a small opening in the aponeurosis of the external oblique muscle, close to the internal abdominal ring. The edges of the parietal peritoneum are seen held apart with two pairs of artery-forceps, while the base of the sac has been transfixed with a needle, preparatory to ligaturing and cutting it across.

sutures is introduced beneath the aponeurosis of the external oblique where it forms the anterior wall of the inguinal canal, and the portion thus in the grasp of the suture is then depressed with the finger, so that when the sutures are tied two parallel folds are approximated as seen in Fig. 317. Two to four sutures are then inserted so as to bring together the pillars of the ring, care being taken that when they are tied the circulation in the cord is not interfered with.

We always place a strip of gauze in the wound before inserting the continuous suture in the skin and only remove it when the last stitch is being inserted. The gauze prevents the accumulation of blood in the wound. Drainage is quite unnecessary and may even prove injurious.

We cannot conceive why, in face of the excellent results obtained with the transposition method, surgeons should employ methods which are less reliable and more complicated.[1]

Recurrence is due either to a fault which ought to be overcome, or, as we have already mentioned, to the fact that catgut is used for the sutures. The sutures should always consist of a non-absorbable material and the best of all is good silk. Those who are continually looking for a substitute to take the place of silk know that no material can give as good a guarantee for asepsis; and further, a fair comparison can only be made between the methods in which non-absorbable sutures are used.

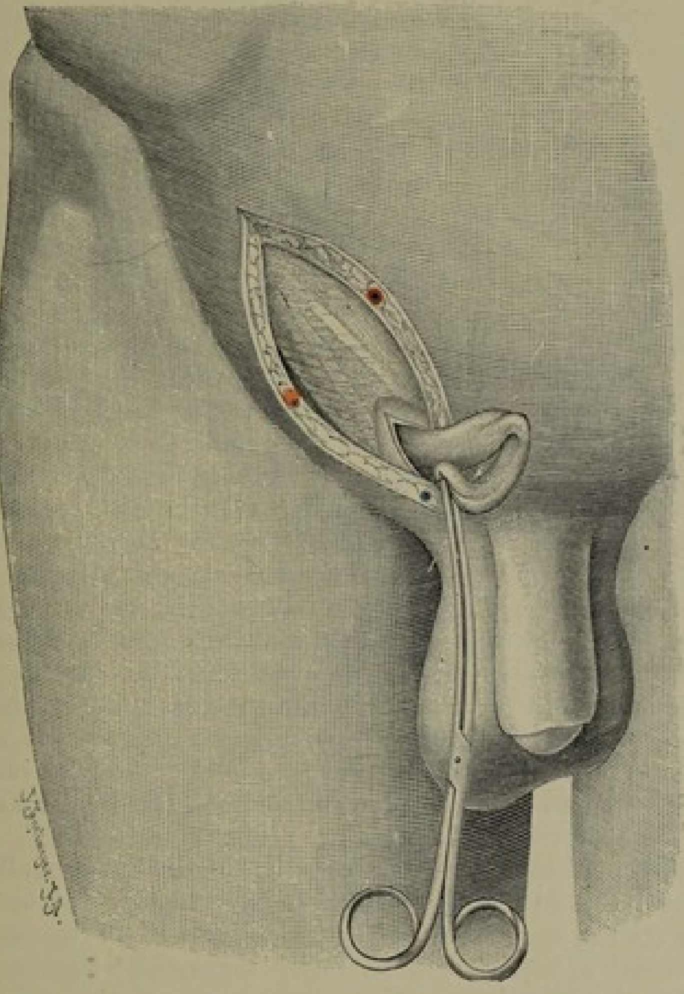


FIG. 316.—The lateral transposition method. The sac is here shown isolated and seized with curved forceps, preparatory to being pushed up the inguinal canal and brought out through a small opening in the aponeurosis of the external oblique, close to the internal abdominal ring.

(*b*) *Complicated Inguinal Hernia.*—Strangulation and inflammation without strangulation are the conditions which most usually complicate the operation of radical cure. In a strangulated hernia the sac must be opened and the contents examined: this must also be done when chronic inflammatory adhesions have formed between the sac and its contents, as, *e.g.*, in an old-standing omental hernia. In addition the sac itself may have undergone changes which may necessitate its removal, *e.g.* in a strangulated hernia, or when chronic inflammatory thickening and adhesions have made transposition impossible. In these circumstances one cannot do better than have recourse to the operation which we are accustomed to record in our registers

[1] From an investigation of a series of cases in Madelung's clinic P. Bernhard concludes that Kocher's method is the one most suited for uncomplicated inguinal herniæ which are not of long standing. Baratynski is of the same opinion.

as the "old method," since it is the method on which the radical operation was first based. Lucas-Championnière has made extensive use of this method, while Czerny and Socin have done excellent service in bringing it to its present state of perfection.

The Old Operation.—This consists in isolating the neck of the sac, ligaturing it as high as possible and dividing it, with subsequent closure of the canal. As already mentioned, it gives as good results as any other method in an uncomplicated case, and is, moreover, very simply performed.

Its simplicity is a strong argument for its use in children, and it may even be employed instead of the transposition method. There is certainly no advantage in Bassini's more complicated method, which Coley and others advocate for children, for admirable results are obtained with this simple process by Tavel and Stiles. Klemm finds it difficult in many cases to separate the sac on account of its close connection with the spermatic cord, and prefers not to remove the sac, but to open and evaginate it, subsequently fixing it to the cord.

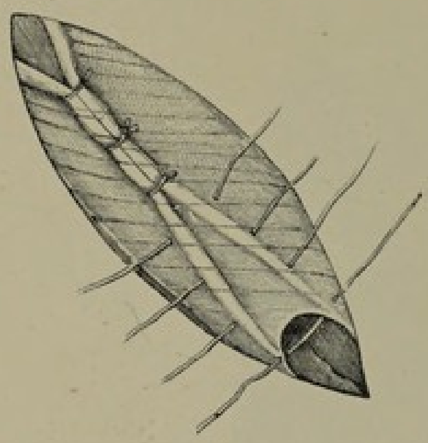


FIG. 317.—Strengthening sutures for the anterior wall of the canal, in position and partly tied.

In infants the simplest form of operation is the best. This consists in freeing the sac right up to the external ring, after dividing the infundibuliform fascia, and applying a silk ligature as high as possible by pulling the sac forcibly downwards. The canal is subsequently closed, or the pillars of the external ring may be simply sutured together (Tavel). We do not doubt for a moment that in children as brilliant results can be obtained by this operation as by Bassini's method and its modifications.

Bassini's Method and its Modifications.—The chief feature to which Bassini's operation owes its popularity is the fact that the whole length of the inguinal canal is laid open by dividing the aponeurosis, or even the muscular fibres of the external oblique muscle, as is done in the treatment of an incarcerated hernia.

By slitting up the canal in this way the relations of the sac are at once made clear, and by pulling on it the highest part of the neck can be readily exposed and ligatured. It is the most convenient routine method, and its use avoids the necessity of considering special treatment of individual cases.

For strangulated hernia, and hernia complicated by inflammatory thickening or adhesions, it must be admitted that Bassini's operation is the one to be preferred. For, by splitting up the sac and the entire anterior wall of the canal as far as the internal ring, omental adhesions can be easily separated, and the sac exposed at a point beyond where the adhesions or thickening exist.

It is quite another question whether, instead of fortifying the anterior wall of the canal by sutures in the simple manner we have described, it is necessary to strengthen the deeper layers of the canal as Bassini does, and at the same time displace the cord. The answer is furnished by statistics. If an operation such as our transposition method, in which the aponeurosis is not divided and in which the anterior wall only is strengthened by sutures, gives results which are not only as good as but better than those obtained by the disciples of Bassini, the obvious conclusion is, that *suture of the deep layers is not necessary for the radical cure of an ordinary inguinal hernia.*

We therefore consider it a matter of indifference as to the method by which the deep strengthening sutures are applied. In Bassini's [1] method the spermatic cord is laid upon the sutured canal and lies immediately under the aponeurosis of the external oblique muscle. Ferguson [2] attributes the cause of the hernia to an imperfect

[1] Langenbeck's *Archiv*, 1890.
[2] *Centralbl. f. Chir.*, 1904, No. 13, and *Jour. of Amer. Med. Assoc.*, July 1899.

attachment of the broad deep abdominal muscles to Poupart's ligament. He therefore first of all stitches the fascia transversalis round the cord, and then sutures the internal oblique and transversalis muscles to Poupart's ligament *in front of* the cord.

Hoffmann[1] applies a purse-string suture round the neck of the sac at the internal ring and stitches the internal oblique and transversalis muscles to Poupart's ligament with silver wire (Drahtnetz-Ringnaht), without further closing the canal. He believes "that merely obliterating the sac is sufficient to cure a hernia." Wölfler employs Ferguson's modification of Bassini's operation and in addition overlaps the external oblique aponeurosis.[2] Polya (Herczel) turns down a flap from the anterior sheath of the rectus, and uses it to strengthen the canal posteriorly.

Fergusson and Hoffmann in their modifications of Bassini's method do not consider it essential for success to follow Bassini's original treatment of the posterior wall of the inguinal canal, for it is quite certain that suture of the united aponeurosis of the internal oblique and transversalis, and the portion, which Bassini describes as fascia verticalis Cooperi, to Poupart's ligament is not always so easily accomplished, and that sutures inserted too deeply may lead to complications (*e.g.* thrombosis of, or even hæmorrhage from, the femoral vein).

We therefore only employ Bassini's method when there is strangulation, when the sac is much thickened, or when the contents are adherent to the sac: it is also suitable for a direct hernia, and for a hernia of very large size. Clinically, the latter, up to a certain stage, may be regarded as a direct hernia.

The essential points of Bassini's operation are: (1) The aponeurosis of the external oblique is divided throughout the entire length of the inguinal canal and the neck of the sac defined, the sac itself being also slit up when the hernia is strangulated, when there are adhesions at the neck, or when the hernia is direct. (2) The contents are reduced[3] and the sac is transfixed, ligatured, and cut off. (3) The spermatic cord is displaced upwards, while the internal oblique and transversalis muscles with the transversalis fascia are sutured to Poupart's ligament as high up as the internal abdominal ring. (4) The cord is then replaced and the aponeurosis of the external oblique sutured over it.

(*c*) *The Radical Cure of very large Herniæ.* Madelung[4] has drawn attention to the difficulty in treating very large herniæ. They cannot be classified with uncomplicated herniæ in respect to prognosis. A hernia larger than a man's head, whether scrotal or omental (specially following laparotomy) possesses peculiar features. The contents are irreducible and the intestines are often so matted together that they either cannot be separated from the sac except with the knife, or the adhesions between the coils cannot possibly be detached, while the prolapsed portion of intestine may be so large that it is impossible to find room for it in the abdomen.

If there is a choice, it is often best to avoid operation, and to rest satisfied with the relief afforded by a suspensory apparatus. When any one has let his hernia grow to such dimensions, he may be allowed to keep it. Often, however, no choice is left, as more or less acute symptoms of strangulation have driven the patient to seek advice. These cases may result in death with extraordinary rapidity, and we have seen one patient with a very large hernia die four hours after the first symptom of obstruction.

Operation must be undertaken without delay and should take the form of a hernio-laparotomy. The sac and its coverings are freely slit up and the nature of the adhesions or constrictions, especially about the neck, is determined. Often the neck has to be slit open to allow of reposition of the intestines.

Constrictions or kinks in the prolapsed intestine should be freed, and all omental

[1] *Centralbl. f. Chir.*, 1904, No. 19.

[2] Slajmer has published 1202 of Wölfler's cases. There were no deaths, but we are unable to find the number of radical cures stated in reports which we have been able to examine.

[3] Ball twists the neck of the sac before removal just as Wood and Macewen endeavoured to obtain a resistant cushion by plicating the sac. Bassini occasionally employs torsion. Jaklin has used torsion as a modification of our transposition method. We do not consider it necessary, and it may even cause necrosis of the stump.

[4] Langenbeck's *Archiv*, Bd. 74, 1904.

bands or adhesions divided; or, when this is impossible, and the patient's condition will allow, the question of performing an enteroanastomosis inside the sac, or resecting the mass, has to be considered.

When the bowel has been freed as much as possible an attempt may then be made to reduce the hernia *en masse*, the ring at the same time being enlarged. If this proves successful, the bowel may be kept in place with gauze pads until the radical cure is completed. When, however, the intestinal coils cannot be reduced, they should be protected by suturing the soft parts, the sac and its coverings over them.

Closure of the ring in the ordinary way is frequently impossible when the hernia is a very large one. A plastic operation must then be employed, and flaps consisting of muscle, fascia, or periosteum must be utilised for closing the ring. A suitable flap can be secured from flaps composed of the rectus muscle and the anterior wall of the sheath. Half the thickness of the rectus is divided transversely a hand's-breadth above its origin from the symphysis pubis and turned down along with the sheath, and fixed with sutures in the hernial aperture.

It is often better, in very large herniæ, to sacrifice the testicle in order to get a more secure closure of the hernial opening, or, according to Bernhard, the testicle may be reduced along with the herniated gut.

No single operation, however, can be regarded as a routine safe procedure. The skilful surgeon should be able to modify the operation to suit special cases and should not rely on any one method for every case.

99. Radical Cure of Femoral Herniæ. In his review on 23,519 cases of femoral hernia, Pott states that the best results are obtained with the old Czerny-Socin operation (already described under Inguinal Hernia), which consists in ligature and removal of the sac with suture of the ring. The percentage of radical cures, however, is only 71·6. It is obvious, therefore, that the conditions of femoral hernia and inguinal hernia are not analogous. The smaller percentage of radical cures, compared with inguinal hernia, teaches us that it is absolutely necessary to divide the sac high up, and that we should utilise all the coverings to strengthen the cure and not, as Hoffmann advises in inguinal hernia, remove them.

In the case of femoral hernia, one can only obtain this support to a very limited extent, while in the inguinal region a broad supporting wall can be produced by extensive closure of the canal. In femoral hernia everything depends on the closure of the hernial aperture after high removal of the sac, an easy process on account of the shortness of the crural canal. The femoral ring, through which the hernia is transmitted, is bounded by the femoral vein externally and by Gimbernat's ligament internally. The former of these structures must not be compressed or in any way narrowed. We have therefore to endeavour, as it were, to prolong Gimbernat's ligament artificially as far as the vein, and to make it as resistant as the natural ligament. Here, again, it is in our opinion absurd to treat all cases indiscriminately by one method. While simple suture is all that is required in the case of a small hernia, more complicated methods are necessary when the rupture is of large size.

(*a*) *Radical Cure of ordinary small and medium-sized Femoral Herniæ.* The incision corresponds to the inner third of Poupart's ligament, and divides the skin, superficial fascia, and the portion of fascia lata which covers the saphenous opening, namely the cribriform fascia. The sac, together with the fat covering it, is then freed by blunt dissection.

By stripping the fat off the sac, the latter can be readily isolated up to the crural ring, through which it has emerged, having pierced or pushed forward the septum crurale and the fascia transversalis which is situated between the femoral vein and the sharp outer border of Gimbernat's ligament. After reducing the contents, the sac is ligatured as high up as possible and removed.

When the sac cannot be freed high enough up, it is best dealt with by transposition and invagination. The contents having been reduced, the apex of the sac is seized with curved "transposition-forceps" and invaginated, the point of the forceps being passed upwards immediately behind Poupart's ligament on to the anterior abdominal wall, and made to project through an incision (4 mm. long) in the outer

pillar of the external abdominal ring. The sac is then forcibly pulled out with artery-forceps, transfixed at its base, ligatured, and removed in the same manner as was described in inguinal hernia. The stump is buried (*vide* Fig. 318), and the small opening in the aponeurosis closed with a suture.

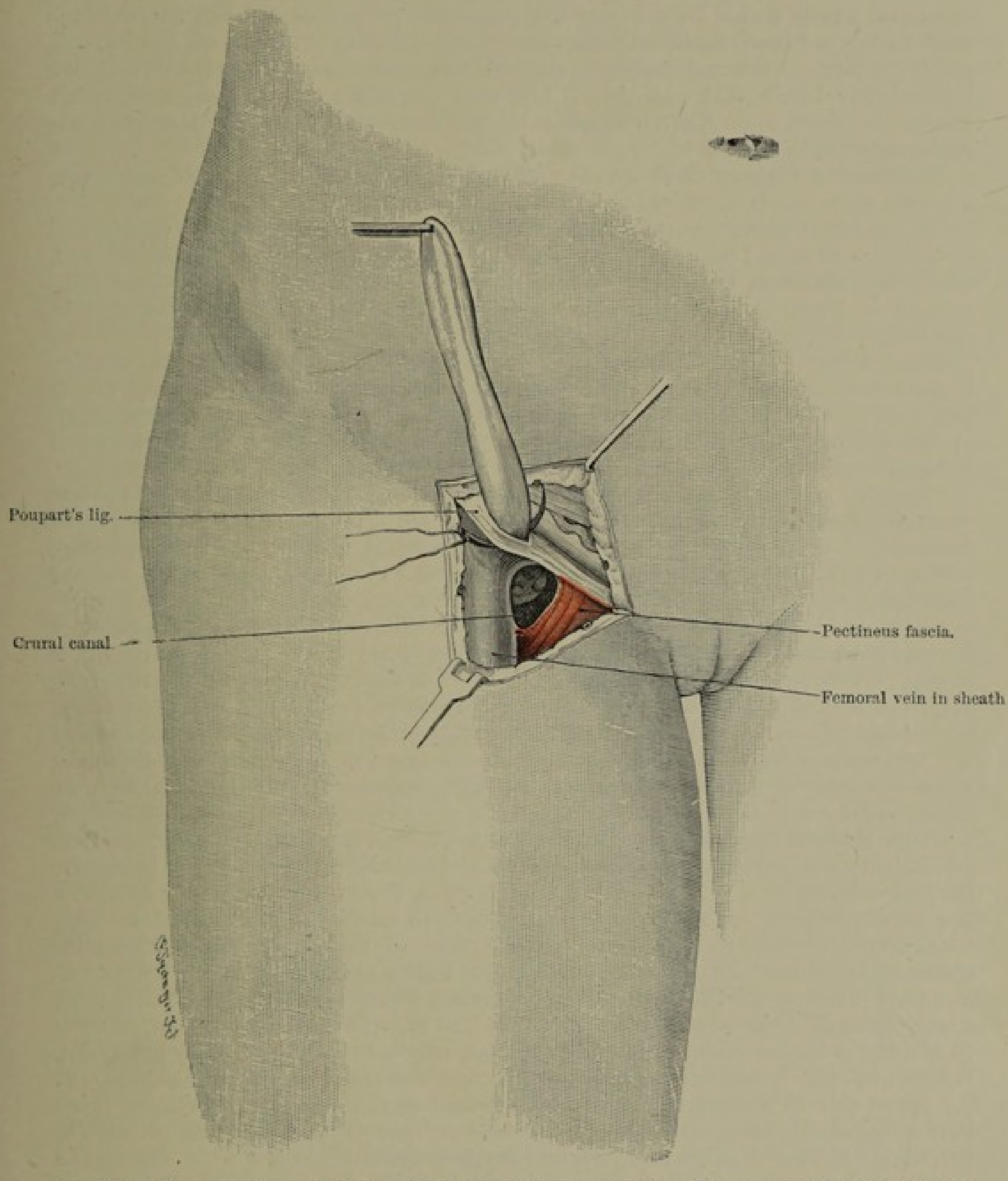


FIG. 318.—Transposition method in radical cure of femoral hernia. The sac is pulled upwards and outwards through the outer pillar of the external abdominal ring. The needle is incorrectly represented passing through Poupart's ligament. This may be seen more correctly by referring to Fig. 315, representing inguinal hernia.

Closure of the ring is the next step. Having defined the inner border of the femoral vein so as to avoid injuring it, a short stout curved needle threaded with strong silk is passed down to the pectineal eminence so as to include the pectineal

fascia and the deep crural arch (ligament of Cooper), *i.e.* a strong layer of fascia which is prolonged outwards from Gimbernat's ligament. By pulling on this stitch one ascertains if it is holding firmly, and if a second suture is necessary, it should also be passed right down to the bone before the first suture is tied.

The needle is then passed upwards through Poupart's ligament, and the suture or sutures firmly tied. In this way the innermost portion of Poupart's ligament is fixed to the pectineal fascia and the femoral ring securely closed, Roux employing a staple for this purpose and driving it through Poupart's ligament into the pubis. We have always found that pins driven into bone eventually tend to become loose, but experience alone must decide whether by the time it is loose, the soft parts are sufficiently firmly united.

(*b*) *Radical Cure of large Femoral Herniæ.* When the hernia is of large size, a plastic operation is required to close the crural canal.

Bonsdorff divides Poupart's ligament at a point opposite the femoral vessels, and turns down a pointed flap consisting of the muscles and fascia of the abdominal wall, which he sutures to the fascia covering the horizontal ramus of the pubis. This method is, however, only applicable to women, where the round ligament may be divided.

Goebel employs a method originally introduced by Mikulicz, in which an incision is made down on to the bone from the pubic spine internally to the femoral vessels externally. The periosteum is then detached and reflected upwards and downwards in the form of flaps, which are sutured to the anterior and posterior borders of Poupart's ligament.

Sprengel goes still further and closes the crural canal from its abdominal aspect through a laparotomy wound. The apex of the sac is grasped with forceps passed from within, instead of from outside as in our method, and the sac is invaginated, coiled up, and stitched along with the round ligament to the abdominal surface of the crural ring.

Polya also uses a plastic operation and closes the crural canal with a portion of the sartorius, over which he stitches a three-cornered flap of the fascia lata (sartorius fascia). The simplest method, however, must always be regarded as the best. When it is impossible to suture Poupart's ligament to the pectineal fascia and periosteum, we would suggest detaching Poupart's ligament from the pubic spine and Gimbernat's ligament from the ilio-pectineal line subperiosteally and displacing them outwards, so that the sutures can be easily introduced and the canal securely closed as far out as the vein.

100. Radical Operation for Umbilical and Ventral Herniae.—(*a*) *Radical Cure of ordinary non-adherent small and medium-sized Umbilical Herniæ.* A transverse incision is made as a rule above the umbilicus, as the skin at the lower border of the umbilicus is more difficult to separate owing to its intimate connection with the urachus and obliterated hypogastric arteries than at the upper border where the obliterated umbilical vein (ligamentum teres) is transmitted.

After dividing the skin and subcutaneous fat, which is often very plentiful, the edges of the ring should be at once exposed. The upper edge is first defined, in order to divide the fibrous prolongation on to the sac, which, as Tavel [1] correctly points out, is here not adherent to the sac, as it is in the neighbourhood of the umbilical cicatrix.

When this thin layer of fascia, which is analogous to the infundibuliform fascia in the inguinal region, is carefully divided the sac is exposed, and should be thoroughly separated all round by further dividing this fascial covering. The hernial sac can now be pulled forward, covered by fascia and soft parts, which Tavel aptly describes as forming a sort of hood: the peritoneum in the region of the ring is movable and must be isolated from its surroundings after the gut is reduced.

After the sac has been emptied and the contents have been returned inside the abdomen, it may be removed without opening it, as Tavel does in the case of children. Considerable force is often required to separate the sac from the skin in the neighbourhood of the umbilical cicatrix.

[1] Tavel, *Revue méd. de la Suisse romande*, August 1904.

If the sac is too intimately connected with the skin, it may be simply cut across with scissors and left behind. When there is a narrow neck, it should be transfixed and ligatured, and the sac removed unopened as in inguinal and femoral herniæ; but when the neck is of a wide nature, the sac should be opened in order to make sure that no intestine is included when the ligature is tied.

A gauze pad is inserted to keep the intestines out of the way, and the sac is divided about 1 cm. from the umbilical ring. The peritoneal edges are caught on either side with artery-forceps and sutured in the transverse axis with fine continuous silk.

The ring is also sutured transversely, in imitation of the natural method of closure of the umbilicus since the fibres of the transversalis fascia, which strengthen the umbilical ring, *i.e.* the fascia umbilicalis (Richet), run transversely above and below the opening.

The stump of the sac is kept back with a gauze swab, while the firm edges of the ring, which should not be rawed,[1] are brought together in a transverse direction with a continuous silk suture. We regard the use of silk as imperative since it holds the edges in contact for a longer time.

Excision of the umbilicus in uncomplicated cases is an unnecessary disfigurement.

(*b*) *The Radical Cure of large Umbilical and Ventral Herniæ.* Except when there are distinct or urgent indications for operating, it is often best to leave elderly people with large long-standing umbilical herniæ alone, as the risk of thrombosis occurring in the omental or mesenteric veins, with consequent interference with the blood supply of the bowel, embolism and pneumonia, makes the operation not always free from danger.

These patients, as a rule, only seek advice when symptoms of strangulation or inflammation call for surgical interference.

The radical operation, including the slight modifications necessary in strangulated cases, may be performed by a transverse incision either above or below the umbilicus, according to its relation to the hernia. The incision, which should be as close as possible to the ring, should be made cautiously, as the skin is thin and the hernial sac lies immediately subjacent to it. The summit of the hernia is often closely adherent to the skin (especially around the site of the umbilical scar), in which case an incision must be made beyond the adherent part of the skin, which must be removed along with the sac.

When there are no adhesions to the skin the sac can easily be freed as far as the ring by dissecting back the soft parts. After the neck of the sac has been isolated and the ring freely exposed on all sides, the sac is carefully opened, because, especially in elderly subjects, large masses of omental tissue lie in the hernia and are attached by broad adhesions to the sac, especially at its neck.

The separation of matted omentum is always a difficult matter, and if the part removed be more than merely the periphery, the point of division comes very close to the transverse colon, and here large vessels may require ligature. Ligaturing *en masse* may lead to thrombosis and cause necrosis in the region of the stump. This must always be considered in old people on account of their predisposition to pneumonia. It is well, therefore, to carefully isolate small parts of the omentum, which is generally very friable, and to tie it as near the periphery as possible, or, if necessary, rather to cut round it and replace a part of the hernial sac along with the omentum. If the hernia be large and composed of intestine (in old people generally the transverse colon) and large masses of fatty omentum, it may be necessary to increase the size of the ring by notching it upwards in the middle line so as to avoid too much crushing and pressure when returning the contents. Eiselsberg's experience is that intestinal hæmorrhages are easily caused, and it is within our own experience that sloughs of the intestinal mucosa may occur within a short space of time.

When the contents have been successfully replaced, it is most desirable, in the

[1] It is quite unnecessary to excise or raw the edges of the hernial ring, for it has no epithelial covering to prevent union; and besides it is sufficiently rawed by dividing the process of fascia which covers the sac.

case of omental herniæ of long standing, not to place a ligature around the neck of the sac, as is usually done in inguinal and femoral herniæ, but to remove the sac close up to the ring, which is often very rigid and thickened, and to introduce deep sutures simultaneously through the aponeurosis (linea alba) and peritoneum (neck of the sac). It is best to use interrupted sutures at intervals of not more than 1 cm., and to apply them in such a way that the umbilical opening is firmly closed in a transverse direction. To prevent the peritoneum retracting, if it be tense, it is cut away 1 to 2 cm. outside the ring, and the redundant portion is pulled forwards with forceps so as to enclose a broad surface in the suture. A broad margin of the umbilical ring must be included in the suture, as it forms the only structure which can be relied on not to stretch.

Special difficulties are frequently encountered in connection with very large ventral herniæ, as for example occur after using interrupted catgut sutures for closing a laparotomy wound, a practice which is still popular with some gynæcologists. Not only does the sac contain masses of large and small intestine, but the coils are often extensively adherent to the inner surface of the sac, while strong bands are often found stretching across the bowel and mesentery which cannot be detached.

In such cases all cicatrices should be cut away so as to free the skin as far as the base of the hernia, while large portions of the sac may have to be left adherent to the intestines before the adherent coils of bowel can be returned inside the abdomen. It is always essential to see that the peritoneum is quite free before closing it with a continuous silk suture. While this is being done the coils of intestine must be kept back (often forcibly) with gauze compresses.

The fascial covering is next closed. For this purpose good silk is used and the sutures must be passed in the neighbourhood of the base of the hernia only through parts of the fascia which are sufficiently resistent. In order to avoid tension, "Relaxation-incisions" (Karewski) may have to be made before the fascia or even muscles can be drawn together with sutures. Approximation of the recti introduced by Gersuny is very useful for herniæ in the middle line.

Graser, following Pfannenstiel and Menge, employs a transverse incision. He incises the fascia covering the hernia transversely, turns it upwards and downwards along with the anterior sheath of the rectus in the form of two broad flaps, and detaches the recti from the posterior layer of the sheath. He then divides the deep fascia and the peritoneum at the base of the hernia and sutures their edges vertically. The recti are then approximated by sutures and the flaps containing the fascia and the anterior sheath of the rectus are sutured transversely.

(c) Surgery of the Gall-Bladder and Bile Ducts

101. Summary and Development. Marion Sims, Blodgett, and Brown were the first to deliberately open the gall-bladder. In each case the operation was undertaken for empyema of the gall-bladder and the patients died. Cholecystostomy was then performed by Bobbs, in a case in which no diagnosis had been made beforehand. In 1878 we published the first case in which, on the strength of the diagnosis, the gall-bladder was opened, thirty-two gall-stones being removed. The ideal operation of cholecystotomy was instituted by Spencer Wells, but the success that now attends operations on the bile passages is largely due to Langenbuch's enterprise in excising the gall-bladder (1882) and to steady improvement in operative technique. Thanks to his lead, the position of biliary surgery is now most satisfactory, and this is proved by the fact that good results are obtained at the hands of general surgeons as well as by such specialists as Kehr, Mayo Robson, the brothers Mayo of Rochester, Körte, Courvoisier, Riedel, and others, who count their operations by hundreds and thousands.

The gradual development of the surgery of the liver and bile passages forms an interesting retrospect. In the early cases (Bobbs and Kocher), the gall-bladder was simply incised (cholecystostomy), Langenbuch then removed it altogether (cholecystectomy). An attempt was next made in suitable cases to limit the operation to cholecystostomy, *i.e.* by opening the gall-bladder and removing its contents

with subsequent suture. A little later the removal of stones and other obstructions in the bile duct was undertaken. Lawson Tait, Langenbuch, Credé, and ourselves (1889) were the first to perform cholelithothripsy. Later, we learned how to expose the retro- and intraduodenal portions of the bile duct (*vide* our publication on Internal Choledocho-Duodenostomy, 1890). Cholecystenterostomy was then introduced by Winiwarter, Monastyrski, Kappeler, and Socin, for cases where separation and exposure of the common duct were impossible. More recently Kehr's operation of hepaticotomy for the removal of an obstruction situated in the peritoneal portion of the hepatic duct combined with drainage of the hepatic duct and hepatico-enterostomy have been introduced. Lastly, Kehr and Enderlen have perfected the idea of direct hepato-cholangiostomy, which we first attempted in 1888 and have extended it in the direction of cholangio-duodenostomy.

Although the removal of gall-stones may be regarded as a perfectly safe operation, provided the technique is good, it is not always possible to prevent the spread of sepsis when the bile passages are the seat of acute infective changes. Deaths from this cause occasionally take place after operations for cholelithiasis, but as the prognosis in such cases is always unfavourable, the operation cannot be held responsible for the results.

As it has always been our endeavour to describe only those methods which are thoroughly approved, we refer the reader to the works of Kehr, Riedel, Körte, Courvoisier, Mayo Robson, the brothers Mayo, and others, for a detailed description of the rarer and more difficult operations. Our present first assistant, Dr Matti, has recently made a careful analysis of 100 of our operations on the bile passages,[1] and has shown that our mortality is less than that of Kehr and Mayo Robson. We feel, therefore, we are justified in recommending the methods we have tried.

In these 100 cases, which included many complicated conditions, with the exception of liver abscess, we had only two deaths, both after cholecystectomy (2 per cent). One was due to embolism, the other to peritonitis, the result of the ligature on the stump of the gall-bladder having slipped. In this case, death might possibly have been prevented if we had passed a drainage tube down to the stump of the gall-bladder. With these two exceptions all the others recovered, amongst which were cases of choledochotomy and many other conditions associated with severe inflammatory complications.

We attribute our good results to the fact that in every case we try to arrive at an accurate diagnosis, specially during the operation, and then adopt the simplest measures. We have not drained the common bile duct or the hepatic duct in a single case, even when they were the seat of inflammation, notwithstanding the fact that Kehr and Körte attribute their success to having employed drainage. Our own statistics, as well as Mayo Robson's 1500 cases, show that drainage is not necessary, and we have never had occasion to change our belief. We have also gone a step further than other surgeons in the conservative treatment of the gall-bladder, only a few patients having had recurrence (3 cases), while the mortality has been diminished.

102. Indications for Operation, and General Remarks on Technique. Surgery of the bile passages, which originated in the treatment of suppurative conditions of the gall-bladder, has reached its greatest development in the treatment of gall-stones. It is the greatest advance modern surgery has made, to afford aid in the frequent combination of both conditions and in acute primary infections of the bile passages.

The treatment of new growths is still limited and forms a group by itself, while the operations on the bile ducts for the treatment of pancreatitis closely follow those for infective cholangitis.

The indications for surgical interference are, as a rule, twofold :

(1) To relieve mechanical obstruction in the course of the bile stream and the conditions associated with it (gall-stones, new growths, and cicatricial contractions).

(2) To provide escape for bile containing bacteria and toxins in all infective cases. These two classes of cases should be clearly distinguished before we decide the form the operation is to take, but it often happens that both conditions occur together.

[1] "Festschrift" für v. Bergmann, 1906, in Langenbeck's *Archiv*.

Had this principle been followed out in the past, the treatment would not have undergone the fluctuations that it has from one to the other extreme. While Lawson Tait and other experienced surgeons employed cholecystostomy almost exclusively,[1] and sacrificed all other considerations for drainage, many surgeons nowadays insist on nothing less than an almost routine removal of the gall-bladder, combined with drainage of the deep bile passages (common bile or hepatic ducts).

As we recorded the first successful cholecystostomy and were among the first to perform cholecystectomy, we can speak with experience on the relative merits of both operations.

Surgeons should realise that it is their duty to the patient to pull him through his illness and not to perform an operation regarded as classic. This object cannot be attained by any routine operation, whether based on old or on the most modern theories. Operations which are theoretically excellent, when put in practice may often cause the death of the patient because his individual needs are not taken into consideration.

In operating for peritonitis, experience has taught us not to attempt too much but to be content only with measures which are of vital importance. Unless we bear this in mind we cannot get beyond the point of view, to which Körte, a surgeon of experience, resigns himself, that in suppurative conditions we must be prepared to lose one case in ten. It is often far better merely to avert the danger to life for the time being and reserve a radical operation for a future occasion, for, with the improved conditions, operation is then more favourable (*vide* our statistics with those of Körte), and may be often not even required. From these considerations we proceed to the choice of operative technique.

Two distinct types of cases must be considered—(1) those in which the inflammatory process has already gone on to phlegmonous pericystitis, and (2) those in which mechanical difficulties are prominent (gall-stones without clinical signs of inflammation).

(1) When the case is an inflammatory one, and the gall-bladder is adherent to the abdominal wall and surrounding structures, with superficial tenderness, or even infiltration of the skin, cholecystostomy is all that is required at first. The incision should not be so large as that used for a radical operation, and should be made at a point where the adhesions are present. If the condition is not cured by opening and draining the gall-bladder, a radical operation may be undertaken later under better conditions.

(2) The treatment of a typical case of biliary colic, uncomplicated by intense inflammatory manifestations,[2] is equally definite.

Here, again, we follow out the principle of first dealing with the mechanical considerations and only thoroughly remove the gall-stones, nothing more, and our results show that our patients have not suffered in consequence. Cholecystotomy, *i.e.* when the gall-bladder is opened, sutured, and replaced without drainage, is the ideal operation when the cystic, hepatic, and common bile ducts are all free and patent. If one of these ducts is obstructed by a stone, the stone should be removed, and the incision in the duct closed by suture.

When the gall-bladder is healthy, no good can be done by removing it, and the results of those surgeons who advocate cholecystectomy *à tout prix* bear this out. It is quite true that gall-stones may develop again in a gall-bladder which has been

[1] Riedel only mentions cholecystostomy, while Mayo Robson has performed 319 cholecystectomies and 845 cholecystostomies.

[2] In the previous edition of this work, we stated that the removal of stones in the gall-bladder, as in other organs, can only be accomplished rapidly and with certainty by surgical measures. We will not go so far as to say that gall-stones "belong" to the surgeon. They belong first of all to the patient, and if he prefers to keep them, and drink Karlsbad waters besides, he has a perfect right to do so. Surgeons, who in the case of their patients are firm advocates of operation, are well known, when they themselves get gall-stones, to adopt this point of view. And if a patient comes to the point of wishing to allow his gall-stones to struggle *per vias naturales* with pain and anguish, that is his own business. On the other hand, a surgeon has certainly the right to say to his patient that he will be more quickly and surely cured of his illness by operation before subsequent dangers arise than by any other treatment.

retained, but this fear—so far as it is not based on inaccurate reasoning—is certainly much more theoretical than founded on practice, and it is quite incorrect to consider the gall-bladder analogous to the appendix.[1]

If the gall-bladder is removed and there is a recurrence of the gall-stones (*vide infra*), any further operative treatment is rendered infinitely more difficult, and, notwithstanding what may be said to the contrary, this is borne out by the reports of the cases in which a second operation was required. For, if the common bile duct becomes obstructed later on, we can no longer avail ourselves of simple measures such as cholecystostomy or cholecystenterostomy, but must perforce undertake some much more radical procedure.

It is well known that the prolonged presence of gall-stones predisposes to malignant disease in the gall-bladder. We are familiar with the frequency of this occurrence in cases of gall-stones which have not been removed or where disease had already occurred before their removal. We do not know of any case in which a more or less healthy gall-bladder has developed cancer after the removal of stones.

(3) In view of the signs of associated general infection, the indications are also clear in dealing with extensive cholangitis where the inflammation has spread right up to the liver. According to Kehr, the first and only thing to do is to provide for thorough drainage of the common bile duct and hepatic ducts, and to drain off the bile as quickly and with as little surgical interference as possible (cholecystostomy, etc.). After the gall-bladder has been opened, the way must be made free as far as the hepatic duct, if necessary, by slitting open the gall-bladder and cystic duct up to the common bile duct, so that thorough drainage of the infective bile from the liver and hepatic duct may be established.

(4) Treatment of long-standing biliary obstruction with symptoms of cholæmia is equally definite. These patients who are suffering from toxæmia should not be interfered with more than to relieve the urgent symptoms. It is sufficient to open the gall-bladder and make sure that the bile escapes freely.

In spite of these clear indications in both early and late stages there remain a large number of affections of the bile passages in which it is only during the operation that the surgeon can first decide which method will best secure a permanent recovery. In such cases we are in complete agreement with the modern opinion that the bile passages must be made freely accessible in their whole extent to allow of a thorough examination being made during the operation.

The abdominal incision must be long enough to permit of inspection and palpation of the parts, and the best incision is the one which inflicts least injury, *i.e.* which avoids the vessels and nerves, and which can be easily closed without danger of subsequent trouble or the formation of a hernia. It is impossible for one incision to fit the requirements of every case. In a patient with a long narrow chest and a prominent costal margin the incision is quite different from that for a patient with a broad chest and a more horizontal costal margin, while stout people require a longer incision than that made on patients who are thin.

We employ the oblique incision described and illustrated in Fig. 319. We prefer it to the vertical and the "wave" incisions through the rectus recommended by Lawson Tait, Langenbeck, Robson, Riedel, and Kehr. Our incision is carried in a straight line obliquely from the tip of the ensiform process, two fingers'-breadth below and at first parallel to the costal margin, after which it descends as far as the muscular fibres of the external oblique, which may be slightly incised. The rectus is divided across its whole breadth, and the nerves supplying it, which run obliquely from without downwards and inwards on the transversalis, are drawn aside. A few branches of the superior epigastric artery (int. mammary) are tied in the muscle.

Körte employs practically the same incision. When required, it can be easily enlarged so that even a gall-bladder lying far to the right can be reached. Hernia is very exceptional, as in 100 of our cases it has only occurred once. In a second case, where we employed a long mesial incision and removed at the same time an ovarian tumour, a hernia resulted.

[1] Article by Albert Kocher, *Korrbl. für Schweizer Ärzte*, April 1900.

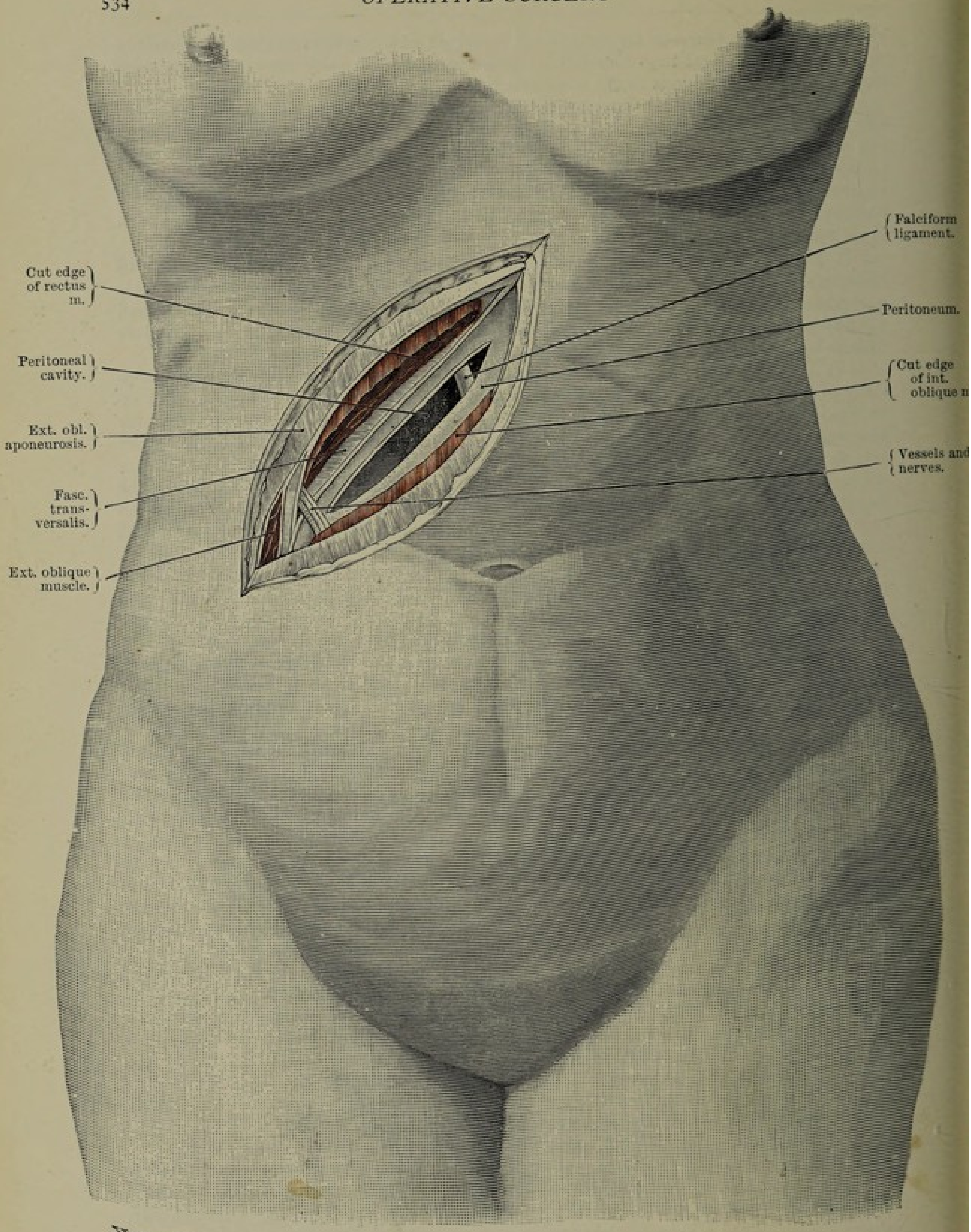


FIG. 319.—Incision to expose the gall-bladder and bile ducts. The sheath of the rectus has been opened and the muscle cut across; the broad abdominal muscles (ext. and int. oblique) are merely nicked; the transversalis fascia and its muscular fibres are completely divided.

By raising up the liver (the incision is parallel to its lower border), it can often be dislocated upwards so that an enlarged gall-bladder can be brought outside the abdomen while at the same time access is got to the bile ducts. Mayo Robson and Witzel attach great importance to this procedure, and the former lays special stress on the fact that by dislocating the liver in this way the gall-bladder, cystic duct, and common bile duct can be brought into a straight line down to the duodenum and head of the pancreas. At the same time the intestines, omentum, colon, and stomach should be packed off with moist gauze pads and pushed downwards, and to the left, with broad retractors. A gauze swab is also placed over the retracted liver and the latter kept rotated upwards.

By retracting the liver and dragging the gall-bladder upwards and the duodenum downwards, we get good access to the structures in the free border of the gastro-hepatic omentum (hepato-duodenal ligament), while at the same time the general peritoneal cavity is shut off. The anterior surface of the kidney covered by peritoneum is exposed with the second portion of the duodenum lying internal to it, while, higher up, the gastro-hepatic omentum is recognised with the bile duct in front and the portal vein and hepatic artery behind. Great assistance is afforded by placing a large sandbag in the lower dorsal region of the patient so as to produce a marked lordosis.

Lastly, the duodenum may be mobilised in the manner we recommended in 1903 [1] by dividing the peritoneum covering the right kidney along a line one or two fingers'-breadth outside the vertical part of the duodenum. This enables one to free the common bile duct down to the head of the pancreas and its termination in the posterior wall of the duodenum without, as Berg, Lorenz,[2] Payr, de Quervain, and others have shown, causing any harm. By enlarging the opening in the parietal peritoneum upwards and separating the peritoneum of the gastro-hepatic omentum by blunt dissection the intraperitoneal part of the hepatic duct can be exposed.

Many surgeons employ Kehr's "wave cut" through the rectus, or Robson and Körte's curved incision, which follows the costal margin above and is then carried downwards along the outer border of the rectus.

The best and most rational substitute for the oblique incision, when the latter is unsuitable, is the hooked incision recommended by Czerny. It is made in the middle line, and its lower end is carried transversely outwards and slightly upwards (*vide* Fig. 320). It is the best of all as regards the motor nerves to the rectus, as the latter are all avoided, and at the same time excellent access is obtained. As far as the preservation of nerves and the direction of the skin incision are concerned, it is, in our opinion, a normal incision, although it involves rather difficult suturing and is consequently rather complicated. A vertical incision at the outer border of the rectus is not so satisfactory since it gives too little room. Mayo Robson makes a longitudinal incision over the middle of the rectus, splits the muscle, and prolongs the wound up to the ensiform process so that he may be able to rotate the liver well upwards. The access got by this method is, in our experience, more cramped than that by the oblique or the angled incision.

Hernia can only be prevented by suturing the wound in layers, not with catgut, but with silk prepared in the manner we have described. Despite the fact that in our oblique incision the rectus is cut across, a hernia has only occurred once, and that was in a case which suppurated. The first continuous suture unites the peritoneum, the posterior layer of the sheath, and the edges of the muscle, while the skin is closed with a second continuous suture.

103. Cholecystostomy. This was at one time the most universally employed of the operations on the gall-bladder. As it is the simplest, and is regarded yet by some surgeons of eminence as the most reliable, we shall consider it first. It was originally performed in two stages by Blodgett and ourselves (ours was the first successful case), and up till now Mayo and Riedel have been its strongest supporters.

Lawson Tait introduced the one-stage operation, which at the hands of Riedel,

[1] *Centralbl. f. Chir.*, 1903, and *Deutsch. Zeitschr. f. Chir.* Bd. 79.
[2] Lorenz, *Deutsch. Zeitschr. f. Chir.* Bd. 79.

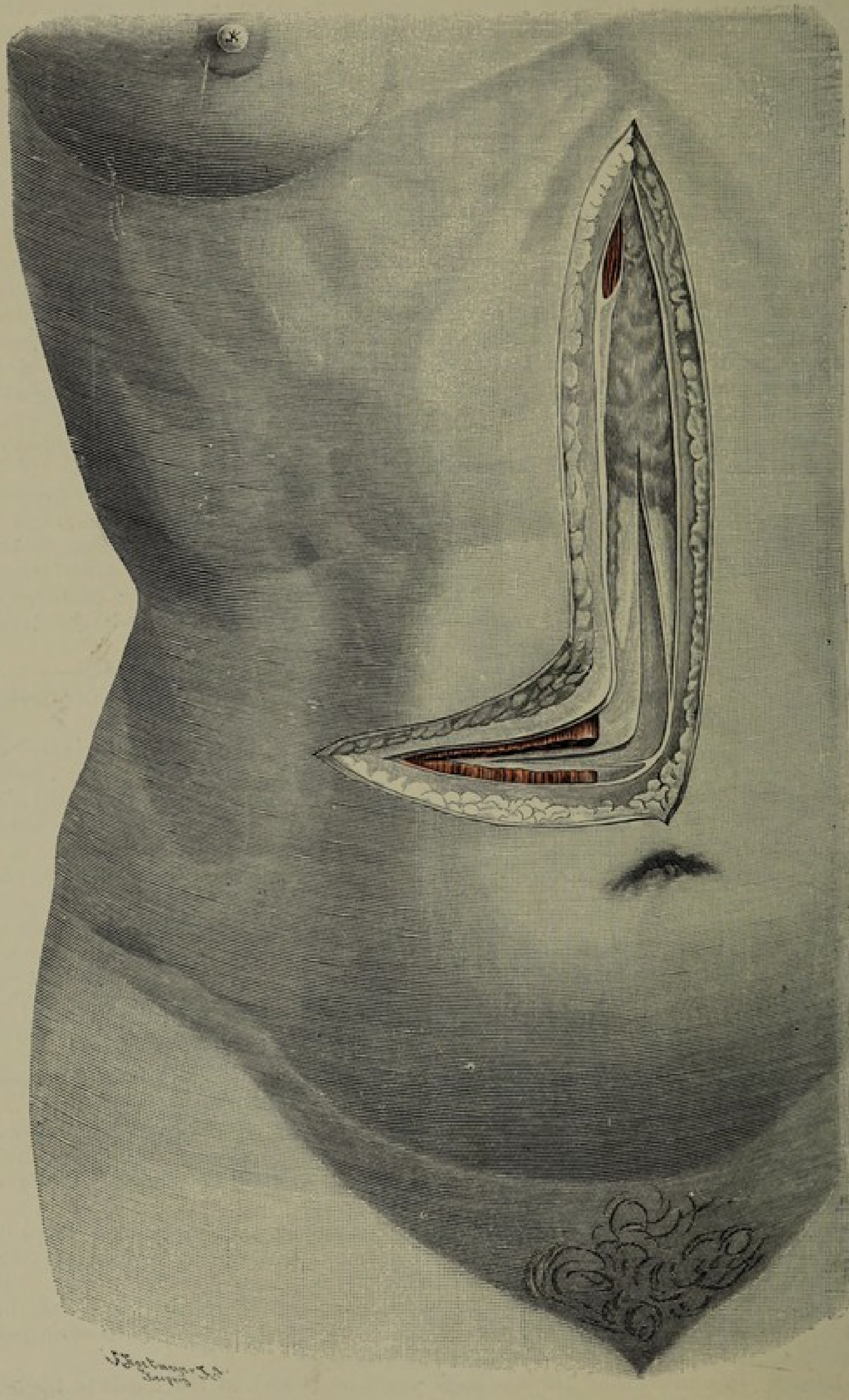


Fig. 320.—Hooked incision for the exposure of the bile passages in difficult cases. The anterior and posterior walls of the rectus sheath are opened and the muscle is cut across.

and more especially Mayo Robson, has now achieved great success, while Richardson has done much to establish its claim as the premier method in the treatment of gall-stones and their sequelæ. Robson has performed cholecystectomy 319 times, cholecystostomy 845 times.

It is the simplest method by which the gall-bladder can be emptied and drained, and Robson's statistics bear this out with the low mortality of 2·1 per cent.

It is indicated when temporary drainage of the gall-bladder and bile passages is required—as, for example, in suppurative conditions. Two types of cases should, however, be distinguished:—First, those in which the inflammatory process has already involved the abdominal wall: here (empyema) cholecystostomy is obviously the correct treatment. More commonly, however, the gall-bladder is only slightly adherent to the omentum or intestines and can be easily separated. In these circumstances the question of removing it altogether has to be considered as well. If cholecystostomy is decided on, the steps of the operation are somewhat different from those required for the former class of cases.

There is as little justification for being content with performing cholecystostomy in the treatment of cholelithiasis merely because it fulfils the mechanical indications for the removal of gall-stones, as there is (and this was the case formerly) reason for regarding it as the normal operation in the case of a mechanical obstruction, *e.g.* of the common bile duct when it merely provides an escape for the bile externally. Cholecystostomy is always indicated when the patient's general condition will not allow of a severe operation, such as finding and removing the obstruction, and when there is cholæmia and general infection. Simple cholecystostomy, under local anæsthesia, is often the only operation the patient can undergo without risk. Robson, with his large experience, lays special emphasis on the employment of this simple treatment of obstruction of the bile duct in critical cases.

(*a*) *Technique of Cholecystostomy, when there is Pericystitis, with Adhesions to the Abdominal Wall.* An incision is made over the point of greatest tenderness with possibly redness and œdema, this corresponding usually to the outer border of the rectus. The incision should not be more than 2½ inches long, and is carried right down to the parietal peritoneum, which is carefully opened, and if the gall-bladder is adherent all round, the latter is simply incised and the hæmorrhage from its cut edges controlled by sutures (catgut) uniting it to the deep fascia. The interior of the gall-bladder is then washed out with warm saline, a glass drain inserted, and the wound packed with xeroform gauze. The gall-bladder need only be packed to arrest hæmorrhage from its internal surface, or as a means of applying antiseptics directly to necrotic patches in its wall.

If the incision opens up the abdominal cavity at a point where the latter is not adherent to the gall-bladder, that part of the wound should be closed with catgut stitches, and the gall-bladder sutured to the abdominal wall, after which the incision is prolonged in one or other direction.

(*b*) *Cholecystostomy when the Gall-bladder is free or easily isolated.* When the gall-bladder is free or only slightly adherent to the abdominal wall, the steps of the operation are different. In the conditions described above (*a*) the adhesions to the abdominal wall persist and may give rise to subsequent trouble, while there is also a risk of a persistent fistula forming. Lastly, there is always the difficulty, unless one can palpate the gall-bladder from outside, of being certain that all the stones have been removed.

A larger exploratory incision is required when the gall-bladder is free, but it may be necessary to reduce operative interference to a minimum on account of the serious state of the general health of the patient. In these cases it suffices to make an incision sufficiently large to allow the gall-bladder to be pulled into the wound and the surrounding parts to be packed off with gauze wrung out of saline solution. After the abdominal cavity has been shut off, the gall-bladder is opened, emptied, and the edges grasped with forceps. It is then temporarily plugged in order to prevent escape from the bile ducts. Mayo Robson lays great stress on washing out the gall-bladder and ducts with warm 5 per cent solution of sapo animalis or olive oil.

Now comes the peculiar difference from the simple incision described in case (*a*). The edges are first tucked in, and a rubber drainage tube is fixed into the gall-bladder by means of a catgut suture which includes the whole thickness of the wall, and at the same time invaginates the edges all round when pulled taut. When a small opening has been made, a purse-string suture may be employed as in gastrostomy by Kader's method. Over this a fine silk serous suture is inserted. By this water-tight method of inserting the drainage tube (Poppert and Kehr) union between the wall of the gall-bladder and the skin is avoided, and the danger of a permanent fistula is prevented.

The end of the serous suture on both sides of the drain is fixed to the parietal peritoneum and fascia transversalis on the under surface of the abdominal wall. As a further precaution against the formation of firm adhesions, one can even, when it is very important that the tube should be removed early and the fistula allowed to heal, follow Kehr and Körte and do away with all retaining sutures, and merely leave in the drainage tube surrounded with gauze. In 189 of Mayo Robson's cases of cholecystostomy, a persistent fistula occurred on fourteen occasions. It is certainly worth while to obviate the possibility of such an occurrence.

There is a further advantage in inserting the drainage tube in this water-tight manner, for if the tube is left long the bile can be drained off directly into a vessel and soiling of the dressings avoided.

When, however, one has to deal with a patient who is strong enough for a systematic operation, it should be a rule always to examine thoroughly not only the gall-bladder but also the ducts for the presence of gall-stones by means of a probe inside controlled by a finger outside. This has a great advantage over the more simple method of merely opening the gall-bladder in urgent cases of empyema. Lennander[1] declares that most cases of cholelithiasis can be properly treated by cystostomy in one stage.

As regards mortality, the results of cystostomy come next to those of cystotomy. Körte had 5 deaths in 99 suppurative cases, and 3 deaths in 36 simple ones. Kehr's mortality is 1·8 per cent, and Mayo Robson's 2·1 per cent (in 845 cases). We have had no fatality after cystostomy.

104. Cholecystotomy. The operation of simple cholecystotomy, which consists in the removal of the gall-stones, with immediate suture and reposition of the gall-bladder, was first performed, in 1883 and 1884, by Meredith and Courvoisier. The latter author described it under the name of cholecystendysis. Much has recently been written regarding the relative value of cholecystostomy and cholecystectomy, while little or nothing is said about simple cholecystotomy. It is indeed astonishing that so little attention is given to this operation, which undoubtedly affords the quickest and safest cure, and at the same time gives the least trouble from adhesions. It is regarded as being more dangerous, but such a statement is quite without foundation. The opening in the gall-bladder can be closed with absolute safety if the proper sort of case has been selected and if fine silk is used for the peritoneal stitches. In none of the cases where we have adopted it have we had the least trouble.

Another argument urged against it is that it does not prevent recurrence. Recurrence undoubtedly has been observed after cholecystendysis, and we have had personal experience of it in three cases; but after all the question is, whether its advantages do not more than counterbalance this disadvantage. From the point of view of possible recurrence one must first of all recognise that there are certain conditions which must be regarded as contraindicating the operation. Cholecystectomy does not exclude the possibility of another stone forming in the ducts, if the original causes still persist, and it must not be forgotten that should recurrence take place in the ducts, the mere presence of the gall-bladder is an advantage. Every surgeon of experience will admit that although operations for recurrent gall-stones after removal of the gall-bladder are not, as Körte says, "unsurmountable," yet they are attended with very great difficulty. Körte himself on three occasions has had to supplement an earlier choledochotomy with cholecystoduodenostomy.

[1] Langenbeck's *Archiv*, Bd. 45.

It is essential to make plain the indications for and against the operation of cholecystotomy.

(1) In the first place we must be absolutely sure that the bile ducts are patent, and just as in all the other operations for gall-stones, we must be certain that no stone is overlooked.

Since careful attention is nowadays paid to this, the results have become correspondingly better. As a general rule, we can determine the presence of a calculus in the hepatic or common bile duct beforehand, if we take the trouble to make a careful diagnosis, but at the operation we can, and must, make sure of this point. Robson determines whether the ducts are patent by forcible injections of warm sterile saline lotion. A mere catarrhal inflammation of the ducts is not a sufficient contraindication. There is a cause for the catarrh. It is kept up either by the presence of stones, by the spread of inflammation from below, or by biliary engorgement. If the ducts are patent and the stones are thoroughly removed the catarrh disappears without external drainage. The natural drainage into the bowel is amply sufficient, and may be relied upon to a far greater extent than most surgeons suppose. Robson removes the drainage tube in a cholecystostomy in a few days and then relies entirely on the internal drainage.

(2) The second contraindication to simple cholecystotomy is the presence of more profound inflammatory changes in the wall of the gall-bladder. The presence of a few bacillus coli in the contents of the gall-bladder should not influence us against the operation. Such a condition is by no means uncommon, and leads to no further consequences as soon as its cause, gall-stones, is removed. If the walls of the gall-bladder have become seriously altered as a result of an acute or chronic suppurative process, it is better to perform cholecystectomy, or if there are serious objections to this, cholecystostomy, for it is in these cases especially that there is a tendency to recurrence.

(3) Impaction of a stone in the cystic duct with thickening of its walls is another contraindication to simple cholecystotomy, for here the patency of the duct is interfered with. If these principles are followed, the dread of cancer subsequently developing in the gall-bladder is considerably lessened.

Cancer is certainly a sequel to cholelithiasis in not a few cases, but why? Because the gall-stones have either not been removed or have been removed too late. It has never been proved that there is a tendency to cancer after cholecystotomy. With the removal of chronic inflammatory contents there is no reason left for atypical epithelial growth. Mayo Robson only knows of two cases in which cancer developed after cystotomy and cystostomy.

We consider that what Bernays calls ideal cholecystotomy and Courvoisier cholecystendysis is a very simple and safe operation for an early case of gall-stones. Cholelithiasis cannot be cured by internal medication, as we have no means of dissolving the stones. The object in treating a case medically is to mitigate the pain till such time as nature may manage to push and force the stones through the narrow bile ducts into the intestine. This operative treatment may, therefore, be very well termed ideal for the early stage of cholelithiasis, since by this means the patient is freed of all his trouble at one stroke without any permanent injury or disability. Primary union can be guaranteed in eight days, and no adhesions to the abdominal wall are formed.

An oblique incision is made 10 cm. (4 in.) long and 4 to 6 cm. below the costal margin. It need not be made so long to begin with, as it can be lengthened subsequently. It should begin over the most prominent part of the rectus abdominis, and should divide skin, superficial fascia, and the aponeurosis of the external oblique, which, in front of the rectus, is united with that of the internal oblique. The rectus muscle is then defined and its outer border notched; the superior epigastric artery, which lies a little internal to it, is ligatured, as are also some muscular branches. The fibres of the external and internal oblique muscles are divided at the outer part of the wound. The intercostal nerves, which pass inwards towards the rectus beneath the internal oblique, should be preserved, since their division results in

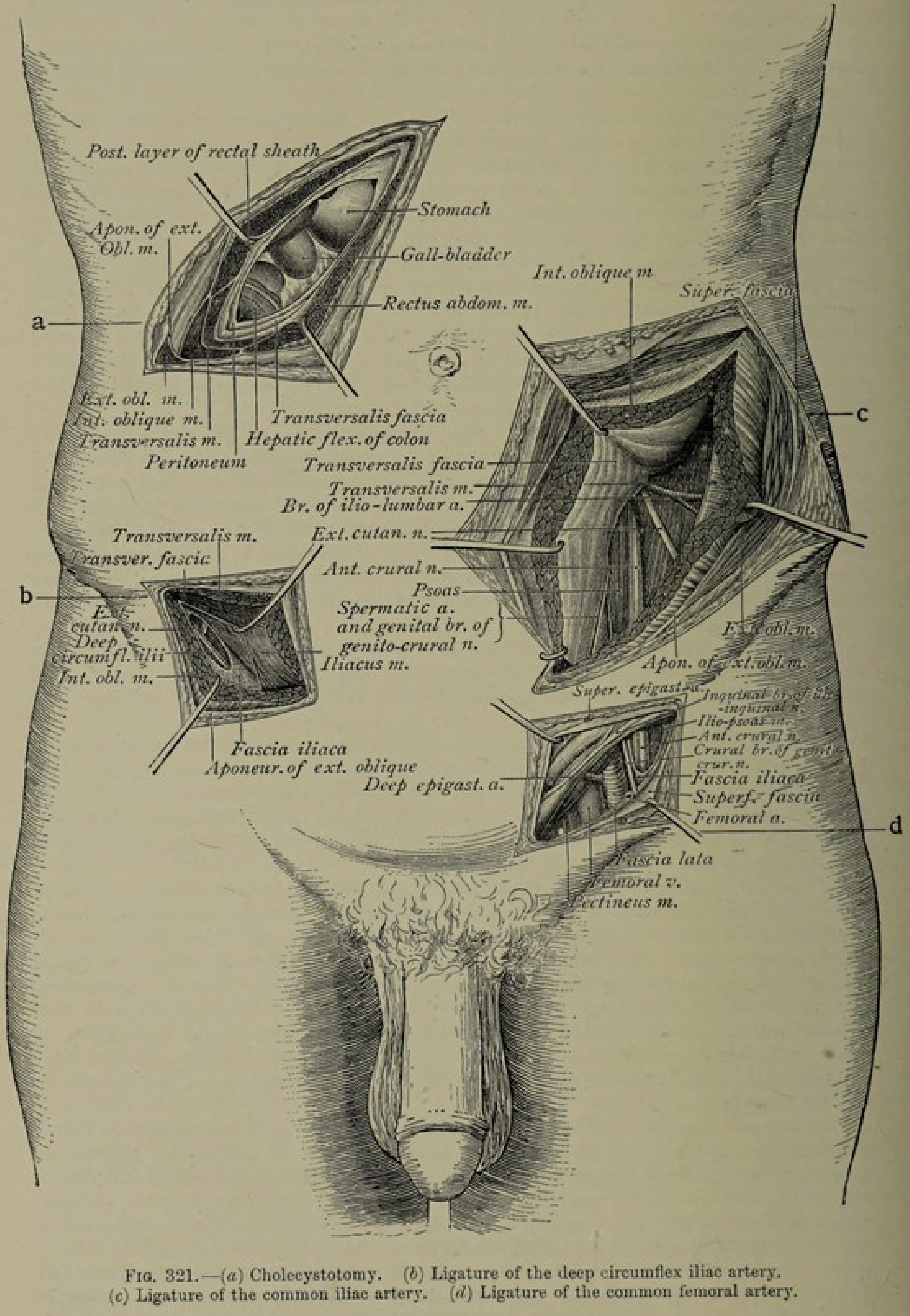


FIG. 321.—(*a*) Cholecystotomy. (*b*) Ligature of the deep circumflex iliac artery. (*c*) Ligature of the common iliac artery. (*d*) Ligature of the common femoral artery.

local paralysis of the rectus. The elasticity of the nerves readily admits of their retraction upwards or downwards. The muscular fibres of the transversalis extend beneath the edge of the rectus to end in an aponeurosis which, having united with the deep layer of the internal oblique, passes inwards behind the rectus to the linea alba. Beneath this, again, are the transverse fibres of the tranversalis fascia, on division of which the peritoneum is exposed.

After the peritoneum is divided, the gall-bladder, if elongated and enlarged, can be seen and drawn forward. Upon its inner side is the pyloric portion of the stomach, upon its outer side the colon. The omentum often lies in front of it, and must be pushed downwards and to the left: it is frequently adherent to the gall-bladder.

The gall-bladder is now pulled into the wound, and held there with fine clamp forceps, while the adjoining structures are packed off with gauze, and the escape of bile into the peritoneal cavity is prevented. The gall-bladder is fixed at its fundus with two of our hooked artery forceps, so that it may be safely emptied, and afterwards stitched, without allowing bile to escape into the peritoneal cavity. The fundus is incised, the fluid contents are evacuated, and then the calculi removed by means of a scoop and forceps. In doing this, we must be careful not to miss stones hidden behind folds in the cystic duct. Occasionally it is necessary to pass the forceps far in to reach stones which are deeply situated. Long, blunt, angled spoons are sometimes very useful in effecting extraction. After extraction of the stones the wound in the gall-bladder is closed by a double row of sutures as in suture of the intestine. The deep layer, which should be catgut, includes the whole thickness of the wall, whereas the superficial row (fine silk) unites the serous surfaces only. The gall-bladder is then replaced. The sutures cut through the mucous membrane and remain *in situ* without injury to the serous layer. The wound is completely closed without any drain. In the case of one of our colleagues, whose gall-bladder was hardly as large as one's thumb, and only projected about 4 cm. beyond the margin of the liver, we recently extracted forty-three medium-sized stones, lying like a rosary one against the other up to the very end of the cystic duct to a depth of 5½ ins.

We have never found much difficulty in finding and removing stones from the gall-bladder and the cystic duct. The work is controlled by a finger outside and a probe inside the duct. It often takes time to remove the last stone, but the necessary time must be given to it. Irrigation assists the removal of stones.

It may happen that one is not certain that the gall-bladder and the cystic duct are quite empty. In these circumstances we do not hesitate to lay the entire track open to the common duct, and then either excise the gall-bladder or perform cholecystostomy.

Cholecystotomy should not be performed unless one is sure that the cystic, hepatic, and common ducts are patent, *i.e.* that there is no obstruction either of an inflammatory nature or due to a stone.

The operation is therefore only suitable for cases in which there have been repeated attacks of biliary colic, without definite inflammatory complications, and for the earlier stages of cholelithiasis. It is stated by some that it is unnecessary to operate on these cases, for the gall-stones may become "latent" under other treatment, and as they are generally of small size may be passed spontaneously. Any one who has endured a genuine attack of gall-stone colic more than once will gladly submit to operative treatment, which affords a prospect of certain cure in one or two weeks, and more especially when the gall-bladder contains hundreds of gall-stones which may be the source of as many attacks of colic.

Technique.—If simple cholecystotomy is decided on, the incision need not be so large as that required for exploring the whole length of the bile passages, an advantage common in many cases to it and to cholecystostomy. A slightly shorter incision than that shown in Fig. 321 dividing the outer half of the rectus and carried into the fibres of the external and internal oblique muscles will suffice to expose the gall-bladder. The oblique incision has the great advantage that it can be easily enlarged if necessary.

The gall-bladder is pulled forward, the fundus held up with two pairs of forceps or

silk stays, and well packed off with gauze after careful examination of the cystic duct as far back as the common bile duct. The fundus is then incised and the contents are evacuated into a suitable vessel. Hundreds of small stones have sometimes to be removed with a blunt scoop before one is satisfied (by examining with a finger and probe) that the gall-bladder is empty and (by irrigation) that the cystic and common bile ducts are quite patent.

The wound in the gall-bladder is closed with fine catgut sutures, which include all the layers, and over this a serous stitch is inserted. There is no object in stitching the gall-bladder to the abdominal wall, as it only gives rise to painful adhesions, while, as there has been no infection, drainage is also unnecessary. In contrast to the cystic or common bile ducts, the gall-bladder may be safely sutured, and the wound is healed in eight days.

Note.—Cysticotomy. Lindner, Hochenegg, and Küster were the first to remove impacted calculi in the cystic duct by direct incision. As a rule cysticotomy is performed along with cystotomy, if the stone in the cystic duct cannot be forced into the gall-bladder. Körte has performed internal cysticotomy for the removal of stones.

105. Cholecystectomy. At the present time there are numerous surgeons, especially in America, who advocate removal of the gall-bladder in nearly every case of cholelithiasis. This we regard as an extreme view, although in the beginning of the year 1890 we drew attention to the good results we had obtained with cholecystectomy. Scudder and Wilson have compared the relative merits of cholecystostomy and cholecystectomy, and have shown that with the former the results are less satisfactory on account of the not infrequent occurrence of persistent biliary fistula, while with cholecystectomy permanent relief is obtained.

There are, however, contraindications to, as well as indications for, cholecystectomy, and although we have helped to show that the absence of the gall-bladder does not in any way interfere with health, we believe it is often a disadvantage to remove the gall-bladder, while in many cases its removal is difficult and entails additional risk.

(1) Cholecystectomy is clearly indicated when the gall-bladder is the seat of malignant disease and when malignant disease is suspected. It not infrequently happens that one finds small carcinomatous nodules, or even a diffuse carcinoma, embedded in the wall of the gall-bladder, which is apparently thickened and indurated as a result of chronic inflammation. In all cases, therefore, where there is even a suspicion of new growth formation the gall-bladder should be excised.

(2) It is, however, much more frequently in connection with inflammatory conditions that the question of cholecystectomy arises, and here a distinction must be made between the changes due to acute and chronic inflammation. We regard an acute inflammation of the gall-bladder in the same light as an acute appendicitis. So long as the inflammation is limited to the gall-bladder and has not already reached the stage of phlegmonous pericystitis, excision is the safest procedure and gives the most rapid cure. It is not uncommon to find, on examination of the gall-bladder after excision in these cases, that there is extensive gangrene of the mucosa involving the whole thickness of the wall and even threatening perforation. Early cholecystectomy is therefore clearly indicated and is to be recommended in acute cholecystitis.

When the walls are much thickened from chronic catarrh, with or without ulceration, cholecystectomy is also indicated, whether the organ is shrivelled, or distended with pus (empyema or hydrops), for in either case the gall-bladder has lost its physiological function as a receptacle for bile and its presence is only harmful.

(3) Excision is further indicated when the cystic duct has become altered, either as a result of impaction of a calculus or chronic inflammation, for the function of the gall-bladder depends on the duct being patent. Attention must here be drawn to the fact emphasised by Robson, that a duct will often appear at first sight to be impermeable, while at the end of the operation, or if an external fistula is established after some hours or days, the bile begins to flow quite freely. Catarrhal swelling must not be mistaken for absolute obstruction.

The indications for excision are therefore numerous, but in our opinion it is quite unjustifiable to go so far as to sacrifice every gall-bladder on purely theoretical

grounds, in order to save the trouble of making a definite diagnosis based on an examination of each individual case. Apart from slight digestive disturbances, and a tendency to diarrhœa, which according to Mayo Robson's experience may follow removal of the gall-bladder, the fact remains that if a second operation has to be undertaken for recurrence, it is attended with far greater difficulties if the gall-bladder has been previously excised. It is much easier to make a thorough examination when the gall-bladder is present, and at the same time one has an opportunity of performing a cholecystenterostomy.

Further, by following the policy of excision *à tout prix*, we find complications not infrequently arise, which would not be encountered with cholecystostomy or simple cholecystotomy.

Separation of the gall-bladder from the liver is often difficult and dangerous when the walls are much thickened and there are many adhesions. Severe bleeding may arise from tearing of the exceedingly friable liver tissue, and if a gall-bladder with infective contents is torn or cut into deep down in the wound, infection is easily set up which retards the healing and leaves dense adhesions. It is sometimes by no means an easy matter to isolate the cystic artery, and if it is included in a mass of dense tissue, the ligature does not hold well: severe bleeding may occur, or the stump may necrose, and so delay the healing. We have experienced such an accident and have had occasion to regret that we had not been content with cholecystostomy. William J. Mayo has occasionally found good results follow the mere excision of the diseased mucous membrane and drainage through the cystic duct.

If the gall-bladder is not much altered, its removal is a comparatively simple matter, provided it is done subperitoneally by incising the peritoneum at its fundus in the manner described in the former editions. Witzel has lately strongly recommended this subserous method of shelling out the gall-bladder with blunt dissection, and the operation is now practised by most surgeons. It can only be done, however, when the subperitoneal tissues are loose, but, when there is little alteration of the walls, in our opinion it is doubtful whether a simple cholecystotomy should not be preferred.

Technique.—The oblique incision already described is made below the costal margin. By tilting the liver well upwards, good access is got to the cystic duct, and if the latter is found to be free, it is as well to clamp it at once at its lower end (together with the cystic artery) with two pairs of Kocher's forceps, placed 1 cm. apart, in the manner advocated by Robson and Mayo. The duct is then divided between the forceps and the gall-bladder stripped backwards towards the fundus. The separation should be carried out as far as possible subperitoneally with Kocher's blunt dissector. The cystic artery is ligatured, then the cystic duct and the peritoneum is sutured over it.

When one is sure that the bile passages are free, the cystic duct may be at once raised on an aneurysm needle, ligatured, and the gall-bladder separated. In this way the hæmorrhage is greatly diminished.

When good access to the cystic duct cannot be got, it is better to divide the peritoneum around the fundus and strip the gall-bladder from the liver up towards the cystic duct, with preservation at the same time of as much of the peritoneum as possible. The gall-bladder can then be utilised as a handle, which facilitates the isolation and division of the cystic duct (and ligature of the cystic artery). In either case the peritoneum must be carefully stitched over the stump with fine silk sutures, after the mucous membrane has been touched with the thermo-cautery, excised, or disinfected with carbolic alcohol. The raw surface left on the liver should be covered over as completely as possible with peritoneum, or should at least be closed with sutures.

Very often it is impossible to strip up the gall-bladder by subperitoneal blunt dissection, as the peritoneum is firmly adherent to the thickened wall. In these cases [1] the gall-bladder must be dissected off the liver with the knife. After removal

[1] We agree with Kehr, Körte, and Robson that complications are best avoided after excision by employing packing and drainage.

of the gall-bladder a gauze drain is inserted down to the raw surface on the liver and the stump of the duct, and it should be made a rule to drain the deeper parts of the wound with a tube. One of our two fatalities was caused by a sudden gush of infected bile in a case where we had trusted to the closure of the cystic duct and had omitted to drain the abdomen. On the other hand we think that a drain down to the point where the cystic duct is tied is amply sufficient.

If the condition of the ducts has not been determined clinically or before opening the gall-bladder, or if, on the other hand, they are the seat of disease, the steps of the operation are different. The gall-bladder should be opened by an incision at the fundus, emptied, cleansed, and packed with gauze. It is then palpated either with a probe or by injecting fluids one ascertains if the deeper bile-ducts are patent. Should nothing definite be found by these means, the gall-bladder and cystic duct are slit open up to the common duct. But if, on the other hand, it is found desirable to drain the hepatic and bile-ducts, and the alteration of the walls of the gall-bladder makes its removal necessary, a rubber tube is passed into the common duct up towards the hepatic duct and fixed in position with a stitch. The cystic duct is then isolated, ligatured, and the gall-bladder removed. If, however, removal of the gall-bladder is not definitely indicated, it is preferable in affections of the large bile passages to leave it and perform cholecystostomy, with drainage of the hepatic duct.

The tube is brought out through the wound and xeroform gauze is inserted down to the site of the sutures and to the raw surface of the liver. Where the gauze is in contact with intact peritoneum and with the edges of the wound it should be covered with gutta-percha tissue, after the fashion of M'Cosh's cigarette drain. The gauze is removed after two days, if there is no more blood-stained discharge, while the tube is taken out a day or two later. Drainage of the wound is only stopped when the bile resumes its natural course through the common bile duct and the cholangitis has disappeared.[1]

As a general rule, drainage of the hepatic duct after cholecystectomy is not necessary: the wound heals quicker and drains as well when the tube is only inserted down to the stump of the gall-bladder. It need only be resorted to when the inflammatory process has spread up the duct into the liver itself.

Note.—Of the surgeons who are opposed to the routine removal of the gall-bladder in disease of the ducts, Mayo Robson,[2] from experience of 3000 cases, declares that recurrence[3] after cholecystotomy or cholecystostomy is exceedingly rare, while, on the other hand, he has found recurrence in and dilatation of the bile-duct after excision.[4] He even holds that cirrhosis of the liver may be set up by regurgitation in the dilated ducts after the reservoir of the bile has been removed, a statement which is not to be disregarded. On the other hand, in only two cases has cancer of the gall-bladder developed after cholecystostomy (Slade considers the combination frequent).

In the same number of the *New York and Philadelphia Medical Journal*, Feb. 1906, Erdmann advises more frequent excision of the gall-bladder as a useless organ, while Carr points out the importance of having the gall-bladder in reserve for subsequent cholecystenterostomy.

To sum up: Our statistics, as well as those of other surgeons, prove without doubt that there are fewer cases of recurrence after cholecystectomy than after cholecystostomy, and still less than after the ideal cholecystotomy. This is explained by the fact that the gall-bladder is the favourite situation for the formation of stones.

Cholecystectomy, even in the hands of the most accomplished surgeons, has still a mortality of 3·2 per cent (Kehr), 3·4 per cent (Mayo), while that of cholecystostomy is 1·8 per cent and 2·8 per cent. Our mortality both for the ideal cholecystotomy

[1] It is much easier to know when to remove the tube, when the latter only goes down to the duct and not into it.

[2] *Indications and Contraindications for Removal of the Gall-bladder*, London, 1906.

[3] Cf. "On Recurrence," H. Mohr., *Klin. Vorträge v. Bergmann-Müller-v. Winkel*, No. 309, 1901.

[4] Halsted in his highly interesting contribution to the Surgery of the Bile Ducts (*Johns Hopkins Bull.*, Jan. 1900), mentions a case of this sort, and reference will be found in an article of ours in Langenbeck's *Archiv*, 1906, to a case where a stone formed in the common bile duct after cholecystectomy.

and cholecystostomy is nil, and on the strength of this we think it is justifiable to take the risk of recurrence.[1]

Further, as regards the question of mortality, we must also repeat that recurrence after cholecystectomy is a much more serious affair, and the prognosis of a second operation is not nearly so satisfactory as when there is recurrence after cholecystotomy or cholecystostomy.

Provided the ducts are thoroughly examined, and care is taken at the time not to leave any stone behind, cholecystotomy may be undertaken without any hesitation, for it involves less risk to life, if the gall-bladder is normal or the seat of catarrhal changes only. Kehr overlooked stones in 4 per cent of his earlier cases and 2·5 per cent of his recent cases. On the other hand whenever the gall-bladder is profoundly diseased, when it is shrunken, when the cystic duct is obliterated, or when there is the least suspicion of malignancy, excision is the correct treatment. If, however, it entails a difficult and prolonged operation and the patient's general condition is not favourable, cholecystostomy should be resorted to.

While we do not deny that infection exists in every case of cholelithiasis which gives rise to clinical signs, we are convinced that in mild cases removal of the stones causes the inflammation to subside whenever free discharge is established into the intestine and without external drainage. External drainage is absolutely necessary only in cases of severe suppurative or phlegmonous cholecystitis.

Appendix. There is, lastly, an alternative method, which Mayo recommends in cases where excision of the gall-bladder is difficult, namely excision of the mucosa only. E. Ries[2] has brought forward arguments against it to the effect that it is difficult to remove the mucosa *in toto*, and especially the glands which penetrate the muscular coat.

It should be borne in mind, however, that in very adherent cases good results may be obtained by slitting open the gall-bladder and cystic duct, by avoiding incising the liver during the separation, but rather by leaving behind the thickened fibrous subserous layer.

106. Cholecystenterostomy. This operation was first performed by Winiwarter, Kappeler, and Mayo Robson. It differs from the operations already described in that it does not remove the obstruction, but provides a channel by which the bile can pass round it. It is, therefore, chiefly employed in cases where the obstruction cannot be removed, *e.g.*, in extensive new growth in the head of the pancreas, or when a considerable extent of the lumen of the common bile-duct has become obliterated. It can also be employed simultaneously with a radical operation for the removal of the obstruction.

Cholecystenterostomy, like cholecystostomy, provides for the escape of bile when its normal passage is blocked, but it differs from cholecystostomy in two essentials which modify the indications for its use. When the bile escapes into the intestine, its function in digestion as a disinfectant and enzyme is not lost; but, on the other hand, there is no reason why one should undertake an anastomosis with the intestine, where it is not required as a permanency.

Indications.—(1) The operation is indicated when the obstruction is situated in the region of the common bile-duct and cannot be removed. This may be due to extensive cicatrization or to the presence of a new growth about the head of the pancreas. In special cases, however, one should consider the question of resecting the common duct with subsequent duodenoneostomy.

(2) It is indicated in cases of temporary obstruction when there is a risk that the loss of so much fluid by external drainage may prove fatal to the patient, especially if he is in a low state (*e.g.* cholæmia, Lennander). Further, when the obstruction can be removed, but when its removal does not offer a permanent suitable escape for the bile through the normal passages (*e.g.* after resection of a tumour of the bile-ducts), an internal biliary fistula may be established with advantage.

(3) In a persistent biliary fistula following cholecystostomy. These are important cases, and the employment of internal drainage ensures a certain cure.

[1] A revision of replies to subsequent inquiries (deducting those that have died in the interval) gives 69 radical cures out of 76 still living = 90 per cent of radical cures (*l.c.*).

[2] *Annals of Surgery*, Oct. 1902.

The anastomosis should be made with the duodenum when the latter is at all accessible, and since the introduction of mobilization of the duodenum, the risks of this operation have been considerably reduced. The anastomosis with the gall-bladder is now as easily made with the second part of the duodenum as with the jejunum, even when the gall-bladder is small and contracted,—in fact it may be made with the cystic duct itself. We recently performed cystico-duodenostomy without any difficulty in a case of persistent biliary fistula. Cysto-duodenostomy is the preferable method in making an internal biliary fistula. At the same time, if the presence of cicatrices or displacement of the viscera make the performance of the operation too difficult, one must then be content with utilising the jejunum, the large intestine, or even the stomach, though the latter is, of course, the least desirable method of procedure.

Once more let us repeat, for the benefit of those who advise excising the gall-bladder as a routine procedure, that in those cases where an internal fistula is indicated, one is fortunate if cholecystectomy has been avoided at a former operation, as a cholecystenterostomosis is much easier to perform than a cholangiostomosis. One condition, however, that is essential for the former operation, but not for the latter, is that the cystic duct must be permeable: if it is not, cholecystenterostomy is out of the question.

Comparison of an Internal Biliary Fistula with External Cholecystostomy.—The last-mentioned consideration also represents the advantage of cholecystostomy, *i.e.* an external fistula over an internal one. As already mentioned, Lennander[1] has pointed out that the cystic duct may appear to be obliterated at the time of the operation, and yet becomes permeable after some hours or days when the tension in the gall-bladder has abated. In cholecystostomy this point is easily and definitely settled.

An external fistula is much more easily made. It can be rapidly performed through a small incision, and is therefore to be recommended in feeble patients. Further, if the cystic duct is patent, and the gall-bladder thick and shrunken, the latter can often be utilised for an external fistula when the immediate result of an internal fistula would be uncertain.

Lastly, the advantage of draining infected bile externally must not be forgotten. This, however, is important only when the infection is severe, with pus or decomposed material in the ducts, for then the exudate must be removed as quickly and thoroughly as possible, with the help, if necessary, of antiseptic irrigation in the most direct manner possible by inserting a drain into the hepatic duct (Kehr's hepatic drainage). On the other hand, a merely catarrhal inflammation immediately subsides and the congestion is relieved by making an internal fistula.

Radziewsky[2] has made experiments to test the truth of the view held by Kehr, Dujardin, and others, that when the retention of bile has gone so far as to produce cholæmia, internal drainage exposes the patient to the danger of ascending suppurative cholangitis. He concludes that further observations are required with regard to the ill effects in man. In this respect, cholecystostomy would therefore seem to possess greater advantage.

Technique.—The long oblique incision, or, in difficult cases, the angled incision described for choledochotomy should be employed. The liver is dislocated upwards, and the duodenum mobilized as described above.

The gall-bladder is opened by an incision at the fundus large enough to admit a finger. It is then emptied, and the patency of the cystic duct determined with a probe (*vide* Cystotomy). The gall-bladder is then packed with gauze. The duodenum (which has been mobilized) is now applied to the gall-bladder without causing any tension, and the posterior serous suture inserted, after which the bowel is lightly clamped with a curved pair of intestinal clamps. The gall-bladder and duodenum are then incised and the edges sutured all round, taking up the whole thickness, after which the anterior serous layer is inserted and the anastomosis completed. A drainage tube is stitched into the gall-bladder according to the method of Poppert

[1] *Wiener Klin. Wochenschr.*, 1893, No. 37. [2] *Grenzgebiete*, Bd. 9.

and Kehr, and the latter is fixed to the parietal peritoneum round the tube. The use of a tube to drain the bile externally is essential for the security of the anastomosis.

The anastomosis is often made with a small Murphy's button or Robson's bone bobbin, and there is no doubt that such artificial aids simplify the operation. Their use is indicated when there is difficulty in approximating the intestine and the gall-bladder. The button, however, should only be employed when the gall-bladder is not much thickened: otherwise it does not hold well. Mayo Robson is strongly in favour of the button.

107. Choledochotomy. The common bile-duct is rarely the seat of primary disease, but is relatively often involved secondary to disease in the gall-bladder. The immediate risks are much greater and the indications for operative interference are more urgent. Since the year 1889, when the first choledochotomy was performed by Kümmel, followed by Thomson, Heussner, and Courvoisier, the surgery of the common bile-duct has been greatly advanced and has now reached a stage at which success can be confidently expected. Obstruction and inflammation of the common duct possess a special importance, for it is from these conditions that disease in the hepatic ducts, the smaller bile passages, the liver itself, and also the pancreas originates. It is manifest, therefore, that in the treatment of certain diseases of the liver and pancreas curative measures must be directed to the common duct.

Most commonly it is because of an impacted stone that surgical interference is required. The obstruction is most easily diagnosed by the presence of persistent icterus coming on after a previous attack of biliary colic, especially if, in addition, the gall-bladder is not distended (Courvoisier). The great risk of prolonged icterus is well known, and the serious results of cholæmia from this cause are recognised by the surgeon from the great tendency to hæmorrhage, which may even prove fatal, notwithstanding the fact that the operation has been properly performed. Radical operation has often to be postponed until the dangers of cholæmia have been overcome by performing either a cholecystostomy (*q.v.*) or cholecystenterostomy. According to Lennander, the latter operation is to be preferred, as it does not interfere with the digestive functions of the bile.

Mayo Robson regards calcium chloride, introduced by Wright, as a good prophylactic against the hæmorrhage of cholæmia. It is administered in doses of 45 gr. per twenty-four hours up to 25 gr. four-hourly by the mouth or in enemata, or, still better, subcutaneously. Mayo Robson gives it during the day before and the day after operation. Kehr also speaks very favourably of the action of this drug.

The difficulties of choledochotomy depend largely on whether the stone is impacted in the free portion of the duct, *i.e.* where it lies in the gastro-hepatic omentum, or whether it is situated in the retroduodenal portion (*i.e.* para- or intra-pancreatic) which is a not infrequent position. When the stone is in the latter position an attempt should always be made to push it upwards into the free portion of the duct, and this manœuvre is greatly facilitated by mobilizing the duodenum in the manner we have described. Mobilization of the duodenum must be regarded as a great help in all operations on the common duct, and Lorenz,[1] Payr,[2] Berg,[3] de Quervain,[4] and Sprengel (Ohl) are of the same opinion.

(a) Choledochotomy in the free part of the Duct

The oblique incision already described gives enough room if carried sufficiently high up. For difficult cases we have used the angular incision (mesial incision, the lower end of which is prolonged outwards). This angular incision is the most rational, for although the rectus is divided, the nerves which supply its upper and lower segments are preserved intact, and the function of the muscle is fully maintained after suture.

The peritoneum covering the kidney is incised along a line one finger's-breadth outside the vertical portion of the duodenum, and the latter carefully separated from

[1] Lorenz, *Deutsch. Zeitschr. f. Chir.* Bd. 79.
[2] Payr, *Deutsch. Zeitschr. f. Chir.* Bd. 75.
[3] Berg, *Centralbl. f. Chir.* Bd. 27, 1903.
[4] Quervain, *Centralbl. f. Chir.* Bd. 40, 1903.

its bed with a finger or by gauze dissection, and pulled up into the wound, *i.e.* turned over towards the middle line, exposing its posterior surface.

By retracting the liver forcibly upwards and packing off the surrounding structures, the common duct can be palpated right down to its termination. It is only when there are dense firm adhesions in the region of the gastro-hepatic omentum that this cannot be done. The knife should not be used to divide the adhesions for fear of injuring the portal vein (*vide* Cholelithotripsy). Occasionally the common duct can be examined by slitting open the gall-bladder and cystic duct (possibly removing the former afterwards). As a rule, however, if the duct can be sufficiently isolated, it may be incised directly. The stone is steadied by the fingers or by means of forceps, and an incision is made down on to it, first of all, according to Elliott, silk stays being passed through the duct at either end of the incision. Whether the incision should be made in the transverse or longitudinal axis will depend on the position in which it is most easy to insert the loops of silk.

After removal of the stone, the bile, which escapes freely, is mopped up, and if the width of its lumen will permit, the duct is examined for other stones with the finger in both directions. If the duct is too narrow to admit the finger it should be examined with a probe guided by a finger outside. The probe should also be passed in a downward direction to see if the opening of the duct into the duodenum is patent. If the latter is free the wound is then closed with two layers of sutures,—the first layer of fine catgut, including all the layers; the outer, of fine silk, including only the peritoneum. To prevent any danger should the sutures give way, a glass drainage tube should be introduced down to the line of suture.

When the wound in the duct cannot be reliably closed, or when one is not sure that the outlet into the duodenum is free, a rubber drainage tube should be inserted into the common duct up to the hepatic duct (Kehr) and the infected bile drained externally for some days. Mayo Robson fixes the tube in position with a catgut stitch. If a large wound has been made in the duct, it is better to close it and make a special opening for the tube higher up. The drainage obtained in this way is just as effective as that obtained after cholecystostomy, while the latter is only possible when the cystic duct is patent. If the gall-bladder has to be opened or removed on account of disease, the tube is passed through the cystic duct into the hepatic duct, the former being slit open if necessary.

A number of authors (Quénu, Körte, W. J. Mayo, and others) do not suture the duct completely, as a fistula in the common duct heals very readily,[1] and a much more certain outlet for the bile is provided. They close the wound in the duct only up to the point at which the drainage tube is inserted. In our opinion primary suture of the duct is only contraindicated in cases of suppurative cholangitis and cholecystitis, where, owing to obstruction of the duct, there is retention of infective bile. Mobilization of the duodenum makes the introduction of the sutures so easy that it is wrong to abandon it altogether. It seems to us that if a drain is employed at the same time it is quite unnecessary to leave the stitches long, as Poppert does, and remove them after some weeks.

W. J. Mayo, in a summary of 1100 cases of gall-stone operations, reports two very interesting cases of direct suture of the common duct with good immediate results,—the one a case of accidental injury during cholecystectomy, the other a case of excision of the gall-bladder for malignant disease involving the common duct.

Besides draining the duct, it is well to pack the wound with xeroform gauze wrapped in rubber tissue, and insert a glass tube for fear of leakage from the duct. The gauze is removed on the second or third day and the glass tube after the removal of the hepatic drain.

(b) Retroduodenal Choledochotomy

This operation[2] presents peculiar difficulties which, however, have been partly

[1] William Mayo alludes to the very rapid healing in a case where the whole length of the common duct was split and then closed with catgut sutures.

[2] Kehr mentions cases by Lane, Kocher, Jordan, Monprofit, Czerny, de Quervain, Payr, and Lorenz.

overcome by mobilization of the duodenum, for by mobilizing the duodenum, this part of the duct can be brought far enough up to allow of its being palpated and even incised.[1] The common duct is raised up along with the duodenum.

It is in the termination of the duct that a stone most commonly becomes impacted. According to Courvoisier's rule, which, however, has its exceptions, if the jaundice is associated with a shrunken gall-bladder the assumption is that the obstruction of the common duct is due to a stone; if, on the other hand, the gall-bladder is distended, the obstruction is caused by a new growth. This is important when one has to consider the question of utilising the gall-bladder for anastomosis with the intestine.

If the duodenal end of the duct can be freed sufficiently to allow one to cut directly down on to the stone, the operation is exactly similar to that just described. It is here very necessary to drain off the bile higher up by means of Kehr's hepatic drainage. It must be remembered, however, that external drainage of the bile, apart from its value in protecting the stitches in the common duct, is chiefly indicated in cases where only temporary drainage is required. Kehr also strongly supports this view.

It is always better, if possible, to establish drainage into the bowel. Lennander maintains that external drainage of the bile is followed by rapid loss of strength, especially in cholæmic patients, and this is much more the case if the duodenal portion of the duct has been interfered with where the duct of Wirsung is liable to injury. This complication occurred in a case of ours in 1903, after we had removed with much difficulty a stone impacted in the lower end of the duct by a direct incision over it; as much as 2800 cc. (approx. 5 pints) of bile and pancreatic secretion escaped from the wound per diem. Kraske has reported a similar experience where several litres a day discharged till the patient died from exhaustion.

Riedel states that in the majority of cases a stone impacted in the lowest retro-duodenal portion of the duct can be pushed upwards. Berg, Lorenz, Payr, and others have had the same experience after mobilizing the duodenum. We agree with Kehr that there are cases where this is impossible, more especially where firm adhesions in the nature of pericholedochitis are present, for then the isolation of the common duct may be so difficult that to attempt to move the stone is out of the question. Büngner, Payr, and others have shown that the lowest part of the duct is completely enveloped by the pancreas (95 per cent according to Büngner), and we have satisfied ourselves from observations on the cadaver, that the duct of Wirsung descends vertically for about an inch alongside the common duct.

In such cases Lithotripsy may be had recourse to, or an anastomosis may be made with the duodenum (duodeno-choledochostomy). De Quervain considers retro-duodenal choledochotomy is contraindicated in such cases, and believes that when it is impossible to free the duodenum owing to the presence of adhesions, the transduodenal operation should be performed.

108. Choledocholithotripsy. Courvoisier was the first to perform choledochlithotripsy. We early pointed out the advantage of adopting such a measure in cases where the duct is imbedded in a mass of indurated tissue from which it cannot be isolated. The operation is very simple when one has to do with soft cholesterin stones, which can be crushed between the fingers or with forceps without opening the duct. At the same time we consider that it is most suited to cases of obstruction of the common duct by a stone, where the presence of firm adhesions prevents the possibility of freeing and opening the gall-bladder, cystic duct, and common duct, so as to reach the point where the stone is impacted.

The need for crushing a stone even in the deepest part of the duct arises less often, as by mobilizing the duodenum one can grasp the stone in front and behind; the pressure employed must always be limited. Kehr and others reject lithotripsy

[1] Mobilization of the duodenum is of more service than the method (Langenbuch) described in 1898, which consists in freeing the first part of the duodenum and in detaching the vertical part forward by dividing the peritoneum. It involves less injury and goes more directly to the mark (cf. Lorenz, Payr, and others).

altogether, on the ground that fragments are left behind, and that the walls of the duct are damaged. But if lithotripsy is to be condemned on the ground that portions of the stone are often left behind, the same argument can not infrequently be urged against cholelithotomy. In 94 cases operated on by Poppert (cholelithotomy), small stones were left behind in 20 (Brüning). According to Robson, the fragments can be removed by irrigation with warm oil or a 5 per cent solution of animal soap. In 31 cases, reported by him, nothing injurious was observed.

109. Choledocho-Enterostomy. Riedel, Sprengel, and Courvoisier were the originators of this operation, in which an anastomosis is made between the common duct and the intestine. It is quite analogous to cholecystenterostomy. The bile passages are so distended by the retained bile that in all those cases in which it can be exposed and sufficiently freed, an anastomosis between the common duct and the intestine is generally quite practicable. As a rule the opening in the duct should be transverse.

It is even more necessary here, than in cholecystenterostomy, to employ external drainage of the bile above the site of the sutures. For this purpose the gall-bladder may be used (cholecystostomy) or direct hepatic drainage where there is room for it. Poppert's watertight method of inserting a tube with a wick of xeroform gauze [1] is to be commended, but we always insert a glass drain [2] as well to a corresponding depth.

The manner in which the drainage is carried out is of great importance. We cannot as in choledochotomy simply leave a portion of the line of suture open and allow the bile to escape thus. The sutures must all be absolutely secure, so that no bile or intestinal contents may escape, either primarily or secondarily. Mayo therefore urges that no gauze packing should be passed down in contact with the line of sutures that is not wrapped round in rubber tissue so as to facilitate its removal. It is more simple to use a glass tube, and fix it with catgut in such a way that it does not come in contact with the sutures at all.

110. Duodenocholedochotomy and Duodenocholedochostomy.[3] A stone impacted in the ampulla of Vater is best removed by an incision through the duodenum [4] when mobilization of the latter is impossible. Kraske holds this opinion now, having previously, like us, injured the duct of Wirsung. Kehr has also successfully employed this method in 20 out of 210 cases of choledochotomy, with only two fatalities. Pantaloni differentiates between the transduodenal lithotomy first performed by M'Burney and the transduodenal choledochoduodenostomy recommended and performed by us. We described it as internal choledochoduodenostomy to distinguish it from that in which an anastomosis is made from without, as *e.g.* cholecystenterostomy and choleangioenterostomy.

(a) Transduodenal Choledocholithotomy

The operation was performed first in 1891 by M'Burney, then by Czerny and Mayo Robson, and up to the end of 1899 it had been performed twenty times with two deaths. It is especially desirable to get free access, and the incision which we have planned, similar to the one used by Pozzi, should be worth recommending. It consists in an incision convex or angular below and to the left, with a median vertical limb, and lower transverse limb passing through the right rectus abdominis.

The middle finger is passed in below, and the duodenum, which has been mobilized, is raised up along with the lower end of the duct and the stone, while the forefinger and thumb hold the gut above and below and keep it closed. We incise the duodenum transversely, because we consider an incision parallel to the vessels to be more rational. The next point is to decide whether the stone can be extracted through the opening of the ductus choledochus with or without an incision into Vater's ampulla.

[1] Note that no dry or strongly antiseptic gauze should be placed in the wound without previously immersing it in carbolic lotion.

[2] Krukenberg proposes to twist the gall-bladder (after Gersuny) before suture, in order to prevent backflow.

[3] Cf. technique of Collins, Kraske, Mayo Robson, Kehr, and Zeller with Kehr.

[4] Lehmann (Heidelberg Klinik) has collected 22 cases (vide *Beiträge z. klin. Chir.* Bd. 42).

According to Collins, who, as opposed to M'Burney, merely dilates the papilla instead of splitting it up, the ampulla is situated at the junction of the posterior and internal wall of the duodenum, below a prominence of the mucous membrane, which is placed 3 cm. below the angle between its first and second parts. Collins introduces a probe, followed by a pair of toothed forceps (a pair of our own artery-forceps would probably answer the purpose), with which he extracts the stone. M'Burney, after introducing a sound, incises the opening for 1 cm., and presses the stone out from behind: he then sounds the canal, as the stones are frequently multiple. They may frequently be pushed downwards by manipulating the duct from without. Any bile which may escape may be mopped up with gauze compresses. The duodenum is closed in the usual way by two rows of continuous sutures. If the peritoneum has not been soiled the abdominal wound is closed: as a rule it is well to put in a drain, such as a strip of xeroform gauze, in the space behind the duodenum.

(b) Transduodenal Choledochoduodenostomy (interna)

In cases in which very large stones have become impacted in the lower part of the common duct, but not actually at its orifice, when access from without is rendered difficult on account of adhesions, when the stone appears to be fixed in this position, and lastly, when it is found impossible to pass a probe in from the papilla, or when the papilla cannot be found without greatly prolonging the operation, the procedure which we adopted in 1894, and which has been repeated by Kehr, Mayo Robson, Sprengel, and others, with equally satisfactory results, is indicated. At the time of our operation we were unacquainted with M'Burney's method.

The operation is as follows:—The stone situated behind the duodenum is fixed with the finger, and after the duodenum has been opened, as above described, at a point opposite to the stone, a longitudinal incision is made down on to the stone. The distended common bile-duct is more likely to be found applied to the duodenum in the whole length of the necessary incision, if the latter be made in the long axis of the stone. We advise, as does Elliot for choledochotomy in general, that the wall of the duodenum and bile-duct right down to the stone should be seized with artery-forceps as soon as incised, and, if necessary, a stitch may be passed through the middle of the entire thickness of both edges of the wound, so as to keep up the apposition of the two walls and facilitate a choledochoduodenostomy, as we have termed the operation, if this be required. After the stone has been extracted the canal should be probed—with the finger if possible—so that other stones may not be overlooked. The mucous membrane of the ampulla is then united to that of the intestine with interrupted sutures, so as to encircle the whole thickness of the walls of both organs. In Kocher's and Kehr's case, in which this method was adopted, no evil results ensued from chance regurgitation of intestinal contents.

To insert no sutures, as is Mayo Robson and Sprengel's practice, is only safe when the stone is situated in the part of the common duct which traverses the wall of the duodenum, and not farther up, that is when one can be sure that infective bile and intestinal contents cannot filter through between the walls of the duodenum and common bile duct. The higher up the stone is, therefore, the less reliable is this method, although it is the simplest. The sutures also arrest any bleeding.

The after-treatment is the same as for transduodenal lithotomy.

Appendix; Choledochectomy (*Resection of the Common Duct*). In Mayo's case of choledochectomy already alluded to the duodenum was mobilised by Kocher's method, the peripheral portion of the divided duct brought up and united to the upper end with catgut sutures including the whole thickness, after drawing the surrounding portions of peritoneum together with supporting sutures. The suture of the duct was not complete, and a drain was passed down to it.

Kehr mentions three cases of resection of the supraduodenal portion by Kehr and Doyen, and three of the retro-duodenal portion by Halsted, Czerny, and Körte. Halstead implanted the divided common duct and the duct of Wirsung into the

duodenum, and subsequently performed cysticoduodenostomy in addition. His patient recovered and lived till recurrence took place a year and a half later.

When a radical operation for carcinoma of the common duct is undertaken, success depends on (1) whether the new growth can be sufficiently isolated to allow of its complete removal, (2) whether it is possible to retain a healthy portion of the hepatic duct which can be freed and utilised for suturing; (3) and, further, whether the duodenum can be securely closed, and the hepatic duct (or remainder of the common duct) sufficiently approximated to permit of a secure hepaticoduodenostomy, with possibly implantation of the duct of Wirsung into a special opening in the duodenum, as in Halsted's case. The introduction of mobilization of the duodenum has now rendered many operations possible which were formerly impracticable.

111. Hepaticotomy and Hepaticolithotripsy. We performed the first hepaticotomy in 1889[1] (cf. Pantaloni), and since then it has been frequently performed by Cabot, Elliot, Czerny, Delagenière, Meriat, and others. The chief credit for having demonstrated the accessibility of the hepatic duct for surgical measures on a larger scale is due to Delagenière, while Kehr, especially by introducing hepatic drainage, has opened up a large field of operations. It is rare that the hepatic duct itself is the object of surgical interference either for stone or new growth. Delagenière states that in obstruction of the common duct by a stone the gall-bladder is undoubtedly shrunken, as stated by Courvoisier, but the hepatic duct is just as regularly dilated. The same is true for other forms of biliary obstruction.

(a) Hepaticotomy

A large incision is required for the examination and exposure of the hepatic duct. One can employ an oblique incision similar to that recommended for getting access to the bile-ducts, *i.e.* obliquely across the rectus, or better still, the angular incision. In difficult cases it may be necessary to fracture the 7th or 8th ribs at the junction with their cartilages and displace the costal margin upwards. Halsted found this procedure of great value in one case.

Technique.—The hepatic duct may be exposed for the extraction of a stone in the following manner:—The liver is turned well upwards and the portal vein exposed, after which a finger is inserted behind the free border of the gastro-hepatic omentum through the foramen of Winslow, and the hepatic duct grasped between two fingers and isolated. It is then incised between two silk stays (Elliot) and subsequently sutured if this can be done securely as in Delagenière's cases. According to Marcel Baudouin, and Kehr, however, it is always safer to drain the duct with a tube 6-8 mm. thick.[2] One should always attempt first of all in these cases to push the stone down to a more accessible part of the duct. If it is impossible to reach the duct on account of the density of the adhesions, we have then a choice of two other methods: (1) When the gall-bladder is thickened and diseased, we may excise it, slit up the cystic duct if the latter is not already distended, and through it reach the lumen of the hepatic duct; (2) if there is no indication for removing the gall-bladder, the latter should be opened, and access got to the common and hepatic ducts from within, the cystic duct, if necessary, being slit up in the manner already described for a difficult case of choledochotomy.

(b) Hepaticolithotripsy

At a discussion on choledocholithotripsy held in 1890 we remarked that the principle might with advantage be applied to a stone in the hepatic duct, and this has since been carried out by Mayo Robson, Baillet, and Delagenière. The latter points out that occasionally the stone may be crushed from within after opening the

[1] "Beiträge zur Chirurgie der Gallenwege," *Deutsch. med. Wochenschr.*, 1890, No. 13 ff.

[2] According to Delagenière, direct hepatic drainage was first employed by Cabot after the removal of a stone for hepaticotomy, while Delagenière introduced indirect drainage through the gall-bladder. Kehr, however, deserves most credit for having developed the method.

gall-bladder and cystic duct. The method is worth trying in difficult cases; the results have all been good, and the theoretical objections brought against it have been proved to be groundless.

112. Hepaticostomy and Hepaticoenterostomy. There are four ways in which infective bile can be drained from the hepatic duct: (1) by indirect external drainage (Hepaticostomia externa indirecta), *i.e.* when a tube is passed into the hepatic duct by way of the gall-bladder and cystic duct (Kehr), or if the gall-bladder be already removed simply through the cystic duct; (2) by direct external hepaticostomy (hepaticostomia externa directa), *i.e.* by suturing the dilated hepatic duct to the abdominal wall. It is only in cases where the duct is greatly dilated that this is

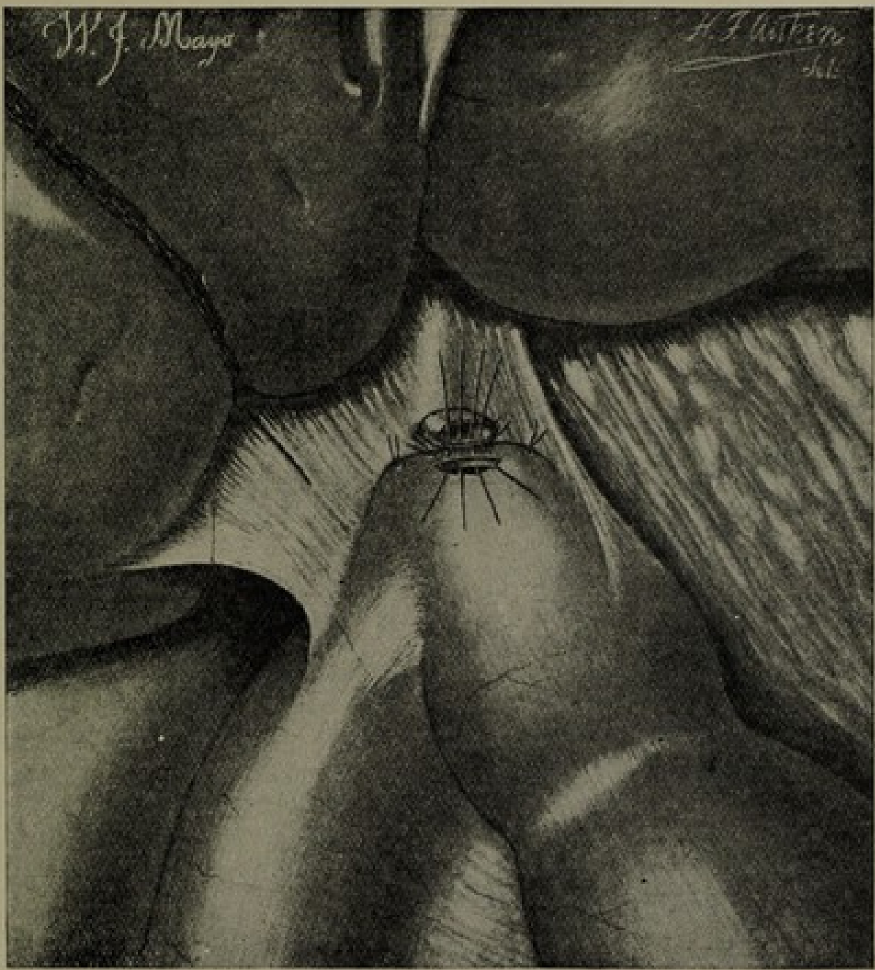


Fig. 322.—Hepatico-duodenostomy (after Mayo) for obliteration of the common bile duct, cholecystectomy having been performed at a previous date. The figure shows clearly the manner in which the duodenum (after mobilisation) is pulled up to the hilium of the liver, and how it is fixed with serous sutures to the hepato-duodenal ligament. At the most convenient point to the end of the hepatic duct the bowel is opened and united to the duct with catgut stitches, including the whole thickness of the wall. (In the figure the posterior sutures have been introduced.)

possible. (3) By trans-hepatic hepaticostomy (hepaticostomia transhepatica), as has been performed by Thomson and Mayo Robson (cf. hepatostomy). (4) Lastly, by hepaticoenterostomy (Kehr).

The technique depends on the anatomical changes present in each individual case; no general description will apply to every case (cf. cholangio-enterostomy below).

We have described a case (*loc. cit.*) in which there was a high degree of cystic distension of the hepatic duct, and Delagenière [1] has alluded to a case of Nicholaysen

[1] *Contribution à la chir. du canal hépatique*, Paris, 1904.

and Besançon in which a communication with the intestine would have been relatively simple. Kehr has accomplished it.

W. Mayo has prepared some very beautiful diagrams to illustrate the manner in which this operation is performed, and with his permission we reproduce one of his characteristic illustrations, which sufficiently explains the method.

In Mayo's case the gall-bladder had been removed at a previous operation. It was otherwise in the following case published by Halsted which shows how, by preservation of the gall-bladder at a first operation, it may be turned to good account in a case of severe recurrence. Halsted designates the operation performed by him under the circumstances mentioned as hepatico-cholecystenterostomy.

In devising the operation in this case, he utilised the idea which we shall consider under hepatocholangioenterostomy (see next section), namely, of using the gall-bladder as an intermediate reservoir for the bile in establishing a connection between the upper (para- and intra-hepatic) bile-ducts and the intestine. The cystic and common ducts were both obliterated, the gall-bladder and hepatic duct being dilated.

He first anastomosed the hepatic duct with the gall-bladder and then the gall-bladder with the duodenum. The result was highly successful. The patient had previously been operated on, and had it not been that, fortunately, the gall-bladder had been retained, this second operation could not have been possible.

113. External Hepatocholangiostomy and hepato-cholangioenterostomy.[1] (*a*) *Hepatocholangiostomia externa.* As a result of an operation we performed in 1882, we were able to point out that the small bile-ducts and biliary canaliculi can become so dilated from obstruction as to become visible on the surface of the liver, where they may even give way and form biliary abscesses, both inside and on the surface of the liver. Bearing this in mind we can therefore provide a temporary escape for the bile, until the obstruction either spontaneously disappears or is removed. In our first case the biliary fistula healed immediately after a stone was discharged (with severe colic) six months after operation.

The operation differs according to the stage at which the patient comes under treatment. If no rupture has occurred, as in Thomson's case, the swelling is exposed over its most tender part, and the liver capsule is stitched all round it to the parietal peritoneum. The "biliary abscess" is then opened, and any stones, or, as in our case, necrotic liver tissue, removed. If there has been perforation on the surface, and the contents have been walled off by adhesions, it is sufficient to lay open the cavity. The hæmorrhage may be very considerable, as in our case, and require packing. Generally speaking, however, one finds the operation comparatively simple, and as our case shows, the obstruction may even disappear spontaneously. It affords immediate relief from the pain and dangers of these conditions, and should be borne in mind when occasion arises.

Hirschberg[2] has described a different operation from ours and Thomson's, in which, after the abdomen has been opened and the liver exposed, a trocar is pushed into the liver and its track dilated until it will admit a finger, when the track is packed with a strip of gauze and kept open with a drainage tube. In this simple manner the retention from cholangitis or hypertrophic cirrhosis of the liver can be at once relieved, so that the method is decidedly worthy of notice. One must not overlook the fact that it is chiefly symptoms and not causes which are treated.

(*b*) *Hepatocholangio-enterostomy.* Recommended by Marcel Baudouin and Langenbuch, this operation was first performed by Jordan[3] and Kehr,[4] while Enderlen[5] and Zumstein have described the anatomical conditions from experimental observations. In both cases the patient died. Notwithstanding Kehr's assertion that external biliary fistulæ are followed by all sorts of calamities which can be avoided by making a fistula into the bowel, it is surely better to avoid the still greater calamity of losing the patient.

Kehr restricts the operation to cases where there is definite obstructions due to

[1] "Beiträge zur Chirurgie der Gallenwege," *loc. cit.*
[2] *Berliner Klinik*, Oct. 1902.
[3] *Kongress d. deutschen Ges. f. Chir.*, 1899.
[4] *Centralbl. f. Chir.* Bd. 7, 1904.
[5] *Grenzgebiete*, Bd. 14, 1904.

cicatrices or a new growth, but the more roundabout method suggested by Enderlen is often to be preferred. He first of all makes an external biliary fistula, and subsequently unites it to a piece of intestine (jejunum) which has been pulled up, and lastly closes the skin wound at a third operation.

A two-stage operation must always be taken into consideration in which first of all the dilated bile channels in the liver are opened up and packed, the ends of the packing being left outside (at the same time choice being made of a suitable spot on the under surface of the liver for later union with the bowel). When the shedding of necrotic portions of the liver described by Enderlen and Zumstein has ceased, and cicatrisation and the processes of regeneration are established, the duodenum or jejunum is then sutured to the liver so that the bile may be discharged into the intestine. The suture line is strengthened by stitching the omentum over it.

Greater security is got by making a fistula in the duodenum, into which an absorbable drainage tube is inserted, such as Mayo Robson's decalcified bone drain, which is fixed to the liver at the point of exit of the bile.

From the evidence of Kehr's case it seems to us a mistake to excise the gall-bladder without strong indications, because the bile passages in the liver can be most easily opened through its deeper wall, while one can also utilise the anterior wall for anastomosis with the intestine, as was done by Halsted. A hepato-cholangio-cystenterostomy, to give the operation its full descriptive name, is then possible.

(d) Surgery of the Liver (apart from the Ducts)

114. Surgical Treatment of Cirrhosis of the Liver. Affections of the bile-ducts yield far better to surgical treatment than does disease in other parts of the liver, but it must not be forgotten that most attention has been given to the gall-bladder and larger ducts, while the appearances at autopsies have too often revealed other conditions which might have been dealt with surgically.

This applies specially to certain forms of cirrhosis of the liver, and in particular to the hypertrophic variety. In the atrophic form, thanks to Talma's lead, we have learned to a certain extent how to treat one of the leading symptoms, namely ascites, not, however, always with permanent relief.

In the hypertrophic variety of cirrhosis, especially when associated with jaundice, much better results can be obtained if the operation is done at the right time.

The cause of the hypertrophy is often to be found in chronic biliary congestion. This has been clearly proved (cf. in some of our own cases) where the typical clinical and anatomical changes of hypertrophic cirrhosis have been traced to a circumscribed carcinoma of the bile-ducts. Other cases, *e.g.* those of Cumston,[1] in which the jaundice and ascites disappeared by draining the gall-bladder for three or four weeks, confirm this view. It may be, therefore, made a rule in all conditions of the liver associated with jaundice, in which the jaundice is obviously not due to some inoperable condition, such as cancer of the liver or pancreas, that the chief indication is to relieve the biliary congestion. The method in which this is to be done is decided by an exploratory laparotomy, in which the bile-ducts are exposed in their whole length.

It is obvious that in these cases, just as in obstruction of the common duct with a stone, operation must not be delayed till the changes in the liver are advanced and cholæmia has supervened. The surgery of the bile-ducts has certainly proved that the risks of the operation are attributable to delay and to the development of this type of toxæmia.

A careful examination of the ducts from the hilus of the liver to the duodenum will decide whether the obstruction to the bile is removable, be it a stone, new growth, or cicatrix, within or without the duct. W. Müller[2] has described a case where the only explanation of the ascites was to be found in adhesions in the region of the portal fissure. The condition was cured by operation. The results may be equally good in similar conditions of congestion in the region of the bile-ducts.

If no obstruction is found in the region of the larger ducts, but some doubt

[1] *American Journal of Med. Sciences*, July 1905. [2] Langenbeck's *Archiv*, Bd. 66.

remains, drainage must be carried out, using the most simple method, viz. cholecystostomy. But if one is convinced that there is no such obstruction, the question has to be considered of performing hepatocholangiostomy, *i.e.* draining the bile direct from the liver. We were the first to perform this operation. Hirschberg recommends it in another form for the treatment of hypertrophic cirrhosis of the liver.

The results of Talma's operation in draining away the blood in this way in cases of venous congestion have been most successful.

115. Talma's Operation for Ascites (Cirrhosis of the Liver). The principle of Talma's operation, which was simultaneously recommended by Drummond and successfully carried out by him and Morrison, consists in the formation of a venous communication between the portal and systemic circulations when the former is obstructed (generally due to cirrhosis of the liver, but not necessarily accompanied by an increase of the connective tissue). The chief symptoms are ascites and hæmorrhages, and it is for the relief of the former that the operation is undertaken. Bunge [1] regards hæmorrhage into the alimentary canal as the special indication.

In our previous edition we referred particularly to the works of Friedman and the experimental researches of Tilmann, but since then much has been published regarding the results as well as the indications for, and contraindications to the operation, while much light has been thrown on its method of action experimentally. As a result the operation is now regarded with much more confidence. Koslowsky records 168 cases with 45 per cent of cures, Greenough 42 per cent in 105 cases, Monprofit [2] 70 per cent in 224 operations, of which 35 per cent were permanent. Bunge states that one-third of his cases were cured, while improvement took place in another third. According to Wheeler, the best results are got in cases of hypertrophic cirrhosis of the liver. He agrees with Bunge in regarding icterus as a contraindication. But this view only partially holds good, for when jaundice is present, the most urgent indication is to drain off the bile in one of the ways described in section 114, after which the Talma operation may be performed. Often, however, it may not be required. As already pointed out, operation should not be considered when the patient is in a low state, as the result of disease of the heart or kidneys, or when there is marked atrophy of the liver. The latter condition is recognised by the presence of bile in the urine and by its absence or diminution in the fæces. According to Bunge, a diminished excretion of urea, increased output of ammonia, and the presence of lævulose in the urine, are to be regarded as serious, if not direct contraindications.

Kusnezow, Ito, and Omi have made a careful experimental study of cases in which clinically a good collateral circulation had been established by operation.[3] After omentofixation, the blood in the portal system is chiefly distributed by way of the gastro-splenic and gastro-epiploic veins into the omental veins, and through these into the epigastric veins, reaching the femoral vein *via* the superficial epigastric, the axillary *via* the thoraco-epigastric veins, and higher up by the intercostal and internal mammary veins.

It follows, therefore, that if the spleen be utilised instead of the omentum as the anastomosing factor with the abdominal wall, a more direct anastomosis is provided.

Kusnezow has shown that ligature of the portal vein in animals causes death in spite of omentofixation, because of the insufficiency of the anastomosis below the gastro-splenic vein. It is on this ground that Ito and Omi assert that "epiplopexy is inadequate, and that extensive adhesions among the abdominal viscera as well as with the abdominal wall are essential to success."

Technique. In properly selected cases, either epiplopexy or splenopexy may be performed. As the former is much more simple, it has been more generally used. Splenopexy is performed subsequent to omentofixation, if the latter has not been

[1] *Die Talma-Drummondsche Operation*, Jena, 1905.

[2] *Congrès français de chirurgie*, Oct. 1904.

[3] Cf. C. Wheeler, Talma-Morison's operation, *Brit. Med. Jour.*, Oct. 1905, with autopsies; *vide* also Prisson, *Deutsch. Zeits. f. Chir.* Bd. 75.

successful. We have had several excellent results from the latter operation. It is far the least dangerous operation if properly performed.

(*a*) *Exo-epiplopexy and simple Epiplopexy.* An incision is made in the middle line above the umbilicus, after which the steps of the operation differ according as to whether one wishes to establish extra- or intraperitoneal adhesions. The simplest method is that recommended by Narath [1] in which the omentum is sutured underneath the skin. For this purpose a pocket is made on the left side with a blunt instrument or a finger protected by a sterile rubber glove, and into this a piece of omentum is stitched. Narath has demonstrated the early appearance of the anastomosing branches between the subcutaneous veins and the imbedded omentum.

Subserous implantation has also proved satisfactory. The fascia of the linea alba is split and a suitable pocket is made on the left side external to the peritoneum. According to Schiassi, Tieschi, and Pascale, the extraperitoneal is more reliable than the intraperitoneal fixation.

The parietal peritoneum is then incised and the omentum pulled through, dragging on the transverse colon being avoided.[2] The portion of omentum that has been pulled through is then stitched all round to the edges of the opening in the peritoneum, or even the deep fascia with interrupted sutures, without constricting it. The fascia and skin are then carefully sutured. No drainage.

The ascitic fluid should be drawn off (aspirated) by means of a long glass tube passed down into the flanks and into the pouch of Douglas. There is a risk in using a permanent drain, as unless the after-treatment can be carefully carried out, it may be the means of introducing sepsis. It is better to puncture the abdomen repeatedly.

Instead of the exœpiplopexy described, epiplopexy can be performed by simply suturing the omentum to the parietal peritoneum without making a pocket for it outside, or by fixing the omentum in the space between the liver and the diaphragm. Guillot and Courbet have employed this method with success. Not only does it drain the portal system in the liver, but it provides fresh communicating vessels with the nutritive system of the hepatic artery. The advantage of fixing the omentum inside the abdomen is that there is less chance of a hernia resulting. Hernia is avoided in exœpiplopexy by means of careful stitching and by selection of a piece of omentum which has a good vascular supply, and which is not too large. Equally good results are got by roughening and scraping the surface of the liver, spleen, omentum, and intestine, and establishing adhesions by these means.

(*b*) *Splenopexy.* Splenopexy is undertaken when omentofixation has either failed or has not been practicable. The spleen is brought out through an incision along the costal margin, and according to Rydygier and Bardenheuer, is then either entirely or partially fixed, according to its size, in a pouch between the parietal peritoneum and the muscles. When there is difficulty in pulling it forward sufficiently, Depage, Franke, and Schlange advise cutting out a flap of muscle and peritoneum, and suturing the spleen to it.

Splenopexy cannot, therefore, be undertaken as a routine operation, for if the spleen is small and situated high up, its fixation is both difficult and uncertain (in one of Bunge's cases the spleen became free again).

Another method of draining the portal system worthy of consideration is by means of Eck's fistula, which consists in directly anastomosing the portal vein and the vena cava. According to Tansini [3] the portal vein and vena cava are exposed and temporarily clamped, with rubber-covered clamps: the former is cut across and the distal end inserted into a lateral opening in the vena cava to which it is sutured with continuous silk (termino-lateral anastomosis). Animals so treated have remained well for months.

Vidal performed the operation on man. The patient lived four months, but subsequently succumbed to acute pyæmia.

116. Hepatopexy. Fixation of the liver may be indicated for the relief of

[1] *Centralbl. f. Chir.* Bd. 32, 1905.
[2] In one of Franke's cases kinking of the colon occurred.
[3] *Centralbl. f. Chir.*, 1902, No. 36.

symptoms, *e.g.* pain, in such conditions as ptosis or floating liver. According to Böttcher,[1] hepatopexy was first performed in 1887 by Michel, in 1890 by Langenbuch, and in 1891 by Gérard-Marchant. In 1900 Böttcher was able to collect 23 reported cases.

When the liver is pushed down as a result of tight-lacing, the operation is quite easy. According to Riedel, if an enlarged gall-bladder is at the bottom of the trouble, cholecystostomy should be performed. In 1884 Billroth performed the first hepatopexy for partial ptosis of the liver of this type. Amputation of the pendent lobe practised by Langenbuch is a radical measure. Simple hepatopexy is intermediate between the two.

Technique. We employ the oblique incision two fingers'-breadth below the costal margin described in the chapter on surgery of the gall-bladder. Langenbuch, Ferrari, Franke, and also Poppert (according to Böttcher) employ this incision.

It must be large enough to allow one to get a good view of the parts, so that one may not be hampered for room in inserting the sutures. In this respect the angular incision already described is to be recommended. With the patient in a sloping position, and if necessary the head dependent, the liver is pushed up into its proper position, and a suitable spot on the parietal peritoneum selected for fixation. The liver is then allowed to slip down again, and two, three, or possibly more sutures are inserted above the upper end of the wound through the parietal peritoneum and deep fascia.

If there are fibrous changes on the surface of the liver, as are found after tight-lacing, these are taken advantage of for fixing sutures. One end of the suture is now thread on a fine curved needle, and passed through the surface of the liver at the desired spot and tied to the other end, the liver, at the same time, being held in the proper position with the patient's head lowered. We use silk exclusively for this purpose and consider catgut a mistake. It is important to insert gauze packing as well as the stitches, as it promotes strong surface adhesions (Langenbuch, Franke, Tascherning, and Poppert). We use strips of xeroform gauze wrung out of 5 per cent carbolic lotion laid between the stitches on the convex surface of the liver. This is the same principle as is employed in nephropexy, and not only does the gauze produce adhesions, but it also forms firm scar tissue round the incision which supports the replaced liver. The packing should not be removed for 8 to 14 days. The wound is completely sutured up to where the gauze is inserted.

In complete prolapse of the liver associated with a general visceroptosis and a lax abdominal wall, one has a choice between Legueu's method, in which the liver is suspended by means of strong looped sutures which include the whole thickness of the organ, and which hold it up as it were in a sling, or Péan's method, which consists in making an artificial diaphragm out of peritoneum below the liver, or lastly Depage's method of excision of the abdominal wall and closure by sutures.

117. Liver Abscesses and Cysts (Echinococcus). No further description is necessary of the treatment of an abscess or cyst of the liver accessible from the front or back by laparotomy. After division of the soft parts, one can either, if the liver is not adherent, wait until adhesions are formed, *i.e.* operate in two stages, or, as is usually done, isolate the area to be incised by means of a circular continuous suture which unites the visceral and parietal peritoneum.

Special measures have to be taken in opening cysts on the convex surface of the liver by way of the thorax—transthoracic laparotomy. For a description of this operation see Section 86, page 502.

118. Resection of the Liver. As the results of immediate laparotomy for injuries of the liver associated with severe hæmorrhage have shown that recovery can follow widespread lacerations of that organ, surgeons need no longer hesitate to carry out extensive resections. Out of 543 cases collected by Elder[2] in 1887, the death rate was 66·8 per cent, while according to Thöle's figures (399 cases) it is only 39·8 per cent.[3]

[1] Böttcher, *Über Hepatopexie*, Leipzig, 1900. [2] Langenbeck's *Archiv*, Bd. 34, 1887.
[3] *Deutscher Chirurgenkongress*, Berlin, 1906.

Nötzel[1] has published a case in which the "right lobe of the liver was almost torn in halves," and Wilms reports a case of complete separation of the left lobe where recovery followed suture and plugging. G. Costa[2] reports success in a similar extensive injury.

Thöle reckons the real mortality as only 16·8 per cent out of 148 resections of the liver.

Keen, who has three times successfully excised tumours of the liver, and who has great faith in this operation, quotes the cases collected by Cushing and Down, viz. seventy-six, with a mortality of only 14 per cent. These cases included twenty hydatid cysts, seventeen carcinomata, and twelve syphilitic tumours. In his last case Keen removed a large part of the left lobe of the liver. As a rule the operation was performed when a tumour was present which could be shelled out, or when a diffuse tumour had developed either in a pendent lobe or at the margin of a normal lobe, for example in carcinoma of the gall-bladder involving the liver tissue.

The deaths which have occurred in cases of resection of the liver were nearly all due to hæmorrhage and shock. Keen only mentions three cases of embolism and sepsis. One of our cases died as the result of a secondary prolapse of intestine.

Arrest of hæmorrhage is therefore the key to the operation. There are a number of experimental studies bearing on the subject, namely, by Kusnetzow, Pensky, and Auvray, and propositions by Cecherelli, Bianchi, Segale, and others. It is not possible to lay down general rules, as the cases are so diverse.

The result of the very thorough experiments by Kusnetzow and Pensky may be considered established, viz. that the large veins in the liver tissue can be satisfactorily ligatured separately by passing a stitch round them. In removing the left lobe of the liver, Keen successfully arrested the hæmorrhage from these large vessels by means of five ligatures. As he divided the tissues severe hæmorrhage occurred, whereupon he put his finger on the lumen of the open vessel, passed a needle threaded with catgut round it, and had the ligature slowly tightened by an assistant.

Parenchymatous hæmorrhages from small vessels can, as a rule, be safely and permanently arrested by plugging. But in spite of this, it is quite possible that before the tampons can be properly secured in position, a very severe hæmorrhage may occur as the liver tissue is being divided.

In order to be sure that the operation before its close shall not lead to an exhausting loss of blood, it is well to sever the liver with the thermo-cautery, always keeping the fact in view that the instrument must be allowed to act very slowly and at a dull red heat. Keen, who has been very successful with his cases, employed the thermo-cautery when he was unable to perform simple enucleation. A method of arresting hæmorrhage which we use, and which is well adapted to some cases, is the application of pressure-forceps. We used the large powerful pressure-forceps which we employ for resection of the stomach. In a case of carcinoma of the right lobe of the liver along with carcinoma of the gall-bladder, it was found by careful examination that the condition of the parts was very suitable for operative interference. The gall-bladder was distended ; the cystic duct could be isolated, ligatured, and divided. On the liver a typical carcinoma nodule with depressed centre at once presented in the wound. Firm adhesions on the under surface led to injury to the serous membrane, which resulted in serious venous hæmorrhage. This was arrested by tampons. In spite of the great thickness of the right lobe, which was in no way divided from the rest of the liver, but was greatly elongated, we put on a pair of large forceps behind the nodule, closed them tightly, and so crushed the liver tissue. The forceps kept their place very well, and stood the strain perfectly. The liver, together with the gall-bladder, was simply cut away with a knife close up to the forceps.

The forceps were kept on for forty-eight hours, and were then removed without any hæmorrhage. On the grounds of this experience we can recommend the use of such forceps, and we advise that they be closed as tightly as possible, for though the liver tissue is friable the serous covering is very tough.

The forceps are therefore of great service, although they have the great disadvantage that if left *in situ* it is very difficult to approximate the edges of the wound

[1] *Beitr. z. klin. Chir.*, Tubingen, 1906. [2] *Policlinico*, 1905.

exactly, and, consequently, if vomiting occurs a prolapse of the gut is apt to result. This happened in two of our cases, once without ill effect, but once with a fatal result. The peritoneum and fascia must, therefore, be closed in spite of the presence of the forceps, and the latter should be removed through the smallest gap possible. Or the forceps may be replaced, as in the case of the stomach, by a mattress suture inserted behind them, and, if necessary, a continuous suture over all. If, in the use of the thermo-cautery, care be taken to make the gap wedge-shaped a few serous sutures may be put in. The after-treatment consists in packing with xeroform gauze (without exception when an exposed wound surface is left) for forty-eight hours, and a drain must be introduced on account of the escape of blood and the outflow of bile. The peritoneum and fascia must be carefully sutured.

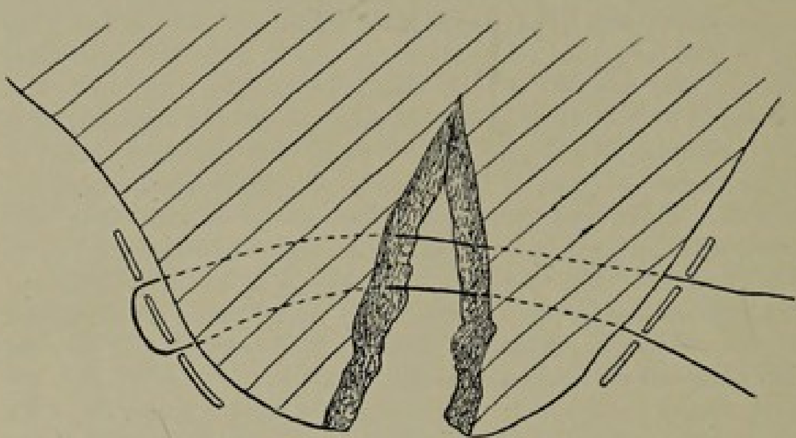


FIG. 323.

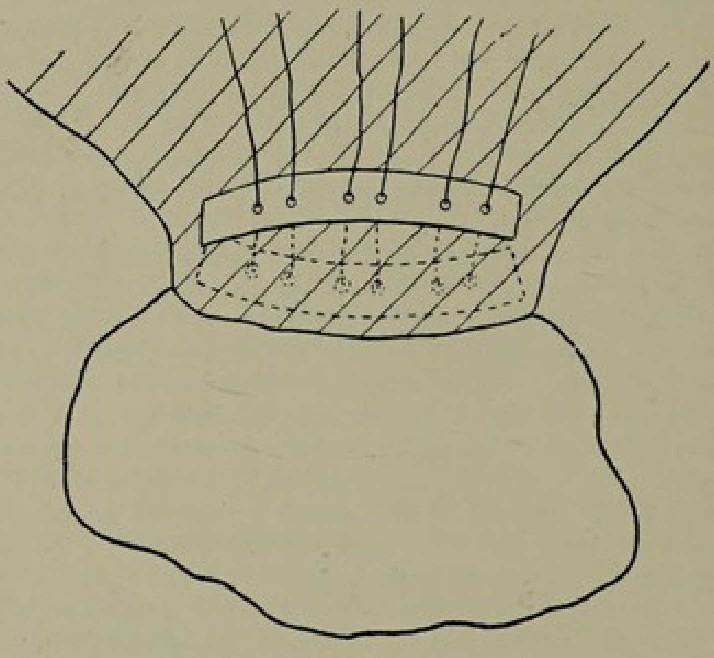


FIG. 324.

As it is desirable that the abdominal wound should be closed for fear of complications, it is better to employ some means of arresting hæmorrhage which can be buried in the organ, rather than use forceps. Payr and Martina [1] have investigated this matter experimentally, and Thöle [2] has reviewed the literature on the subject.

B. Müller [3] has shown that the oozing that takes place during the division of the liver can be controlled by injections of adrenalin (1 in 1000 to 1 in 10,000 in saline) as well as by the thermo-cautery. By making a sufficient area anæmic no bleeding occurs, while the larger vessels can be clearly seen, temporarily clamped, and subsequently ligatured according to Kusnetzow's method.

At the same time both temporary and permanent control of the vessels can be got by "ligature *en masse*." The ligature is tied tightly so as to cut its way through the friable tissues as far as the vessels. It appears to us to be a suitable and more certain method of employing the ligature *en masse*, to apply one ligature after another and to tie them in the course of the removal of the portion of liver or tumour. This does not exclude the ligature of isolated vessels for greater security, as they become visible in the incision.

[1] *Kongress d. deutschen Ges. f. Chir.*, Berlin, 1906.
[2] *Cod. loco.*
[3] *Munch. med. Wochenschr.*, 1904, s. 526.

The "plate-sutures" used by Cecherelli, Cernezzi, Segale, Beck, and Bianchi, act in an analogous way to ligature *en masse*. From numerous experiments on animals, Payr and Martina have found magnesium plates the most reliable, as they stimulate the formation of new connective tissue, and become entirely absorbed in a few weeks.

Figs. 323 and 324, taken from Payr's paper in the *Centralblatt*, give a sufficient idea of the method. One disadvantage connected with the use of plates is that if the sutures are pulled too tight necrosis is apt to occur, which may give rise to complications, especially of an embolic type (pneumonia). And although the good results obtained in animals by Payr and Martina cannot be doubted, we might point out that the necrosis which occurs from the use of plates is more serious than that produced by "ligature *en masse*" because the former remain embedded in living tissue, which is not the case with the latter method.

If possible, the portion of liver excised should be wedge-shaped, whichever method is adopted to arrest the bleeding, so that the peritoneum may be completely united by sutures. The latter sutures should be silk, while the material in ligature *en masse* should be absorbable catgut.

If the peritoneum cannot be completely brought together, a strip of xeroform gauze wrung out of carbolic is placed on the line of suture, and one to three drainage tubes are inserted between the stitches in the abdominal wall down to it.

119. Ligature of the Hepatic Artery and Portal Vein. In view of the increasing number of extensive operations now undertaken in the region of the hilum of the liver for disease of the bile-ducts, duodenum, and pylorus, it is well to know what measures one should adopt in case of injury to the portal vein or hepatic artery. If a lateral ligature cannot be applied to a tear in the vein, there is no choice but to plug the wound. Death does not necessarily result, and several cases have been reported in which very severe bleeding about the hilum of the liver has been arrested by plugging.

Experiments on animals have shown that it is possible to divide the vein, ligature the central end, and implant the peripheral end into the vena cava (Tansini). But to what extent this can be carried out in man (Eck's fistula) remains to be seen.

Hitherto an accidental injury necessitating ligature of the hepatic artery during a difficult excision of the pylorus has proved fatal from necrosis of the liver. Kehr, however, successfully applied a proximal ligature in the case of an aneurysm of a branch of the hepatic artery which had perforated into the gall-bladder.

Kehr mentions Mester, Langenbuch, Ehrard, and Hausson's work, and recently Haberer has repeated Cohnheim and Litten's experiments, which show that it is possible to ligature the trunk of the hepatic artery, as a collateral circulation is established by the gastro-duodenal and right gastro-epiploic arteries.

If, on the other hand, the hepatic artery is tied below the point where these branches are given off, necrosis of the liver as a rule sets in. Necrosis will also occur if the hepatic is ligatured after the arteries of the stomach have been divided, *e.g.* in pylorectomy.

According to Kehr's experience necrosis need not follow ligature of the hepatic artery if the circulation has been affected by the formation of an aneurysm. In this case, as mentioned by Langenbuch and demonstrated by Haberer, a collateral circulation is formed between the phrenic arteries through the coronary ligaments and the capsule of Glisson.

In regard to the technique, just as in a difficult case of exposure of the bile-ducts, it is absolutely essential to have plenty room (*vide* the angled incision in Fig. 320). The liver is then turned upwards, the duodenum and gall-bladder put on the stretch, and the hepato-duodenal ligament brought into view, with the artery, portal vein, and bile-duct (or hepatic duct) lying together.

(e) Surgery of the Pancreas

120. General Remarks. Pancreatic surgery has developed in two directions: firstly, in the prevention of the dangers associated with the escape of pancreatic

secretion (fat necrosis) in injuries or disease of the organ; and, secondly, in preventing the effects of disease of the pancreas on the flow of bile and the intestinal contents by operations on the bile system or alimentary canal.

The difficulty in diagnosis is the chief obstacle to success in the operative treatment of pancreatic disease, especially as most of the latter conditions, *e.g.* injury and inflammation, require prompt interference. Taking into account, however, the immediate danger to life the results are brilliant, but, unfortunately, we know that many patients are allowed to die from ignorance that such conditions can be cured.

On the other hand, some surgeons go too far in regarding as an operation on the pancreas every case in which, during the removal of disease in the bile-ducts or the pylorus, small portions of the pancreas are either cut away with the knife or separated with the finger. This is surely only a complication of the original operation —an important one perhaps—as every injury of the pancreas calls for plugging and drainage to secure removal of pancreatic secretion.

121. Operations for Secondary Disease of the Pancreas and Palliative Operations. Mayo Robson[1] has furnished some very valuable observations on the variations that exist in regard to the manner in which the pancreatic duct opens into the duodenum. They are important as showing how the pancreas may be affected by disease of the bile-ducts and *vice versa*.

In general (90 per cent, Opie) the bile-duct and duct of Wirsung open separately into the ampulla of Vater. An impacted stone or an inflammatory swelling in this situation will therefore necessarily react on the pancreas or *vice versa* the liver. In the rarer cases where the openings are distinct this is not so. The different relation of the common duct in its pancreatic portion is of importance, for in two-thirds of the cases it is enveloped by the pancreas, and in one-third runs alongside it.

In a few cases the duct of Santorini, which has a separate orifice, is so large that it can take the place of the duct of Wirsung.

Considering these relations, we can easily understand how readily the pancreas may be involved in diseases of the bile-ducts, and especially in cholelithiasis and its complications. The majority of cases of pancreatitis, whether slight or severe, chronic or acute, can be referred to this origin, and therefore must be treated by removing the cause. Removal of gall-stones from the pancreatic and intraparietal portions of the common duct, combined with thorough drainage of the infectious bile for a sufficient period, are therefore the principal methods of treating diseases of the pancreas.

Chronic and acute catarrh of the pancreas of mild or severe suppurative types can be cured by these measures, and their consequences can be avoided, namely, suppurative interstitial pancreatitis with formation of abscess, hæmorrhagic, necrotic, and gangrenous pancreatitis, and atrophy and cirrhosis of the pancreas (with diabetes). Mayo Robson, in his *Hunterian Lectures*, called attention to the possibility of suppurative pancreatitis arising as a result of cholelithiasis in the same manner as suppurative cholangitis and liver abscess. He believes that pancreatitis as a rule exists in all cases where there is a stone in the intraparietal and pancreatic portion of the common duct associated with inflammation.[2]

Technique. For the method of treatment of diseases of the bile-ducts leading to pancreatitis, reference may be made to the chapter on surgery of the bile-ducts. In all cases where there is associated disease of the pancreas, the pancreas must be made accessible for examination and must be pulled forward. A long oblique incision or the angular incision is used, and the duodenum is mobilised provided this is not impossible on account of adhesions.

The question whether simple cholecystostomy, or, as Körte advises, cholecystenterostomy is to be performed, in cases of biliary congestion and inflammation of the bile-duct, must be determined by the local condition and the general state of the patient. Mayo has demonstrated that very good results can be obtained by the much more simple method of forming an external biliary fistula.

[1] Address in Surgery, Canada Med. Association, Aug. 1904.

[2] Robson lays great stress on a "pancreatic reaction" in the urine discovered by himself and Cammidge for the diagnosis of disease of the pancreas, *Lancet*, March 14, 1904.

In cases where the duodenum is displaced by pressure, gastroenterostomy, according to the rules given in the chapter on that subject, is called for.

122. Intrinsic Operations on the Pancreas. (*a*) *Exposure of the Pancreas for injury.* Mikulicz has collected 45 cases of injury to the pancreas, and the reports show that, compared with the great danger to life of expectant treatment, operative interference gives very good results.

A middle-line incision is advisable, for one can never be sure that other viscera, and more especially the stomach and intestines, may not be involved as well.

The gastro-colic omentum is separated [1] and the lesser peritoneal sac opened, in the floor of which the pancreas lies covered by the parietal peritoneum of the posterior abdominal wall. Injuries are best dealt with by careful suture with strong catgut to arrest the bleeding and prevent the escape of pancreatic secretion, after which a cigarette drain is passed down to the gland. In Küttner's case the pancreas was almost completely torn across.

(*b*) Cysts are by far the commonest affections of the pancreas for which operation is undertaken. When they project forwards in the middle line between the stomach and colon they are readily diagnosed, but when they are located in either the head or tail of the gland, their recognition is by no means easy. They are usually of considerable size and can be exposed without difficulty.

The routine treatment should consist merely in incision and drainage. To do this, the abdomen is opened above the umbilicus over the most prominent part of the swelling, if possible in the middle line, but sometimes the incision has to be made at the outer border of the rectus, especially on the left side. The operation Gussenbauer described in 1882 is easily performed.

After opening the abdomen, access is got to the cyst either through the gastro-colic ligament, the lesser omentum, or the great omentum below the transverse colon, depending on its situation. The cyst wall, which is covered by the peritoneum of the posterior abdominal wall, is then firmly sutured to the parietal peritoneum and fascia by means of a circular stitch, after which it is opened and washed out with sterile saline lotion. The operation may be carried out in two stages, the opening of the cyst being deferred until the third day. If the cyst is very tense it is a good plan to puncture it, and aspirate part of the fluid.

By operating in two stages there is no risk attached to opening the cyst except the possibility of hæmorrhage from the cyst wall. This is an important point, as the secretion contained in the cyst may erode the edges of the wound. Leakage may take place through the stitch holes, and if this happens the cyst must be incised at once. The opening should just be large enough to admit a long drainage tube, which should reach down to the bottom of the cyst.

The larger incision that Delagenière employs has the advantage that it allows one to palpate the pancreas from the inside of the cyst, which may lead to the detection of other cysts, new growths or calculi, the removal of which will result in a radical cure. It is attended, however, with greater risk from the escape of the contents and from the accumulation of blood inside the cyst. Of course if the original cause of the trouble is not removed (*e.g.* obstruction of Wirsung's duct by stone, etc.) mere incision of the cyst leads to a permanent fistula.

Drainage through the loin is more difficult and unnecessary. A fistula forms as readily if the primary cause is not removed, while a cure can be obtained just as well by anterior drainage. The only advantage that drainage in the loin possesses over drainage in front is that the sinus track is considerably shorter.[2]

Excision of Pancreatic Cysts. Of 21 operations collected by Körte [3] 7 were incomplete, 6 died, and 15 recovered. In undertaking the excision of a cyst, one has

[1] Going through the gastro-hepatic omentum above the stomach does not give such easy access to the head of the pancreas since one dare not divide the "hepato-duodenal" ligament. It is only in cases of gastroptosis that it is a proper and direct route.

[2] Moynihan quotes Takayasu's collection of 64 cases with 8 deaths, and Körte's larger statistics of 84 cases with 5 deaths.

[3] *Deutsche Chirurgie*, bei Enke, Stuttgart, 1808.

to convince oneself first of all that it is possible to separate it from its deep connection with the pancreas. For this purpose the cyst must be incised and carefully examined from within. It is also important to decide whether it is attached to the body or to the head of the pancreas. Cysts in the latter situation cannot, as a rule, be separated.

Mikulicz's case recovered, notwithstanding that he had to ligature the splenic vessels. Special care must be taken to avoid injuring the superior mesenteric artery and vein. The cyst is separated from the pancreas, and the cavity plugged or sutured, and a drain of gauze passed down to the sutures. Ligature *en masse* should be avoided, and if the pedicle is large it is better to suture it.

(*a*) *Extirpation of Solid Tumours of the Pancreas.* The pancreas is reached by dividing the gastro-colic ligament, and turning the stomach upwards and the transverse colon downwards. It lies behind the peritoneum on the posterior wall of the abdomen in the bottom of the wound. Excision can only be attempted in the case of a circumscribed tumour; diffuse and adherent tumours cannot be removed.

The first successful case was published by Trendelenburg in 1882. Körte collected ten cases, of which six recovered, while Moynihan has collected 13 cases. The tumour is removed from its situation in the body or head of the pancreas and the cavity dealt with by ligature or suture. The subsequent treatment is the same as for cysts.

The treatment of acute and especially of hæmorrhagic pancreatitis is of much greater importance than the excision of pancreatic tumours, most of which are discovered accidentally as the result of errors in diagnosis.

Surgical Treatment of Acute Pancreatitis. In 1898 Körte collected 7 cases in which operation had been undertaken for pancreatic abscess. Of these 4 recovered, but since then other cases have been published. They are dealt with in the same manner as that described for tumours, the abscess cavity being cauterized (for which purpose we recommend swabbing out the cavity with 5-10 per cent carbolic acid in alcohol), packed with gauze, and drained.

In 1898 Körte had no definite treatment for acute hæmorrhagic pancreatitis. Mikulicz,[1] however, has described the results of operation in 75 cases, which included other varieties than the hæmorrhagic form. At the French Surgical Congress in 1905 Garre reported seven recoveries out of eleven cases operated on. Mayo Robson in 1904 advocated operation for acute pancreatitis for reasons similar to those governing the treatment of gangrenous appendicitis, to stop bleeding and drain septic exudate.

He has operated on five patients, three of whom recovered, and knows of 59 acute cases with 23 recoveries. Unless operation is resorted to immediately death as a rule follows. The diagnosis is made from acute epigastric pain, severe vomiting, collapse, and signs of intestinal obstruction. Operation should be undertaken in the first twenty-four hours, so as to avoid extensive fat necrosis and secondary peritonitis.

Technique. When there is severe collapse the operation merely consists in exposing the pancreas with as little interference as possible, and evacuating the exudate. The pancreas may also be incised. In Muspratt's case it was of a deep purplish red colour and acutely distended. The bleeding was arrested by ligature.

An incision of medium length is made in the middle line and the gastrocolic ligament, or occasionally the transverse mesocolon is divided. Moynihan prefers the access through the lesser omentum (gastro-hepatic omentum). The diagnosis is confirmed, according to Moynihan, by the presence of yellowish white spots of fat necrosis in the omentum along with a blood-stained serous effusion. Ample drainage must be provided on account of the collapse. Although it prolongs somewhat the operation, incision of the pancreas is very desirable. In 37 cases where incision was practised 25 recovered according to Mikulicz;[2] while of 42 which were merely drained only 4 recovered (Moynihan). Gauze surrounded with rubber tissue (a large cigarette drain) is the best form of drainage to employ.

When pus has already formed, Mayo Robson emphasises the importance of inserting a tube through the loin in the costo-vertebral angle. The pancreas can be examined from this point with the finger. Suppuration either above or below the liver

[1] *Annals of Surgery*, May 1903. [2] *Ibid.*, July 1903.

must be dealt with by appropriate incisions and drainage, and if there is obstruction to the bile, cholecystostomy must also be performed.

Pancreolithotomy and Wirsungo-duodenostomy. When the stone does not occupy the terminal portion of the pancreatic duct, it should be cut down on by an incision through the substance of the gland. After removal the opening is closed with catgut sutures and the wound drained. Robson has performed this operation, and Moynihan cites cases by Pierce Gould, Dalziell, and Allen.

Moynihan [1] and Robson have both performed wirsungo-duodenostomy for a stone impacted in the duct of Wirsung. In Mayo Robson's case a longitudinal incision was made through the rectus, the bile-ducts, pancreas, and duodenum were exposed, and the duodenum opened. The ampulla of Vater was then incised and the stone removed with a scoop. Beyond closing the wound in the duodenum the operator employed no sutures. Drainage. Uneventful recovery.

(f) Surgery of the Spleen

123. Splenotomy and Splenectomy. The spleen may be incised to open an abscess and for the purpose of transplanting the thyroid (Payr). It is not always easy to reach the spleen through a small incision, as we have repeatedly found when transplanting the thyroid. It is certainly not advisable to make a large incision, such as is suitable for extirpation of the spleen.

A suitable short incision is one extending from the costal margin downwards along the outer border of the rectus, otherwise we condemn it on account of the division of the nerves. If this does not give much room, *i.e.* if the spleen does not come up when the fundus of the stomach is pulled upon, and it is found necessary to insert the hand to pull up the spleen on account of adhesions or of its deep situation, a transverse incision may be combined with it running obliquely upwards and outwards from its lower end. This incision may be made by splitting the muscles without dividing their fibres transversely.

Apart from enlargement of the spleen due to malaria, simple hypertrophy, Banti's disease, etc., for which special text-books must be consulted, the chief conditions for which splenectomy is performed are injuries, tumours, cysts, and especially sarcoma.

Injuries of the spleen [2] demand excision of the gland. No evil effects follow its removal, while the danger of hæmorrhage is effectually stopped. In a report on six of his own cases [3] Noetzel points out that as injuries of other viscera are so commonly associated with injuries of the spleen, it is advisable to employ an incision in the middle line.

If this does not give sufficient room an incision should be carried from the lower end of the wound transversely outwards through the rectus, and if necessary the broad abdominal muscles. In the case of the latter muscles the incision will be more or less in the direction of their fibres, and will not produce much injury to the muscles themselves or to the nerves going to supply the rectus.

An angular incision similar to that we recommended for exposing the bile-ducts should always be employed if the spleen is much enlarged or deeply placed; for, as we pointed out before, it is a more rational incision than one along the outer edge of the rectus, or one which necessitates longitudinal separation of the muscular fibres. The wound after suture is quite strong and there is no danger of the muscle becoming atrophied.

If there are many adhesions, an oblique incision along the costal margin—similar to that used for liver operations—can be used with advantage, along with resection of the ribs in the manner recommended by Vanverts and Auvray. A more simple procedure than that of resecting the eighth, ninth, and tenth costal cartilages is to fracture or divide the ribs and turn backwards the costal margins as a flap (Marwedel).

The presence of adhesions requires that the incision is well planned and of sufficient

[1] *Abdominal Operations*, London, 1905.
[2] Cf. Edler, Langenbeck's *Archiv*, Bd. 34, and Berger, *ibid.* Bd. 68.
[3] *Beiträge zur klinischen Chirurgie*, Bd. 48.

size. Omental adhesions can be easily divided between two ligatures. The pedicle should be early exposed and the vessels in the gastro-splenic omentum (splenic artery and vein and vasa brevia) ligatured if possible. If the artery, vein, and smaller vessels can be isolated and ligatured separately, it is preferable to do so, but one is often glad to ligature or clamp them *en masse*.

Among the normal ligaments and means of fixation other than the connection with the stomach, mention must be made of the phrenico-lineal ligament to the diaphragm and kidney. Division of this frees the spleen from its posterior connections.

W. Jebson and F. Albert[1] have collected thirty-two cases of malignant tumours of the spleen. Of these twelve were operated on, eleven cases being of total extirpation. Eight recovered and four remained well at the time of publication.

124. Rydygier's Splenopexy. Splenopexy is undertaken for floating spleen and in Talma's operation for the cure of ascites (biliary congestion).

Sutures should not be passed through the substance of the spleen, as they cut through very easily and may give rise to hæmorrhage.

Adhesions are procured most readily by Kouwer's method, in which the spleen is exposed and the wound packed with gauze.

Rydygier's operation is the typical one. The parietal peritoneum is incised, and a pocket is formed by stripping it off the abdominal wall into which the spleen is placed (Bardenheuer) either entirely or partially. The spleen then occupies an extraperitoneal position. This exosplenopexy is comparatively easy where the spleen can be pulled well forward, *e.g.* floating spleen, and can be conveniently carried out through an oblique incision along the costal margin. If the spleen is not movable, a more extensive division and separation of the parietal peritoneum is necessary through a longer incision nearer the normal position of the spleen.

(g) Surgery of the Stomach

125. General Remarks. In an address delivered in 1904, Mikulicz emphasised the important position the physician occupies in regard to modern gastro-intestinal surgery, and it is a gratifying fact that in recent years practitioners are coming more and more to recognise that a large number of affections of the stomach can only be cured by mechanical or surgical measures. Formerly the majority of chronic affections of the stomach were indiscriminately regarded as chronic gastric catarrh; now, however, it is realised that the catarrh is not a primary condition, but is the result of purely mechanical causes, especially stasis of the contents and difficulty in emptying the stomach. Credit for this discovery is due to those physicians who recognised the mechanical value of the stomach tube. In place, however, of the inconvenience and only partial benefits of gastric lavage, surgical measures now provide a rapid and certain cure.

By far the greatest number of the operations on the stomach are now directed towards establishing proper mechanical relations, and most prominent of all is the operation of gastroenterostomy, which was evolved in so brilliant a manner by Wölfler from an idea of Nicoladoni's. It cannot be denied that occasionally surgeons have been led away by the brilliant results obtained, and have undertaken it on insufficient grounds. But at the present time it is a more serious fault to allow patients to drag along for years with ineffective medical treatment when an operation alone can afford a certain and rapid cure.

Even more important than the failure to appreciate the necessity for restoring the mechanical relations in many cases of so-called gastric catarrh, is the fact that the overwhelming majority of gastric tumours, especially cancer, are as a rule treated in the first instance as gastric catarrh with the result that valuable time is lost.

As will be shown later, the results of the radical treatment of cancer of the stomach prove that in many cases early diagnosis only is needed to avert the melancholy effects of the disease and to enable a cure to be obtained by resection of

[1] *Annals of Surgery*, July 1904.

the stomach. This point will only be realised when the profession has learnt definitely that catarrh of the stomach is a secondary condition. If the primary cause is not to be found in chemical or other injurious agents, such as alcohol, irregularities of diet, etc., or in some general disease, which has an indirect influence on the gastric functions, then some mechanical cause or the presence of a new growth must be suspected and a thorough examination undertaken with this in view.

In comparison with these two principal operations, gastrostomy, gastropexy, and gastroplasty, etc., are of secondary importance.

126. Gastroenterostomy.[1]—*General Directions.* Apart from being the most frequently called-for operation on the stomach, gastroenterostomy is of the greatest value in restoring alimentation when the patient has been greatly reduced under medical treatment. It has achieved its greatest triumph in the treatment of simple gastric ulcer and its sequelæ, but at the same time it is a valuable makeshift in the treatment of cancer where radical operation is no longer possible. It must be admitted, however, that in this connection, many of the brilliant results recorded, where there has been complete restoration of health for years, leave room for the suspicion that the original tumour had been mistaken for cancer.

The results in the treatment of simple ulcer give the best index to its value. Our own statistics have been recorded on three occasions.[2] In 92 cases where gastroenterostomy was performed for non-cancerous affections we have only had three deaths, none of which could be directly attributed to the operation; two were due to hæmorrhage from the ulcer (one from erosion of the splenic artery, and one from a duodenal ulcer) and one was due to pneumonia. In the last case alone can the result be associated with the operation. Both the other patients would have died sooner or later without operation (possibly later), while the patient who died of pneumonia was in an extremely reduced condition, and was the subject of arteriosclerosis, atrophy of the heart, and pulmonary tuberculosis. The mortality may thus be considered as 1 per cent.

There is no danger in the operation itself; it is only from general or local conditions that complications are to be feared. One cannot guarantee that there will be no subsequent bleeding from the ulcer; one of our cases succumbed from a subsequent hæmorrhage. There are other post-operative conditions which may also give rise to danger or prejudice recovery. Apart from hæmorrhage, these may be regarded under two heads—(1) symptoms of regurgitation, described under the general term "vicious circle," varying from slight nausea and vomiting to symptoms of ileus; (2) the development of peptic ulcers in the loop of intestine connected with the stomach.[3] At the same time we should mention the possibilities of volvulus and internal hernia after a posterior gastroenterostomy. Moynihan reports 4 cases of the latter condition.

These complications must be prevented at the operation. We have had to open the abdomen again on six occasions for more or less severe degrees of vicious circle, and three times for peptic ulcer. In every case, however, the patient recovered. But although the damage may be repaired by a new correct operative interference, it is better to prevent it at the outset.

To Roux belongs the credit of having established the real principle by which the vicious circle is to be prevented. Essentially it consists in ensuring that the contents of the upper loop of intestine empty into the lower, when it will not matter if some of the gastric contents pass through the pylorus into the upper portion of the gut, or *vice versa* if some contents escape from the newly-formed opening into the upper end. Peristalsis can always be relied upon to empty the bowel from above downwards. It is only when the contents of the proximal loop cannot empty into the lower that

[1] The reader is referred to Krönlein's paper and the subsequent discussion at the Surgical Congress at Berlin, 1906, the discussion at Surgical Congresses in other countries, and at the Congress of the International Society of Surgery in Brussels, 1905.

[2] Kaiser, *Deutsche Zeitschr. f. Chir.* Bd. 61; Humbert, Dissertation, Bern, 1902; Gilli, *ibid.*, 1907.

[3] Von Braun first drew attention to the relative frequency of peptic ulcer. Since then Brodnitz has collected 14 cases, Tiegel 26, Gossel 31, and we can add two more, both after the Y-operation.

there is any danger, for then the loop becomes distended from the passage of food into it, either through the pylorus or the anastomotic opening, with the result that it is regurgitated back into the stomach and the vicious circle is set up. If the efferent loop is constricted by the weight of the proximal loop the condition becomes more exaggerated. Regurgitation, when it is really only reflux and not a disguised vicious circle, does no harm, for it has been proved experimentally (by Oddi and Dastre) as well as by the results of cholecystogastrostomy [1] that the presence of bile in the stomach does not produce any real disturbance as long as there is a free outlet from the stomach.

The methods we can employ to ensure that both the stomach and proximal loop of intestine can empty are:—(1) to make the anastomotic opening of large size by approximating a sufficient extent of the gut to the stomach; (2) To form an enteroanastomosis below the gastroenterostomy according to the method advocated by Braun or Roux (Y-method); (3) to unite the stomach with the duodenum. So long as a proper outlet is provided, it does not matter whether the anastomosis is made in front of or behind the colon, though much importance has been attached to this point.

It is more important to make the anastomosis at a point where the stomach empties most satisfactorily. We were the first to call attention to this by our operation of "inferior gastroenterostomy," in which we showed the importance of making the opening at the most dependent point of the greater curvature, the stomach being empty, *i.e.* generally in the antrum pylori.

The observations of Kelling, Cannon, and Blake [2] have shown that the most dependent part of the stomach during contraction corresponds to the pylorus, that the peristaltic pressure is greatest at this point (Kelling), and further, that a longitudinal opening in the stomach above this becomes contracted into a mere slit. The fact, confirmed by W. Mayo, that disturbances of the nature of vicious circle are most often seen when gastroenterostomy has been performed in cases where the pylorus is still patent, is in agreement with this idea. We have frequently been able to confirm this. Food passes as before through the pylorus and back through the anastomosis into the stomach, even if the latter opening is of large size.

It follows, therefore, that care must be exercised in discriminating between cases where the pylorus is patent and where it is almost occluded. In the former (in operations for ulcer, ptosis, or simple dilatation) one must be particularly careful to provide ample escape for the contents of the upper loop of gut, while in cases of marked stenosis or closure of the pylorus every method answers the purpose.

Our classification of the different forms of gastroenterostomy is based on this important characteristic, in order to draw attention to the advantages and disadvantages of the individual methods.

(a) Gastro-jejunostomia Inferior Longitudinalis

127. Gastro-jejunostomia Antecolica Inferior Longitudinalis. The anterior method is much the most simple. In pyloric stenosis its results are excellent, and as it entails the least interference with peritoneum, it gives rise to the fewest adhesions. Not only is the anastomosis most easily made, but, when proper cases are selected, there is complete freedom from discomfort, and pain from subsequent adhesions. Further, if a second operation, *e.g.* for peptic ulcer, has to be undertaken, the anastomosis is easily located and the second operation is facilitated.

Wölfler's original operation has been improved by following Kappeler's suggestion, and uniting a greater extent of intestine and stomach than is required merely for the anastomotic opening. In this way obstructive kinking at the opening is avoided, the lower loop of intestine is not compressed by the weight of the upper loop and a spur is avoided. It is a further improvement to make the opening a large one.

Dollinger, who has had excellent results in twenty cases, is a firm advocate of the simple anterior method. He makes the anastomotic opening $2\frac{1}{2}$ to 3 ins. long.

[1] Perrin, *Thèse de Lyon*, 1901.
[2] Division of Surgery, Harvard University, May 1905.

Technique. A middle-line incision is made about 5 ins. in length, of which three-fourths should be above the umbilicus. The lower part of the incision is carried slightly to the left of the umbilicus, so as to facilitate the subsequent stitching. The skin, linea alba, and fascia transversalis are divided, a few vessels near the umbilicus secured, and the peritoneum is opened. A careful inspection of the stomach and duodenum is then made, and the nature of the disease defined.

The transverse colon and omentum are turned upwards, and the duodeno-jejunal flexure sought for by passing the finger underneath the mesocolon to the left side of the vertebral column. Having identified the commencement of the jejunum, a loop, about 16 inches long, is selected, emptied by stripping it between the fingers, and clamped with a pair of light forceps (crushing-forceps must not be used), which are applied so as not to include the mesentery. The loop is placed with the proximal end pointing towards the cardia and the distal end towards the pylorus.

Fig. 325.

The stomach, which must be empty, is then pulled downwards, and the most dependent part of the pyloric portion identified. At this point the gastrocolic ligament is separated from the greater curvature for at least 3 inches, and any small branches of the gastro-epiploic vessels, chiefly veins, passing on to the stomach are ligatured. The gastro-epiploic vessels themselves should not be ligatured. A fold of the greater curvature is then clamped in a similar way with a pair of light forceps. If there is any difficulty in applying clamps to the intestine, a stout ligature may be passed round it so as to include a loop about 8 inches long, and lightly tied, without constricting the mesentery, the ends of the ligature being left long and secured with forceps. The stomach may be also held up between the fingers of an assistant so as to bring the anterior wall in relation to the bowel, the finger at the same time preventing any escape.

The selected portions of stomach and intestine are brought up into the wound as far as possible, and after the transverse colon, omentum, and intestine have been replaced, the field of operation is shut off with gauze pads. The introduction of the pads is facilitated by raising up the edges of the wound with blunt hooks.

In making the anastomosis, the first serous layer of sutures, which should be of fine silk, should be inserted for a distance of 3½ inches, leaving the ends long and clamped with artery forceps. The peritoneal and muscular coats of the stomach and intestine are then incised ⅛th inch from the suture line and for a distance of 2½ inches, and united by a continuous suture of fine silk, the ends of which are left long. The mucous membrane is then divided and the edges are brought over the sero-muscular suture without any tension, and united with continuous catgut, which is carried right round the posterior and anterior walls without interruption, thus completing the communication between the stomach and intestine. The anterior seromuscular suture is next completed with the ends of the posterior suture, which were left long. When the wall of the intestine is too thin to allow of stitching it in layers, the serous, muscular, and mucous coats should all be included in one stitch. After the stomach and intestine have been opened, the exposed mucous surfaces should be cleansed with gauze wrung out of lysol, and before beginning the anterior serous suture, the stomach and intestine are cleaned with lysol, and the soiled pieces of gauze nearest them removed. The anterior serous suture is completed with the long ends of the posterior serous

suture. In this way a portion of intestine half an inch long is applied to the stomach above and below the opening.

128 Gastro-jejunostomia Retrocolica Inferior Longitudinalis. This operation, which is associated with Peterson's name, was developed in Czerny's clinic from a method v. Hacker had previously described. It has met with much favour, and in the hands of experienced surgeons such as Mayo, Moynihan, and Czerny it has given particularly good results.

As before, the opening in the stomach is placed at the greater curvature, but, unlike the anterior operation, where the anastomosis is made at least 16 inches from the commencement of the jejunum, here the loop of intestine is made as short

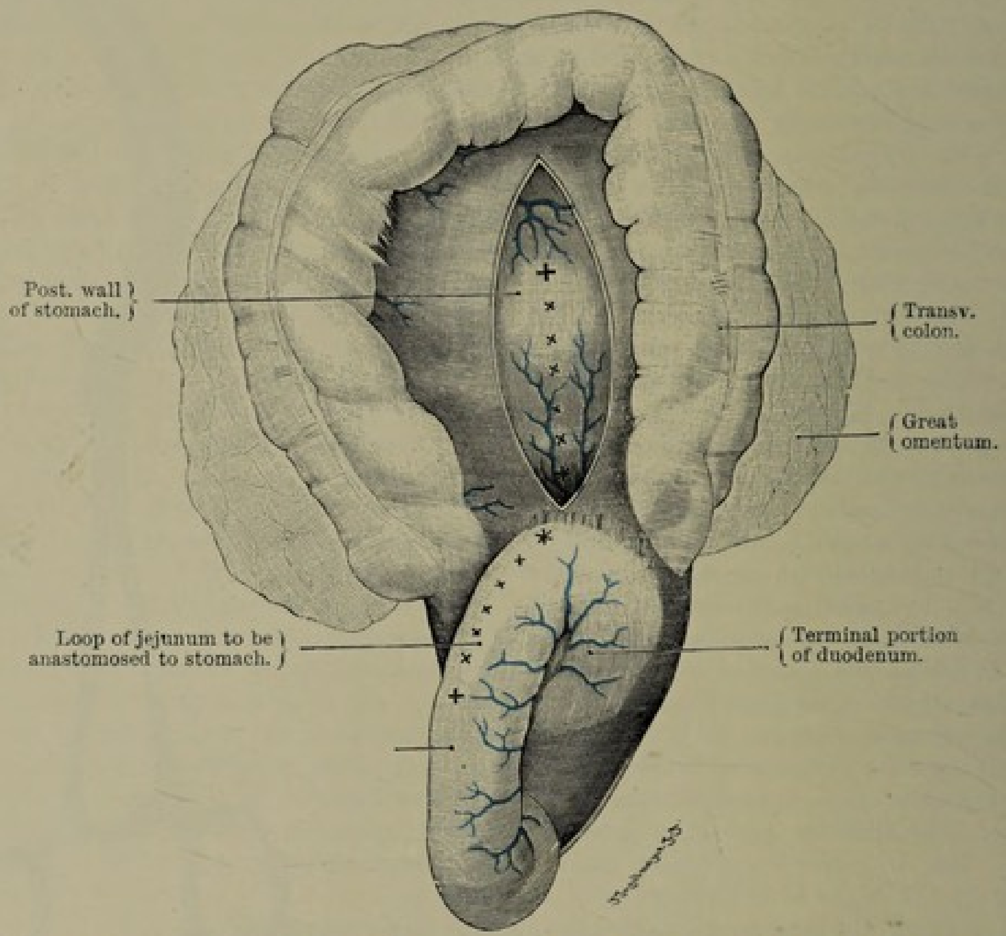


FIG. 326.—Gastrojejunostomia retrocolica verticalis. Stomach and transverse colon are thrown upwards and the transverse mesocolon is split longitudinally. Between the edges of the latter are seen, above, the vessels of the greater curvature, below, those of the lesser curvature. The vertical apposition of the jejunum is represented by crosses, the larger crosses indicating the upper and lower ends of the line of sutures. Below is shown the commencement of the jejunum, and below and to the right the termination of the duodenum.

as possible. In addition to placing the gut for anastomosis in the long axis of the stomach, the afferent limb, as shown in Fig. 326, is sutured in a vertical direction on the posterior wall of the stomach, so that, owing to its downward direction, no regurgitation can take place into it. In the majority of cases this has the desired effect, but it sometimes happens that as the dilated stomach becomes reduced in size, and the greater curvature comes to occupy a higher level, the upper loop, instead of being directed downwards and forwards, becomes drawn upwards so that its axis is from below upwards, thus reproducing one of the harmful features that occur with anterior gastroenterostomy. We have encountered one such case.

In order to prevent this, the anastomotic opening must be made of large size, *i.e.* $2\frac{1}{2}$ inches.

Technique. The abdomen is opened as described in section 127, the transverse colon and omentum are thrown upwards, and the posterior surface of the stomach, including the greater curvature, is exposed through a slit in the transverse mesocolon between the branches of the middle colic artery and vein (see Figs. 326 and 338). The greater curvature is freed as before by detaching the gastro-colic ligament along with its vessels, and the margins of the slit in the transverse mesocolon are stitched with interrupted sutures to the stomach, leaving a portion of the latter exposed. This

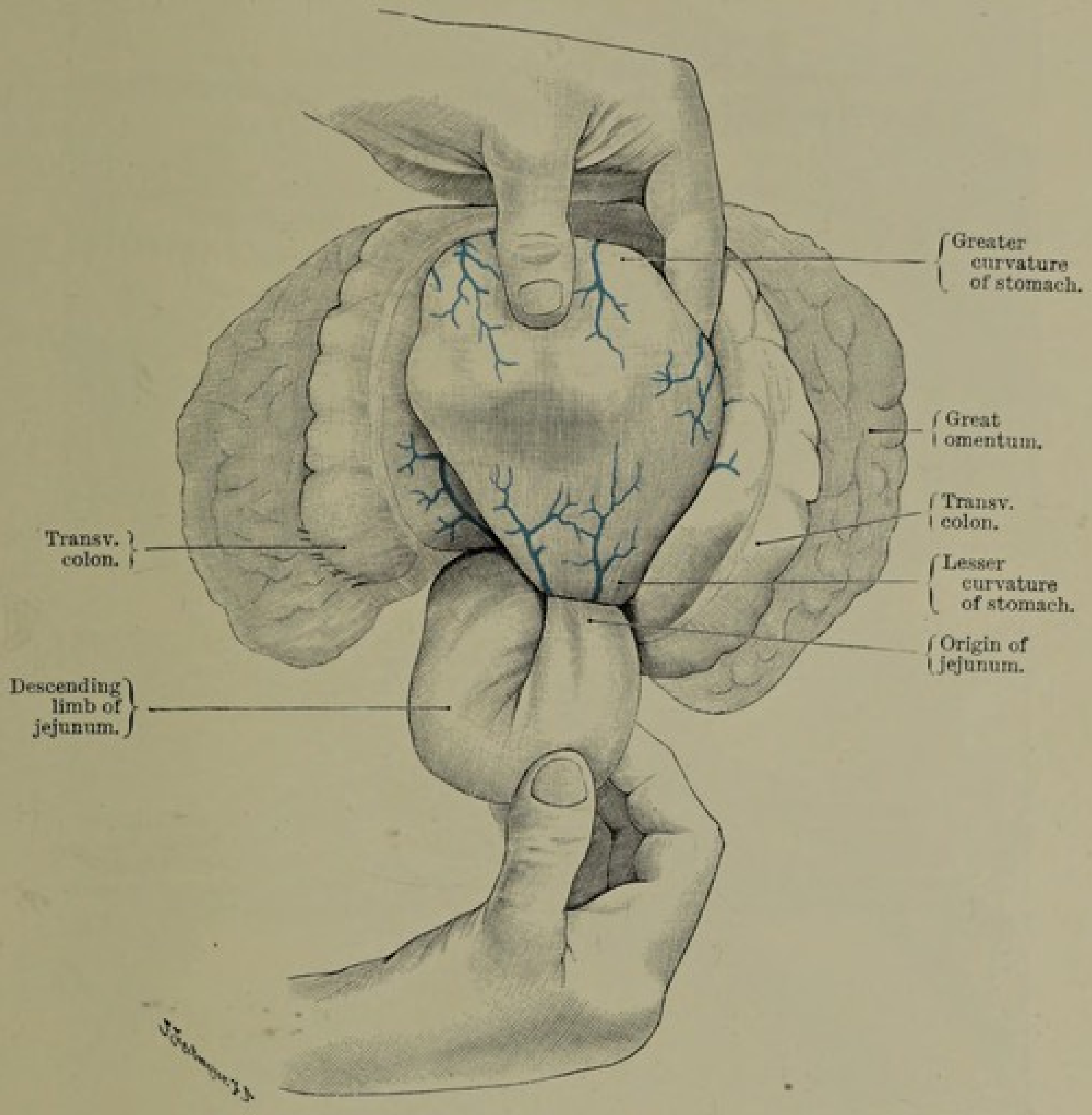


FIG. 327.—Gastrojejunostomia retrocolica. The stomach, which has been thrown upwards along with the transverse colon, is here shown pushed forwards by the fingers of the left hand introduced behind it. The upper loop of the jejunum is pulled downwards, prior to its being stitched, with a continuous suture to the stomach, from the point where it is in contact with the lesser curvature, in a line transverse to the curvatures. The anastomosis is made with the greater curvature in the manner shown in the following figure.

manœuvre is necessary to prevent the gut becoming constricted, or becoming herniated into the lesser sac, several cases of which Moynihan has collected.

The jejunum, as near its commencement as possible, is then applied in a vertical direction to the stomach (care being taken that there is no tension), and fixed in position with sutures.

Clamps are applied to the stomach and intestine as before, and the anastomosis is made in the same way as was described for anterior gastro-jejunostomy (No. 127).

It is, however, rather more difficult. It is a good plan, as proposed by Gould,[1] to make the opening in the stomach at right angles to the greater curvature, for this allows the opening to be prolonged down to the lowest part of the stomach. As Figs. 328 and 329, which are taken from Gould's work, show, he converts the opening when made into a longitudinal one and so obtains better gaping of the communicating aperture.

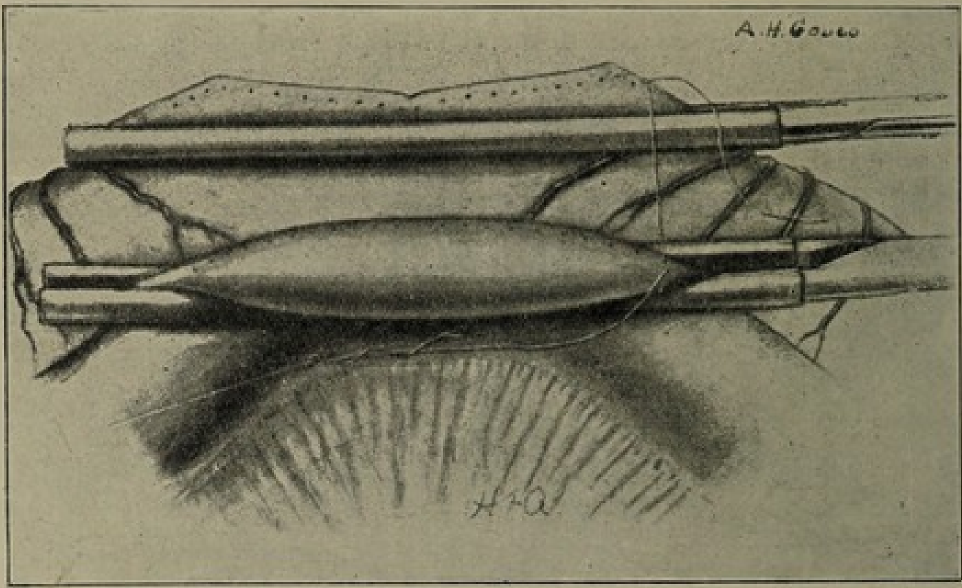


FIG. 328.

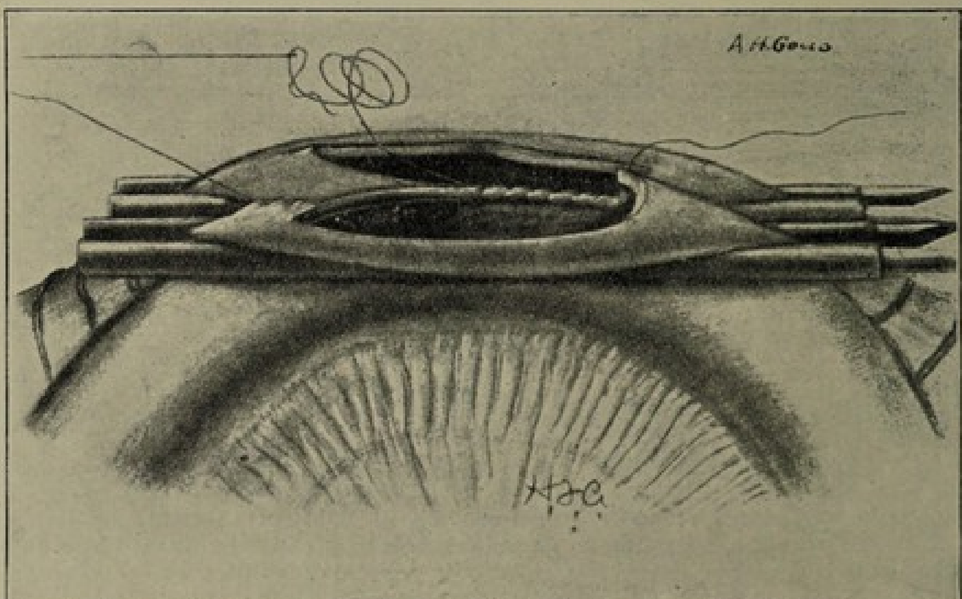


FIG. 329.

FIGS. 328 and 329.—Gastroenterostomia inferior longitudinalis. Gould's modification. The transverse opening at the greater curvature has been converted by the clamps into a longitudinal one, corresponding with the direction of the opening in the jejunum.

(b) Gastro-jejunostomia Inferior Verticalis

Although the horizontal attachment of the gut to the stomach allows of a large opening being made, and ensures free escape from the stomach, it also permits a

[1] Gould, Division of Surgery, Harvard University, May 1905.

regurgitation of the contents of the upper loop. This, of course, does no harm if sufficient provision has been made for its escape into the lower loop, and by neutralising the hyperacid gastric juice it may even tend to promote the healing of an ulcer and prevent the production of peptic ulcer in the jejunum.

With the bowel in the vertical position free escape downwards is obtained, but the size of the opening is limited to the diameter of the intestine, and in these cases

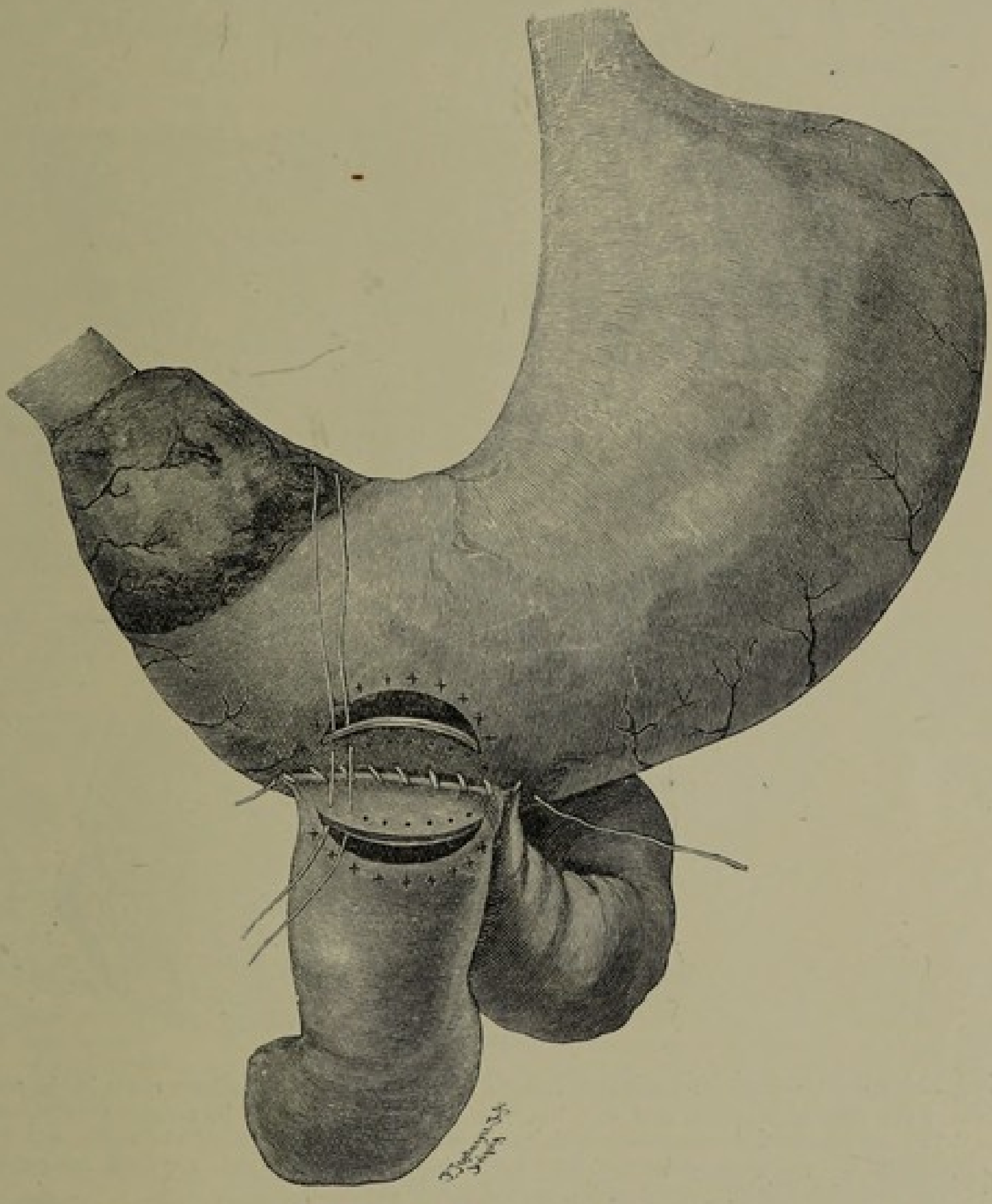


FIG. 330.—Gastroenterostomia inferior antecolica verticalis. The jejunum at a point 16 ins. from its commencement has been applied vertically to the greater curvature of the stomach (in the figure the opening in the stomach is drawn too high above the greater curvature), and the two have been united with a continuous serous suture of fine silk. The stomach and jejunum have been opened (the descending limb is anterior) and the deep suture through the entire thickness of their coats begun. The incisions in the stomach and intestine should be longer.

where the pylorus still allows the gastric contents to pass into the duodenum and the proximal loop becomes filled, there is a risk of kinking taking place and of the afferent loop becoming obstructed.

This may be prevented by attaching more of the afferent end of the gut to the stomach, but to make quite sure, the contents of the upper loop must be made to empty into the bowel at a point below where the anastomosis has been made.

There are two ways of ensuring this: (1) By making an anastomosis between the afferent and efferent loops (Braun); (2) or by cutting across the bowel, and inserting the distal end of the upper portion into the lower portion, below the point where the latter is implanted in the stomach.

As regards the escape from the stomach, it is quite immaterial whether the anastomosis is made in front of or behind the colon, provided that the opening in the stomach is made in the lowest portion of the greater curvature (pars pylorica). In the anterior operation a long loop of bowel is selected in order to avoid any trouble from pressure on the colon. We have never seen any harm result from this method of treatment.

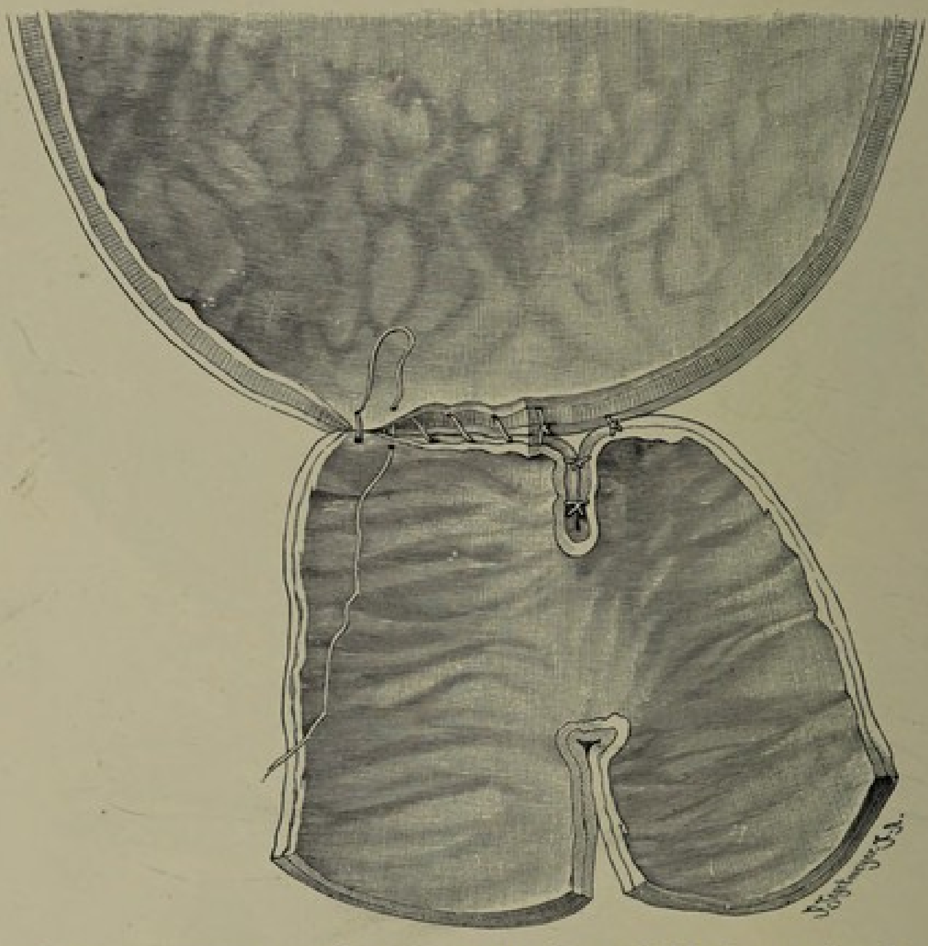


FIG. 331.—Gastroenterostomosis antecolica inferior verticalis. A fold has been made in the convexity of the loop of jejunum, and this has been fixed to the stomach by sutures (sagittal section). The deep sutures for the anastomosis have been inserted through all the coats, and the continuous serous suture is begun. The figure shows how the gastric contents are guided into the lower limb of the intestine, *i.e.* on the left of the figure.

In our opinion, equally good results are obtained with either the anterior or posterior methods, and we have found that entero-anastomosis is quite as reliable as the Y-operation. It therefore comes to be a question as to which operation is the easier for surgeons who have not frequent opportunities for performing gastroenterostomy, which method will subsequently give rise to the least trouble (especially from adhesions), and finally which affords the best chance of performing a second operation, should subsequent complications ensue.

As has been already mentioned, anterior gastroenterostomy best fulfils these three conditions, and the majority of surgeons find a lateral, easier than an end-to-side anastomosis. We will therefore describe anterior gastroenterostomy with Braun's anastomosis as being the easier, although the Y-method can be very well combined

with the anterior method,[1] and also describe the Y-method with retrocolic anastomosis, since it was practised in this form by its principal exponent Roux. Braun's lateral anastomosis can also be performed with the posterior method.

129. Gastro-jejunostomia Antecolica Verticalis cum Enteroanastomosi. The abdomen is opened, and after the omentum and transverse colon have been turned up,[2] and the greater curvature exposed through a small opening in the gastro-colic ligament, a loop of intestine 16 inches long is pulled up, as described in paragraph 127.

The parts to be anastomosed are brought up into the wound and the rest of the peritoneal cavity is thoroughly shut off with sterile compresses.

The loop of intestine (Fig. 333) is then clamped with light clamps (Fig. 335), which hold the two limbs parallel side by side, and the latter are united with a silk serous suture which is begun about $1\frac{1}{4}$ inches below where the gut is kinked.[3] This suture should be inserted for 2 inches and the ends are left long, to be tied later. The gut is then incised longitudinally for $1\frac{1}{2}$ inches 3 mm. on each side of the suture

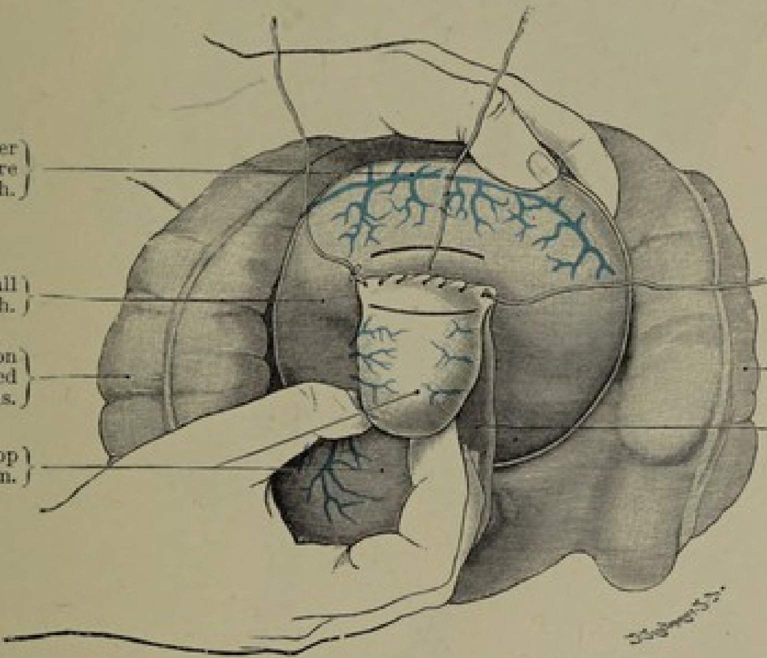


FIG. 332.—Gastrojejunostomia retrocolica verticalis. The jejunum has been sutured to the stomach. The central of the three threads represents the upper end of the suture uniting the jejunum and stomach in the vertical direction. The two lateral threads are the ends of the posterior serous suture of the anastomosis. The dark lines on the stomach and intestine show the direction of the anastomotic opening, which is transverse to the long axis of the jejunum and equal to its diameter.

and the contents are mopped up with lysol swabs. A continuous catgut suture is inserted through the whole thickness of the wall, accurately uniting the mucous layers, the parts are again cleaned with lysol, and the anterior serous suture is completed with silk and tied to the ends of the posterior serous suture.

The intestinal anastomosis is now complete. The flexure of the gut above the clamp is then applied to the stomach, after the latter has been clamped or held in position and closed by the fingers of an assistant. The whole breadth (Fig. 334), or, if preferred, length of the convex surface of the jejunal loop is then sutured to the greater curvature, the ends of the suture being left long. In incising the muscular

[1] Rothgaus (*Nederl. Tijdschr. f. Geneesk.*, 1902) has obtained excellent results with gastroenterostomia antecolica anterior in Y.

[2] If the omentum is too thick, then it can simply be divided longitudinally.

[3] To prevent a peptic ulcer, it is better not to make the anastomosis too low down.

coats the incision should be made slightly convex, and the edges united with a posterior sero-muscular suture, the ends of which are also left long.

The mucous membrane is then divided, purified, and united with a circular catgut suture all round. The introduction of the anterior sero-muscular and serous sutures (silk) follows, after cleansing the whole region again with lysol and changing the

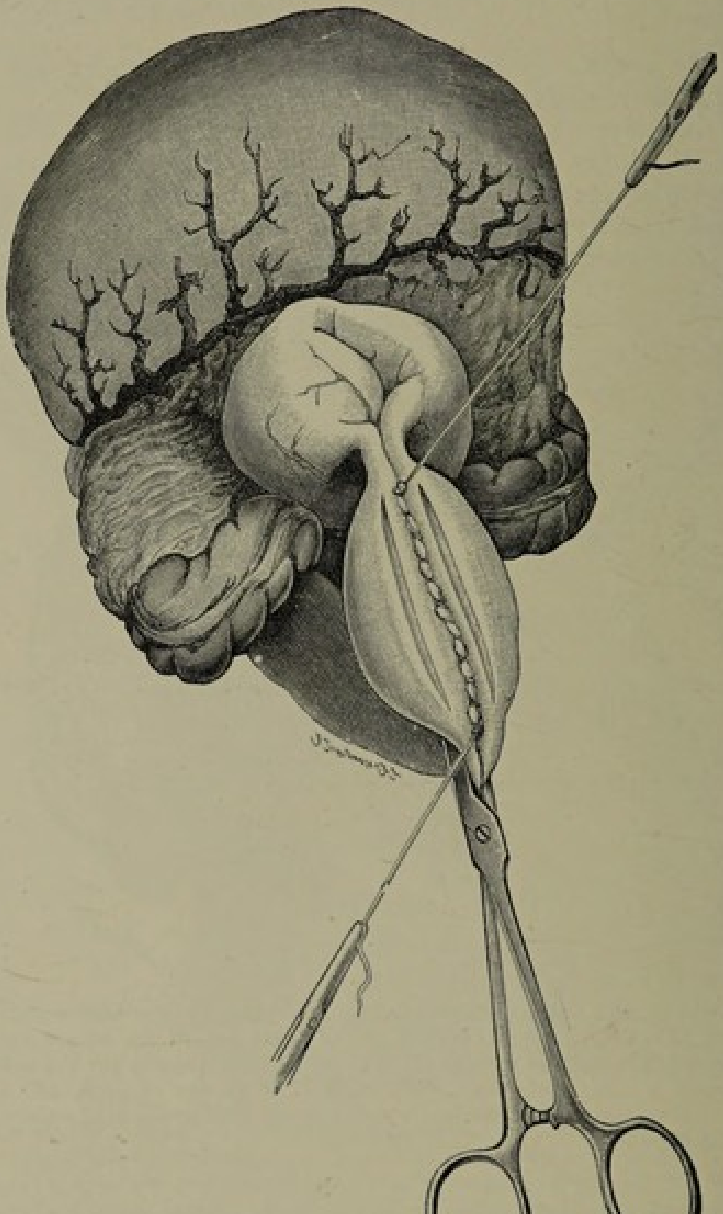


FIG. 333.—Gastrojejunostomia antecolica cum enteroanastomosi. Stage 1: The two limbs of the jejunal loop are clamped 16 inches from the duodeno-jejunal flexure, and the first layer of serous sutures is inserted.

small gauze compress in contact with it. If the wall of the gut is thin it is easier to include the mucous layer in the sero-muscular suture.

130. Gastro-jejunostomia Retrocolica Inferior Verticalis Y-formis.—Roux's operation is performed as follows: The initial steps are the same as those described in section 128, viz. the abdomen is opened, the colon and omentum are turned upwards,

the mesocolon is divided, the edges are stitched to the posterior wall of the stomach, and the commencement of the jejunum is identified.

The loop need not be so far removed from the commencement of the jejunum as in the anterior operation, but should be sufficiently long to be pulled forward comfort-

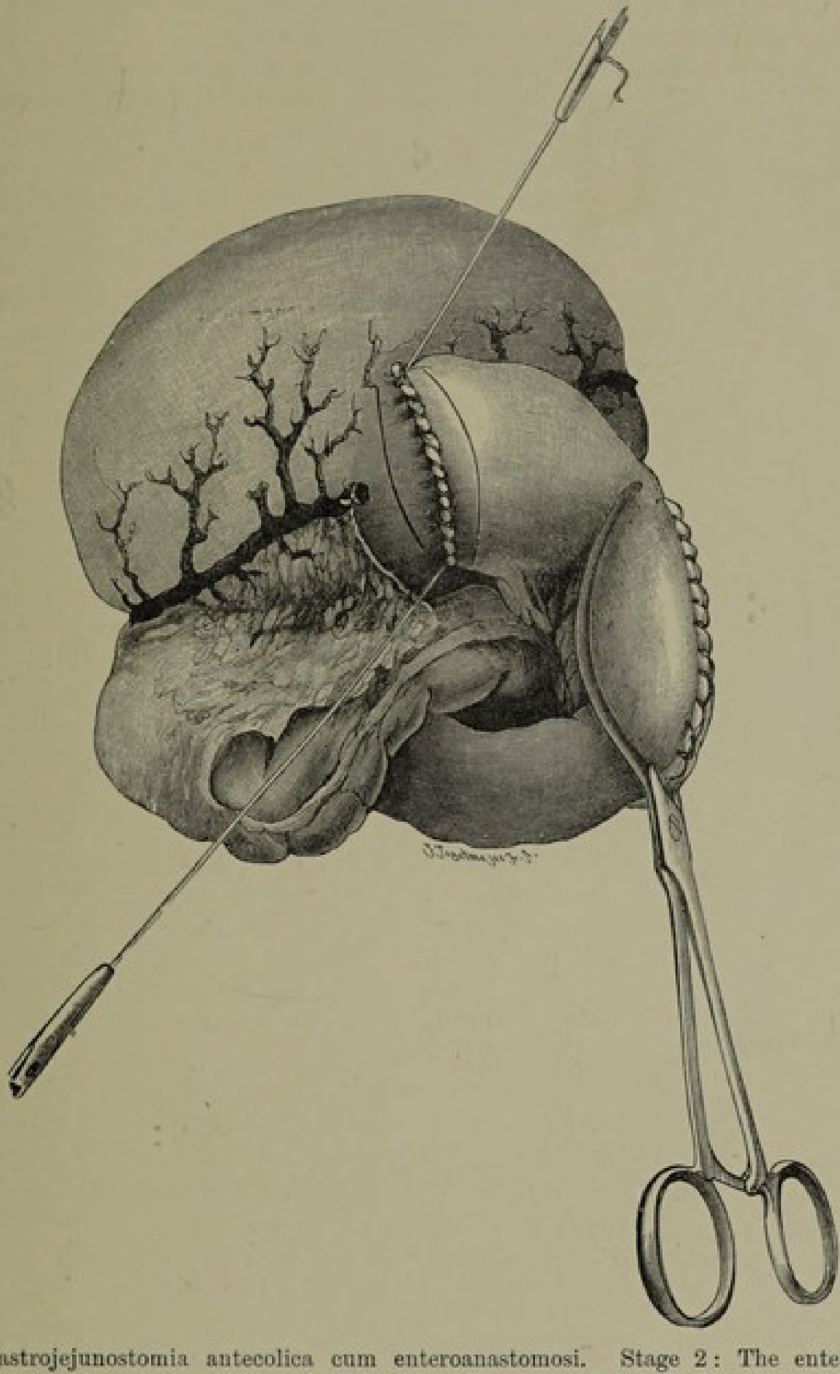


Fig. 334.—Gastrojejunostomia antecolica cum enteroanastomosi. Stage 2: The enteroanastomosis is completed, and the clamp is left *in situ*. The convexity of the loop is seen applied to the greater curvature transversely, the vessels having been divided and ligatured. The posterior serous suture has been inserted, and the direction of the incision is shown on the stomach and jejunum.

ably. The jejunum is drawn forwards and is best clamped by means of two thick silk ligatures which are passed round it above and below through the mesenteric attachment and lightly tied, leaving the ends long and securing them with artery forceps. The intestine is grasped with two strong toothed Kocher's forceps, or two small crushing-forceps placed close together, and cut across between them, the division

being carried into the mesentery as far as the first large arterial arch (*vide* Fig. 337). The redundant bowel is cut off flush with the forceps, and the ends are cleansed with lysol and alcohol.

The greater curvature and posterior wall of the stomach are protruded through the opening in the meso-colon, and the two surfaces of the stomach are kept firmly in contact by the fingers of an assistant to prevent escape of the contents (Fig. 337); or, when possible, it is more convenient to use a clamp.

Using the compression forceps as a handle, the lower end of the gut is then applied to the stomach behind the greater curvature, either transversely or longitudinally, according to which is found the easier, and is fixed there with a layer of serous sutures. The forceps are of use in slightly rotating the gut and bringing the posterior wall close up to the stomach.

FIG. 335.—Intestinal clamp, the grip of which is light and elastic in contrast to the crushing-forceps.

An incision, equal in length to the diameter of the intestine, is now made in the stomach, and the edges of both are united all round with a continuous catgut suture, including all the layers, after which the anterior silk serous suture is inserted and tied to the posterior suture.

Thorough cleansing of the stomach and intestine, as well as the line of suture, must not, of course, be omitted before completing the serous suture.

The anastomosis with the stomach being completed, the upper end of the intestine is implanted into the lower limb at a point $2\frac{1}{4}$ inches below it[1] in the usual way with two rows of sutures. We find it better to incise the lower portion of bowel transversely for half its circumference, parallel to the course of the vessels and its circular fibres. Roux employs a longitudinal incision. The pressure-forceps on the upper end of the jejunum are removed whenever the posterior serous suture has been inserted, as the gut is then in position, and the deep sutures can be inserted through the whole thickness of the wall so quickly that there is little bleeding from the compressed edges.

Finally the gap in the mesentery is closed with interrupted sutures and the surrounding parts are cleansed with lysol swabs.

It is interesting to observe that Monprofit, Graser, and others who have employed the Y-method exclusively maintain that it is the best of all methods. The originator of the method, Roux, on the other hand, in one of his latest publications, has ascribed limitations to his operation. He employs it only in cases where there is mechanical obstruction, and has returned to ordinary gastroenterostomy for simple ulceration, in order to take advantage of the neutralising action of the regurgitated alkaline intestinal secretion on the hyperacid gastric contents, a concession which is quite in agreement with the statement we have already made.

The first occasion on which we had recently to operate again for fresh gastric symptoms, arising from an ulcer on the lesser curvature, was a case in which six years previously the Y-operation had been performed. Here the Y-method had functioned faultlessly—too faultlessly to neutralise the hyperacid gastric juice.

[1] A lower insertion may be more convenient. Roux allows 8 to 12 inches. We are afraid of the action of the gastric juice on the connecting portion, with associated peptic ulcer, since the gastric juice is not neutralised by the bile and pancreatic secretion.

(c) Gastroduodenostomy

In those cases where the indications point to gastroenterostomy, and in which the pylorus is found to be quite patent, if gastro-jejunostomy is performed

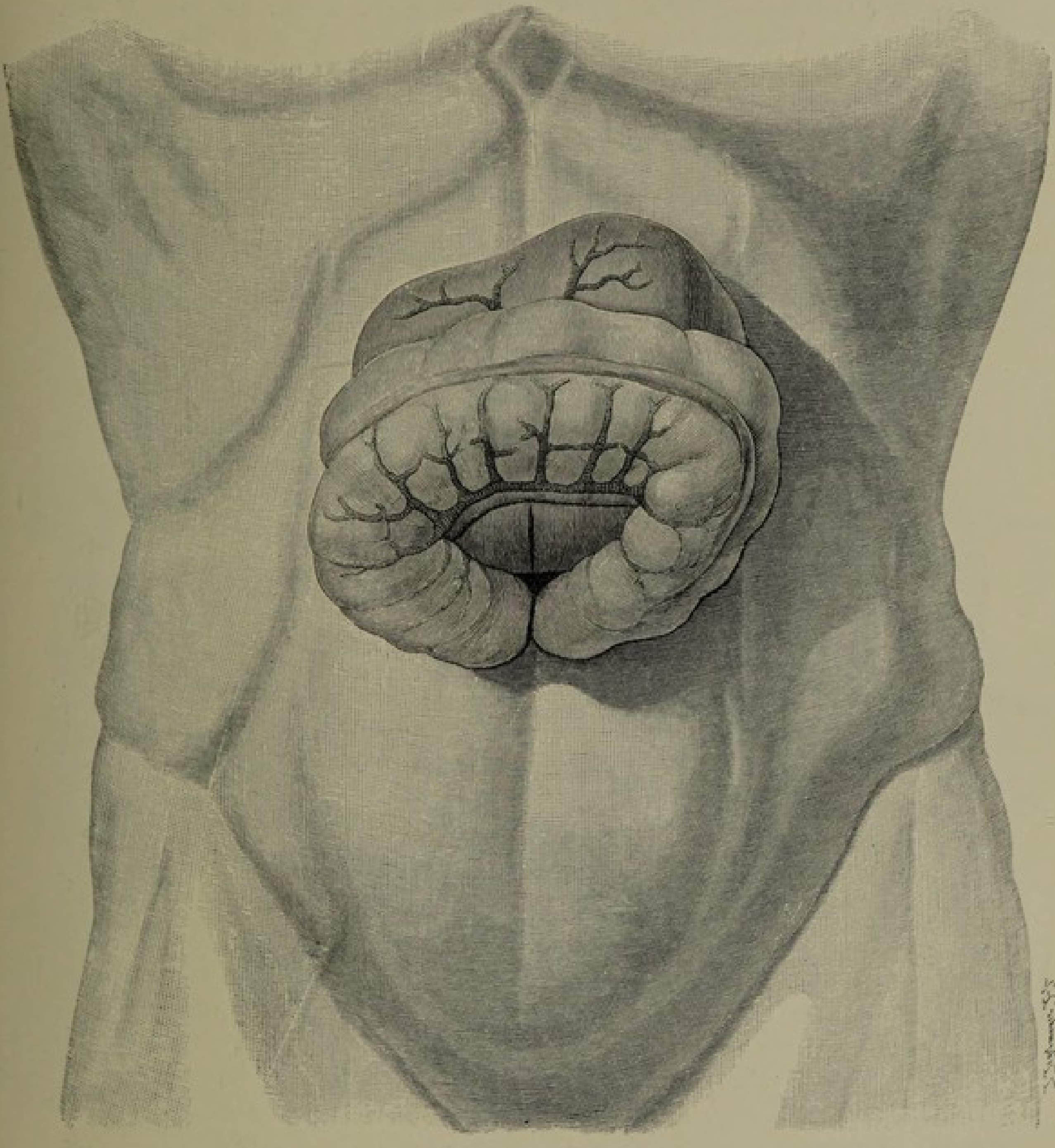


FIG. 336.—**Y**-method of gastroenterostomy (gastroenterostomia retrocolica posterior), first stage. The stomach has been pulled out and thrown upwards along with the transverse colon. Below the loop of colon the posterior wall of the stomach covered by transverse mesocolon is seen, a longitudinal incision having been made into the latter.

there is a great risk of the loop above the anastomosis becoming loaded with bile, and steps have to be taken to ensure complete evacuation into the lower portion of bowel. This can only be obtained with certainty by a second anastomosis, which, however, always means a prolonged operation to avert, as it

does, the onset of peptic ulcer. There are, however, few observations on this point.

Many surgeons, including Tavel, de Quervain, Krönlein, Koslowsky, and Jaboulay, not unnaturally conceived the idea of anastomosing the duodenum instead of the jejunum with the stomach, and in 1894 Jaboulay made an unsuccessful attempt in this direction. Henle, however, in 1898 obtained a very good result with it in a

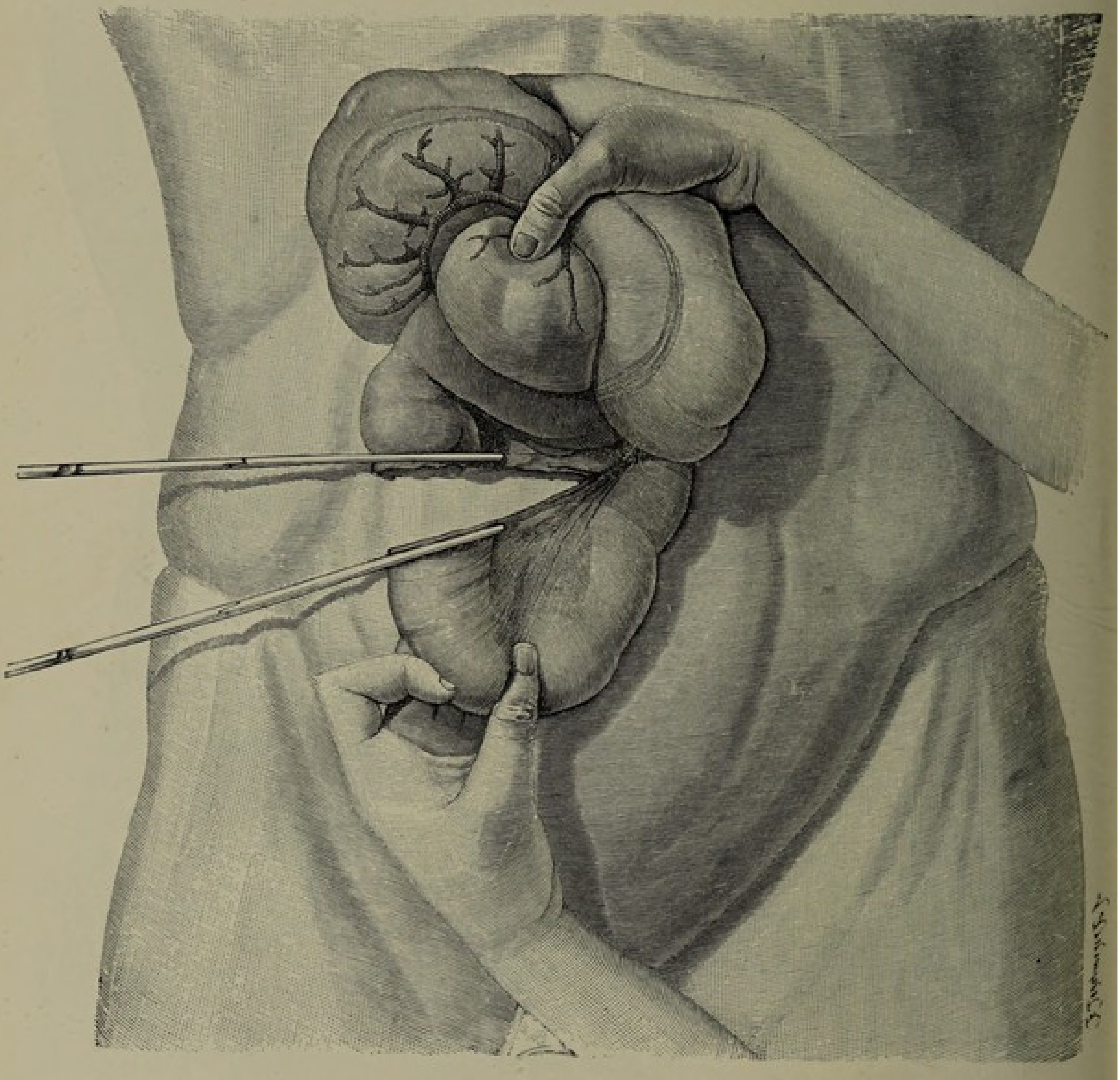


FIG. 337.—**Y**-method, second stage. The loop of jejunum is pulled forwards and divided between two pairs of crushing-forceps, the division being carried into the mesentery; the posterior wall of the stomach is projected through the opening in the transverse mesocolon by the fingers of the right hand.

case in which he found it impossible to carry out his original intention of performing pyloroplasty.

Villard[1] has an extensive experience of this anastomosis, which he makes below the pylorus and describes as "Gastro-duodénostomie sous-pylorique." Although he

[1] *Revue de chir.*, Paris, December 1903, "Gastro-duodénostomie sous-pylorique."

has employed it frequently, he agrees with the earlier operators that it is not to be chosen as a substitute for the other forms of gastroenterostomy, or even for pyloroplasty, but will remain an alternative in the presence of contraindications for the one or the other. The suturing of the stomach and duodenum is much more difficult than the operations usually practised.

We were the first to assign definite indications for the operation and to show how, by simplifying the technique, the operation can be made more effective, and therefore why it should be more often employed. By mobilising the duodenum [1] in

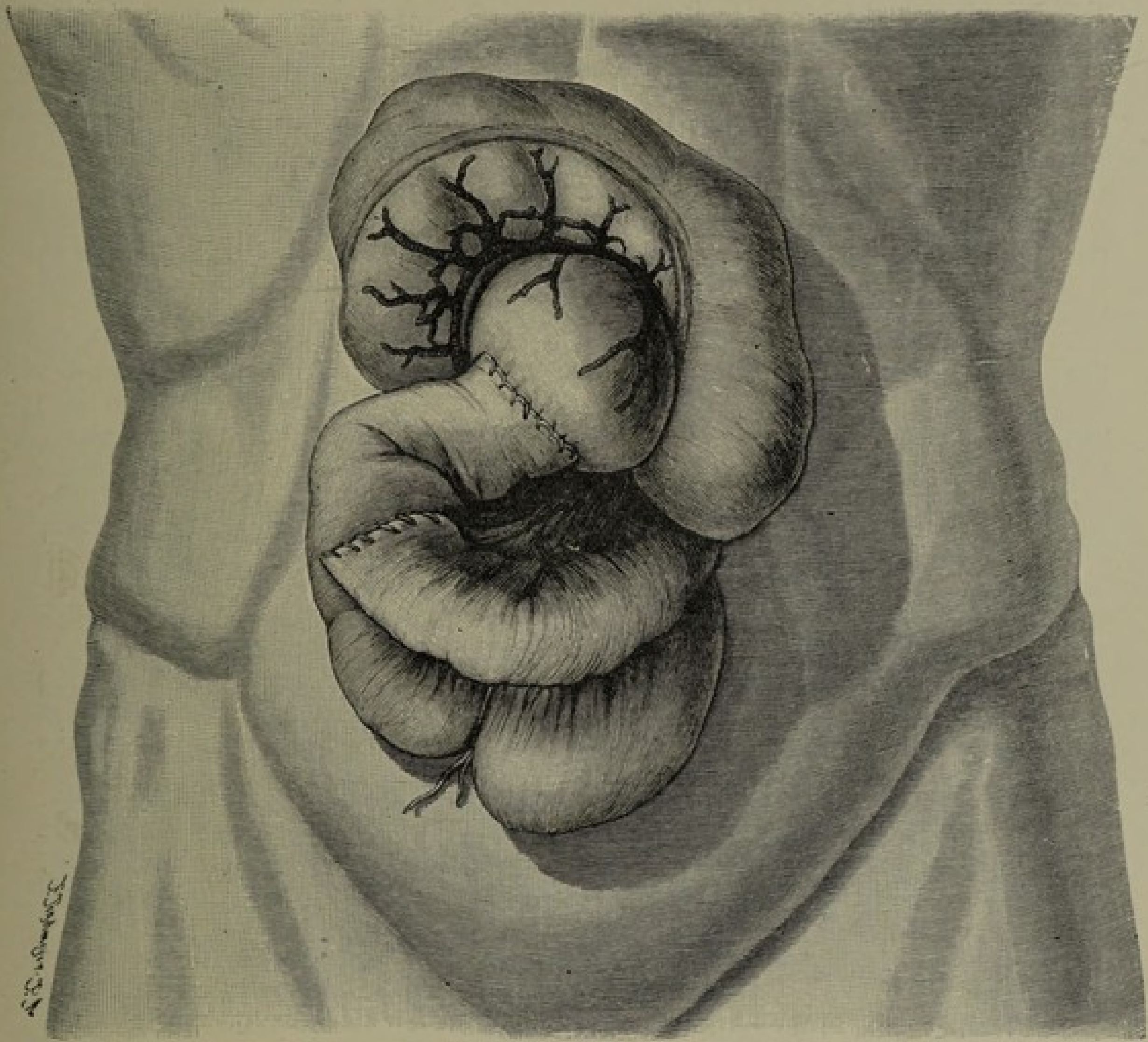


FIG. 338.—Y-method, third stage. The lower end of the divided jejunum is stitched to the posterior wall of the stomach with a double row of continuous sutures; the upper end, after being folded downwards and to the left, has been anastomosed with the bowel below. A temporary ligature has been tied round the emptied loop of bowel.

the manner we introduced, gastroduodenostomy will give in suitable cases as good results as the other forms of gastroenterostomy.

Dr. Gilli, who, in his dissertation, has collected 13 of our cases, comes to the conclusion that, as regards the immediate results, nothing better could be desired (none of the patients died), and that the final results are better than from all other methods. Apart from one patient who died of some unknown affection sixteen months later, one who died of hæmorrhage from an ulcer, and a third who could not

[1] "Mobilisierung des Duodenum und Gastro-duodenostomie," *Centralbl. f. Chir.* Bd. 2, 1902.

37 *b*

be traced, in only one case is the condition described as merely materially improved. In all the others the result is stated to be entirely satisfactory.

The explanation of these good results is self-evident—there is no loop of intestine in which the bile can collect, and therefore a vicious circle is made impossible.

Regurgitation of bile of course occurs, as it does in all the other methods of gastroenterostomy, but it is only of a temporary character and ceases when the anastomosis assumes the function of the pylorus and closes itself. This is amply proved by the results.

The following conditions may be regarded as contraindications :—(1) When the mobility of the duodenum and pylorus is interfered with by adhesions, or by cicatricial infiltration of their walls due to an extensive ulcer. Gastroduodenostomy is only possible when the duodenum can be made freely movable, and, further, the anastomosis can only be made with healthy walls ; (2) where there is a marked degree of atonic dilatation of the stomach associated with ptosis, the method is equally unsatisfactory, for, in order to ensure that the stomach is thoroughly emptied, it is necessary to make the opening in its most dependent point. Gravity, however, is not the principal factor in expelling the stomach contents. Schnitzler, who has reported several successful cases of lateral gastroduodenostomy, has established this as a contraindication, for in one of his cases he had to open up the abdomen a second time.[1]

The operation is positively indicated in cases where evacuation of the stomach by the normal route is interfered with but not prevented, inasmuch as there is no great dilatation of the stomach or depression of the greater curvature far beyond the level of the umbilicus, such as occurs in severe pyloric stenosis. This method is particularly suitable when the disease which gives occasion for the operation is not situated in the neighbourhood of the pylorus, *e.g.* when ptosis, impaired motility, or hyperacidity in cases of ulcer in some other part of the stomach, necessitate an operation. These cases are by no means rare, and call for consideration distinct from that for obvious cases with a high degree of stenosis and marked gastric stasis.

Technique.—If there is any uncertainty as to what method is to be employed, a mesial incision is made, or preferably one over the right rectus, incising the sheath, displacing the muscle, and then dividing the posterior layer of the sheath and the peritoneum. If necessary, more room can be obtained by prolonging the incision at its lower end transversely outwards and dividing the rectus in the manner already described as the typical incision for cholecystotomy.

But if there is no doubt beforehand, and it has been decided that gastroduodenostomy is required, the most suitable incision is the oblique one, two fingers'-breadth below the costal margin, already described (see p. 533). It leads directly down to the duodenum. The peritoneum covering the right kidney is incised vertically about an inch outside the second portion of the duodenum, and the latter is then detached inwards, and together with the head of the pancreas brought forward into the wound. The upper flexure of the duodenum is held in position by the hepatoduodenal ligament, while the lower flexure along with a portion of the third part of the duodenum can be mobilised as far as the point where the latter is crossed by the right colic artery.

When this separation has been effected, as is shown in Fig. 339, the fingers can be passed behind the pylorus and the second part of the duodenum, which allows of a curved clamp being applied to bring both parts in suitable apposition for the anastomosis being made.

The posterior serous suture is then inserted (as described in section 130), beginning above at the upper end of the second part of the duodenum. The serous and muscular coats are then incised vertically on either side and united with a posterior suture, after which the mucous membrane is divided, cleansed with lysol, and united with a continuous suture from behind forwards. Over this the anterior sero-muscular suture

[1] We are assured that Schnitzler is convinced that mobilisation of the duodenum can be performed quickly and easily and does not involve any interference with the nutrition of the duodenum or the healing of the wound.

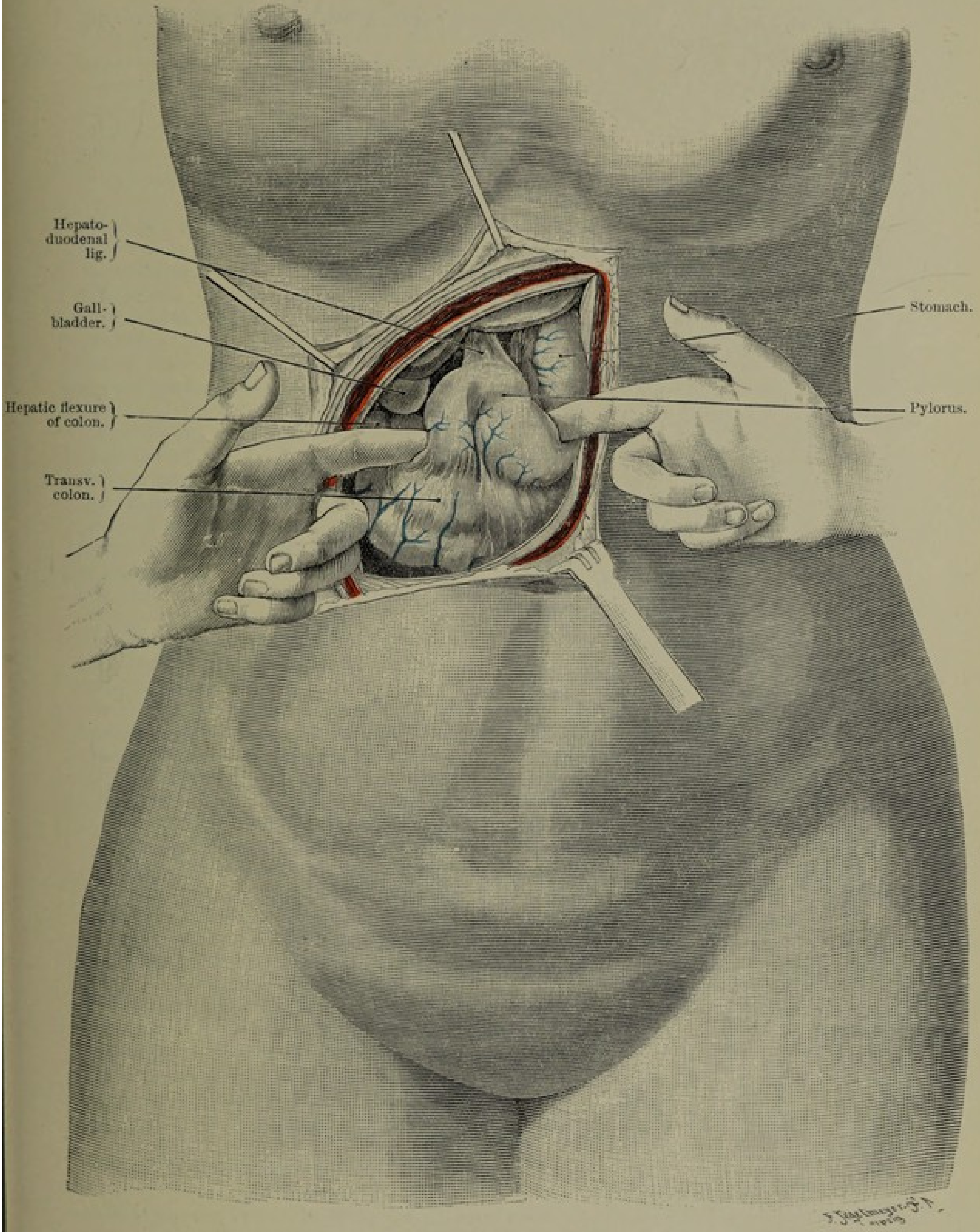


FIG. 339.—Gastroduodenostomy after mobilisation of the duodenum. The pyloric portion of the stomach and the second part of the duodenum are shown raised up on the index fingers and approximated from behind. Above the index finger of the left hand the hepatic flexure is exposed. The duodenal flexure is held in position by the hepato-duodenal ligament.

is inserted, and finally, after the anastomosis has been cleansed, the anterior serous suture is completed with silk.

The size of the opening between the stomach and duodenum need not be more than $1\frac{3}{4}$ inches, and it should be made as high up in the second part of the duodenum as possible, without causing any tension.

The ampulla of Vater lies opposite the lower end of the opening. As is to be expected, occasionally the bile and pancreatic fluid find their way at first into the stomach. This naturally neutralises the acidity of the gastric contents, but as a rule it is only a temporary condition.

Appendix. — Kocher's Gastroduodenostomy for simple Stenosis without Resection. Instead of lateral gastroduodenostomy, Meinhard Schmidt[1] has in certain cases recommended a method which is somewhat analogous to our operation of excision of the pylorus. It consists in dividing the pylorus transversely, closing the upper end, and implanting the duodenum into a special opening in the posterior wall of the stomach.[2] There is no doubt that there may be indications for this operation, for it certainly prevents any chance of regurgitation into the stomach, even better than the lateral method, and in our cases of resection of the pylorus we have always found this end-to-side union function perfectly.

Schmidt's method has a further advantage which he himself does not allude to, viz. that by pulling up the stomach we may insert the duodenum farther away from the pylorus into a portion of the stomach which is more dependent, *i.e.* the greater curvature, a point which would add considerably to the efficacy of the operation.

In the fourth edition of this work we dealt at length with the history, indications, and results of gastroenterostomy. In the present edition we only record what our recent experience has taught us. It has taught us that more consideration must be given to the ultimate results, now that, with an improved technique, the immediate dangers of the operation are negligible.

The matter rests thus: Gastroenterostomy must be regarded as one of the most satisfactory operations for the treatment of affections of the stomach associated with narrowing of the pylorus with which medical measures are powerless to cope. But in a certain number of cases it is followed by complications which result from the unavoidable formation of adhesions, and which are influenced by the operative method employed. The simpler the method[3] the less the trouble from adhesions. According to our series of cases, the best permanent cures are obtained with simple anterior gastroenterostomy. Other late complications, especially the occurrence of peptic ulcer,[4] are manifestly dependent on the method selected.

We must learn to avoid these dangers also. The surgeon who operates on hundreds of cases and never sees them again may easily be an enthusiast for one method if the immediate results are good, but it is only by carefully following up the patients that a knowledge of the serious disadvantages is gained. This has been the case with posterior gastroenterostomy and the Y-operation, in both of which the immediate results are good, but in which the troubles already mentioned may subsequently occur.

Further, the anastomotic opening not infrequently contracts again, causing a recurrence of the symptoms, and for this the responsibility lies with the method adopted. We have seen the opening become narrowed after the use of Murphy's button and the elastic ligature, and in the former case we should be surprised if subsequent disturbances of this nature did not occur. Systematic suturing in layers with accurate union of the mucous membrane is the best guarantee against later cicatricial stenosis.

If in describing the various forms of gastroenterostomy we have omitted to refer

[1] *Centralbl. f. Chir.*, 1901, No. 4. [2] See next section on Gastrectomy.

[3] It is worthy of consideration that Paterson in his Hunterian Lectures (*Lancet*, February to March 1906) gives the preference to anterior gastroenterostomy. Kümmel also with his rich experience adheres to anterior gastroenterostomy (Cf. Ringel, Hamburg, 1901).

[4] Delaloye (in a publication of Feurer's experience) has collected 29 cases from literature, Dissertation, Bern, 1906; *vide* also Tiegel, *Grenzgebiete*, Bd. 13, and Gosset, *Revue de chirurgie*, t. 26.

to that ingeniously constructed instrument, Murphy's button,[1] and modifications of it by Robson, Lamotte, Jaboulay, De Beule, and others, or to contrivances such as M'Graw's elastic ligature, it is for reasons mentioned. All these modifications, though very convenient at the time of the operation, only invite accidents, which can be avoided with certainty by the use of sutures. In anterior gastroenterostomy the suturing can be so easily done outside the peritoneal cavity that no one need grudge the little trouble it entails.

Appendix.—Pyloroplasty. Pyloroplasty has been advanced by Loreta, Heinecke, Mikulicz, and Finney as a simpler method than gastroduodenostomy. Loreta aims simply at stretching the stenosed pylorus by divulsion. It can only be considered in the presence of limited cicatricial bands, otherwise recurrence is certain, unless the divulsion is performed so energetically as to produce complications.

Heinecke and Mikulicz have attempted to dilate the stenosed pylorus by incising it in its longitudinal axis and stitching it up in a transverse direction. The ultimate results, however, are neither so effective nor so certain as gastroduodenostomy and the immediate results are in no way more satisfactory.

With Finney's operation, on the other hand, a sufficiently wide pyloric opening can be obtained. He[2] does not confine himself to mere division of the stenosis, but prolongs the incision into the stomach and the duodenum, and unites the cut edges of both all round right up to the pylorus and thus provides a wide communicating channel. Gould's[3] improvement on Finney's operation is shown in Fig. 340.

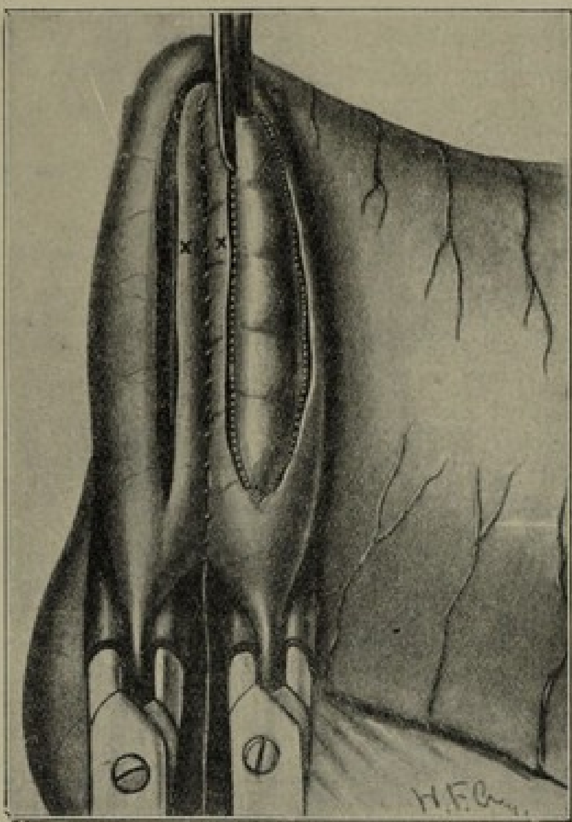


FIG. 340.—Gould's modification of Finney's pyloroplasty. The stomach and duodenum are clamped, the incision has been carried through the contracted pylorus, and the posterior continuous sero-muscular suture inserted.

Although the method provides a free communication between stomach and duodenum, it is no more effective than our lateral gastroduodenostomy and is more difficult to perform. We do not think it is beneficial to include in the suture the cicatrised part of the pylorus, as in many of our cases this portion of the pylorus was so cicatrised as to be practically immovable, and we were glad to leave it alone. The indications, therefore, for this method, are in our opinion even more limited than are those for gastroduodenostomy (by the methods described by Villard and ourselves).

131. Gastrectomy. Gastrectomy was first performed in 1879 by Péan and shortly afterwards by Rydygier, but it is due to Billroth's enterprise and the careful experimental observations of Gussenbauer, Winiwarter, Czerny, and Kaiser that the operation now owes its success. The first successful resection was done by Billroth.

Reference will be found in our previous edition to Guinard's valuable work, which deals with 291 cases, *i.e.* up to 1898, the mortality being 35 per cent. More recently, however, Leriche[4] has published a very complete and carefully-compiled review of

[1] *Vide* also Graser's communications at the Berlin Surgical Congress, 1906.
[2] Finney, *Bulletin*, Johns Hopkins Hospital, Baltimore, July 1902.
[3] Division of Surgery, May 1905, Harvard University, Boston.
[4] *Des résections de l'estomac*, Lyon, 1906.

1366 cases, collected under the supervision and at the instigation of Poncet, in which operation was undertaken for cancer of the stomach, the mortality being 25 per cent. Sarcoma of the stomach is also dealt with (Lécène and Petit, 57, and Howard, 61), and 24 cases in which gastrectomy was performed are quoted with a mortality of 11 per cent.

Gastrectomy is employed in the treatment of simple ulcer as well as malignant tumours. Very different opinions are held in regard to the whole question of gastrectomy for simple gastric ulcer, for while Krogius, Jedlicka (Maydl), and Rydygier attribute to it a wide sphere of usefulness, the majority of surgeons hold it is only indicated when the ulcer exhibits any sign of malignancy. We have come to a definite opinion regarding the latter condition, and from our experience of several very troublesome cases we would warn our younger colleagues against excising innocent ulcers. If the ulcer is freely movable, whether at the pylorus or elsewhere in the stomach, excision may be employed, but if, as is so often the case, it is surrounded by adhesive perigastritis with thickening, an attempt to excise it may land the surgeon in the greatest difficulty and lead to injury of adherent organs or important vessels.

(a) Gastrectomia Partialis

132. Pylorectomy. According to Leriche's figures (*vide supra*) Mayo and Mikulicz have performed the greatest number of resections of the stomach, viz. 100. We have now had an experience of 120 cases, and are in a position to justify the merits of the operation we recommend by stating our results, both as regards immediate and permanent recovery. In the first 52 cases we did, before 1898, which have been published by Broquet, the mortality was 25 per cent; in a subsequent series extending to 1903, collected by Dr. Matti, it was 17 per cent, and in the 21 cases[1] we have operated on within the last two years the mortality is also 17 per cent. But these figures are more interesting when we come to consider the diversity in the cause of death. Of the first 52 patients, two died of collapse, three of gangrene of the colon, two of gangrene of the duodenum, three of sepsis, two of pneumonia, three of pulmonary embolism, while in one case death was due to perforation by the Murphy's button; in the 47 cases collected by Matti the deaths due to local complications were only two, one from the stitches giving way and one from gangrene of the colon; while six were the result of broncho-pneumonia and degeneration of the myocardium, three patients being in an extremely reduced state. Finally, of the four deaths in our last 21 cases three are attributable to simultaneous resection of the colon, and one to pre-existing suppurative pancreatitis.

Our statistics of combined pylorectomy and gastroduodenostomy are proportionately more favourable. According to Matti, the mortality in 71 patients operated on between 1881-1904 was 16·8 per cent, and if we could be accused of having carefully selected our cases in this instance, the same cannot be said of our last 21 cases, for in these our method was used nineteen times.[2] In one of the two other cases, so much of the stomach had to be excised, that as the lumen of the remaining portion was so small, we united it directly to the duodenum, according to Billroth's first method. In the other case, a gastro-jejunostomy had been previously performed by one of our colleagues, and this we utilised after closing the stomach and duodenum.

Of the above 19 cases in which our method was employed, only two ended fatally —a mortality of 10 per cent. But even this percentage does not adequately express what can be accomplished in the radical treatment of cancer of the stomach by the possession of a proper operative technique. Complicated and uncomplicated cases should be regarded separately in comparing the results of simple resection of the stomach with those complicated by simultaneous resection of the intestine (transverse colon), pancreas, or liver.

[1] Deducting one case of death under the anæsthetic.

[2] This disposes of the statement by Kelling and others that the better statistics of gastroduodenostomy depend on the fact that only the more favourable cases are suitable for this operation.

In the 32 cases tabulated by Broquet where Kocher's method was used, of the five deaths, two were in cases complicated by resection of pancreas and one by resection of the colon. In Matti's 39 cases, one death was due to gangrene of the colon, while of the two deaths in our last 19 cases, one was after an extensive resection of the colon and the other after resection of both the colon and the duodenum. It will thus be seen that although both Broquet's and Matti's cases give the mortality of simple gastrectomy as 13 per cent (two-thirds were due to cardiac degeneration and pneumonia, and only 4·3 per cent to complications in the course of healing of the wound), all the 17 uncomplicated cases operated on during the last two and a half years recovered.

Further experience has confirmed our opinion that surgery has reached a point where resection of the stomach, if performed at the right time, can be regarded as free from danger, *i.e.* in regard to the method of resection we employ, with closure of the stomach and gastroduodenostomy.

It has been urged that our method is difficult to perform. In answer to this, we would point out the difficulty which even experienced surgeons have in obtaining secure closure of the duodenum, a difficulty which is not diminished, and which cannot be evaded even with the Billroth II. operation. But the best answer is afforded by a glance at our results. Guinard shows that out of a total of 291 pylorectomies, the mortality after Rydygier-Billroth's operation No. 1, which was performed 148 times, was 35·3 per cent, while that after Kocher's operation (54 cases) was only 15·6 per cent. Similarly Hartmann's statistics with Kocher's operation are better than those of most of the surgeons who employed other methods.[1]

There is finally the question of permanent cure. It has been often alleged on theoretical grounds that in order to be able to perform gastroduodenostomy, an insufficient extent of duodenum must necessarily be removed.

Here again a reference to statistics affords the most conclusive evidence of this fallacy. Ninety-seven of our patients have been traced by Matti, and of these, twenty, *i.e.* 20·6 per cent, were alive, and with the exception of a girl aged nineteen who had an acute type of cancer, were in good health. In two of these nineteen cures the tumours could not be regarded histologically as carcinoma. Eight patients had been operated on for more than three years previously and one had died of pulmonary phthisis nine years after the operation, no recurrence being found at the autopsy. Four others of this list have since reported themselves as well. Five had died, either after a longer interval than three years or of some other condition and without any trace of recurrence. Deducting, therefore, these patients who have not yet reported themselves and also the 2 cases of simple ulcer, 18·4 per cent, *i.e.* 17 out of 92 cases, may be regarded as radical cures.[2]

All our patients operated on by the combined operation recovered with three exceptions. In two the tumour was not situated at the pylorus and were dealt with by circular resection of the stomach. In one case the Rydygier-Billroth method was employed, while the latter can also be included in our list as a proof that recurrence does not take place in the duodenum.

Leriche instances several cases of local recurrence after Billroth I. and Kocher's operations, but this does not at all prove that the recurrence was in the duodenum and not in the stomach. On the other hand, we maintain, with a proper technique, no more of the duodenum is required for anastomosis with the stomach than is required for the insertion of occlusion sutures. This argument, therefore, against gastroduodenostomy cannot be upheld, for even occlusion is always necessary and more duodenum cannot be removed and at the same time be reliably closed with a double row of sutures.

[1] Makkas states that in Mikulicz's resections of the stomach the mortality by Billroth I., where the duodenum is used, is less than by Billroth II., and Martin has lost 3 cases out of 4 by Billroth II. from complications immediately traceable to the method.

[2] Makkas (*Gedenkband für Mikulicz*, Jena, 1907) collected 130 of Mikulicz's cases of resection of the stomach. No report could be got of 10. Of 119 of which information was obtained, 17 were alive and apparently free from recurrence. Five, however, had died which had been hitherto regarded as radical cures, because they lived more than three years. This corresponds to radical cure in 18·4 per cent.

In this connection it is interesting to see what fruit the theoretical fear of our method has produced. Brunner[1] has come to the conclusion that the weak spot (*partie honteuse*), in the second Billroth operation (Billroth II.) is the closure of the duodenal stump and quotes a number of examples in his own experience as well as in the clinics of Czerny, Körte, Garré and Krönlein, where the sutures closing the duodenum gave way and led to suppuration and usually to death.

Schönholzer's views (Körte), which agree with those of Makkas (Mikulicz), are of special interest, namely, that the direct mortality from the first Billroth method is less than that from Billroth II. But Billroth I. is equivalent to our method as regards the amount of duodenum retained.

Steinthal[2] found that in three out of four patients who died after pylorectomy the cause of death was due to faulty closure of the duodenum, while in two other cases the same thing occurred without, however, being fatal. Kausch[3] in a review of 184 cases from Mikulicz's clinic refers to the obvious drawbacks of Billroth II. Peritonitis has frequently been found as the result of insufficiency of the sutures with perforation generally of the duodenal stump. In addition there is the risk of vicious circle.

In order to avoid the danger of the duodenum giving way, Brunner now recommends that it should be sutured to the abdominal wound. Steinthal, who tried this in 10 cases, found the results unsatisfactory, only one healing well, while a persistent fistula was left in the others. He recommends that the wound should be packed with gauze down to the duodenal stump. Kausch does not approve of either method and prefers Billroth I.

The last argument against gastroduodenostomy was destroyed when we demonstrated the simple manner in which the duodenum could be mobilised without endangering its blood-supply, and we maintain that gastroduodenostomy is possible in every case where, as in Billroth's second operation, the stump of the duodenum can be closed. The proof is to be found in the results obtained both by us and those other surgeons who have adopted our method.[4] With the exception of one case where a colleague had previously performed a palliative gastro-jejunostomy, the duodenum was implanted into the stomach in all of our last series of cases, and as they all made excellent recoveries, it seems to us that our combination of pylorectomy and gastroduodenostomy has established sufficient claims to be regarded as a standard method, for it possesses all the advantages of Billroth's second operation without its disadvantages. Those cases where the duodenum is involved and so adherent that it cannot be sufficiently freed to allow of its being securely stitched must as a rule be regarded as unsuitable for a radical operation. The first Rydygier-Billroth operation is inferior to our method and is no more simple to perform.

133. Technique of Pylorectomy with Gastroduodenostomy. After what has been said in the introduction to the surgery of the stomach and intestines, and in connection with gastroenterostomy, it is scarcely necessary to repeat our observations. *It should be a rule that the anastomosis be made with sutures*, as they are preferable to every other method. Murphy's button should only be used in extreme circumstances. With two or three rows of Czerny-Lembert sutures one has the satisfaction of knowing that the anastomosis is secure and can watch the further course of the case without anxiety. On the other hand, the use of Murphy's button and its modification (Jaboulay) exposes one to the risk of complications and makes one dependent on the skill of the instrument-maker.

Further, care must be taken that the proper kind of forceps are used for occluding the stomach and intestine. As already stated, crushing-forceps must be clearly distinguished from ordinary clamp-forceps. We believe we were the first to direct attention to the value of using strong, closely-fitting, crushing-forceps in operations necessitating division of stomach and intestine, and we attribute our good results partly to their use and to the fact that we do not hesitate to invaginate

[1] *Centralbl. f. Chir.*, 1905, No. 47. [2] *Ibid.*, 1905, No. 50.
[3] *Ibid.*, 1906, No. 5.
[4] Cf. the list of authors on this subject in our fourth edition.

the crushed edges with sutures.[1] When forceps such as those illustrated as stomach forceps in Fig. 341 are used, the section is made close to the blades. No necrosing edges are left, and the forceps form a convenient handle and facilitate the introduction of the sutures.

In contrast to these crushing-forceps, which grasp the extreme edges of the divided tissues, ordinary clamps should not cause any crushing. Doyen's pattern is too strong for this purpose. Ordinary clamps take the place of the fingers and shut off the lumen of the gut with the lightest pressure at some distance from the point where the division is made. Although they may be readily replaced by the hands of an assistant they are more convenient. A ligature tied lightly round the gut will serve the same purpose.

The Typical Operation. A mesial incision, 6 inches in length, is made above the umbilicus, and may be prolonged if necessary by carrying it to the left of the umbilicus. Skin, superficial fascia, and the aponeurosis of the linea alba are divided, and any bleeding points near the umbilicus secured. The extraperitoneal fat, which is often present in large amount, is divided and the peritoneum opened. Immediately above the umbilicus the peritoneum is covered by a fairly distinct layer of transversely-striated fascia (fascia umbilicalis).

The stomach is drawn forward and the position, extent, and mobility of the tumour are defined, while at the same time the mobility of the duodenum should be determined.

If any glands are present along the lower border of the pylorus or in the hollow of the duodenum, they must be freed by blunt dissection, taking care to ligature all the small vessels. As a rule the superior pancreatico-duodenal artery will also have to be tied. The gastrocolic ligament is then divided along the greater curvature, the separation being carried beyond the tumour as far as the point at which it is proposed to divide the stomach. The right gastro-epiploic artery will generally have to be tied.

Having freed the lower border of the duodenum, keeping close to the gut and avoiding unnecessary injury to its blood-supply, attention is then directed to the upper border of the duodenum. The fold of peritoneum attached along its upper border is divided close to the gut and the vessels in it are double ligatured.

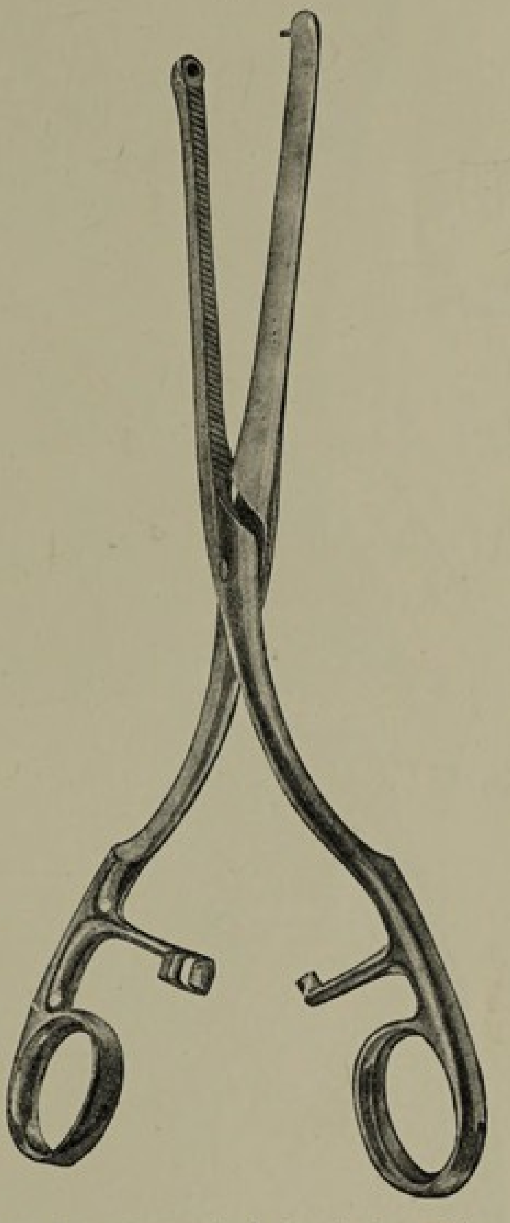


Fig. 341.—Large-sized intestinal crushing-forceps. The forceps are applied as firmly as possible and the intestine is cut through flush with the blades. The distal ends are here drawn rather too thick and heavy. Note that the forceps can be opened by still further pressing together the handles, and can thus be removed without causing injury.

A finger is now passed behind the first part of the duodenum to make sure that the division will be through healthy tissue, and that it is sufficiently free to allow of its being sutured to the posterior wall of the stomach. If, however, it will not reach

[1] In order not to lose the advantage of secure occlusion, one may not employ F. Schultze's modification of our operation, which presupposes a convenient access to the interior of the stomach.

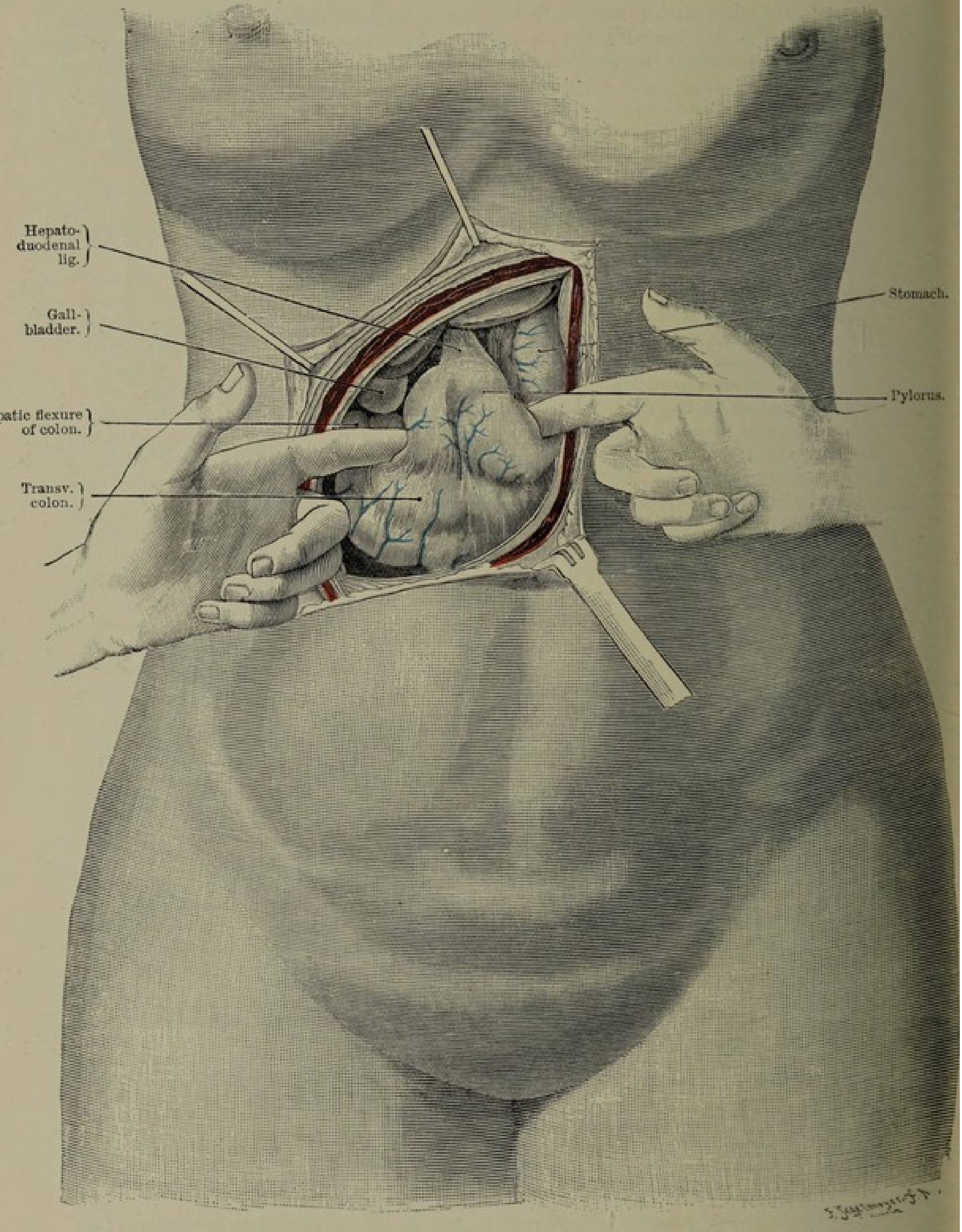


FIG. 342.—Gastroduodenostomy after mobilisation of the duodenum. The pyloric portion of the stomach and the second part of the duodenum are shown raised up on the index fingers and approximated from behind. Above the index finger of the left hand the hepatic flexure is exposed. The duodenal flexure is held in position by the hepato-duodenal ligament.

the stomach, it must be mobilized in the manner described under gastroduodenostomy (*vide supra*), *i.e.* by incising the peritoneum over the right kidney a thumb's-breadth outside the second part and detaching the latter inwards towards the stomach (see Fig. 342).

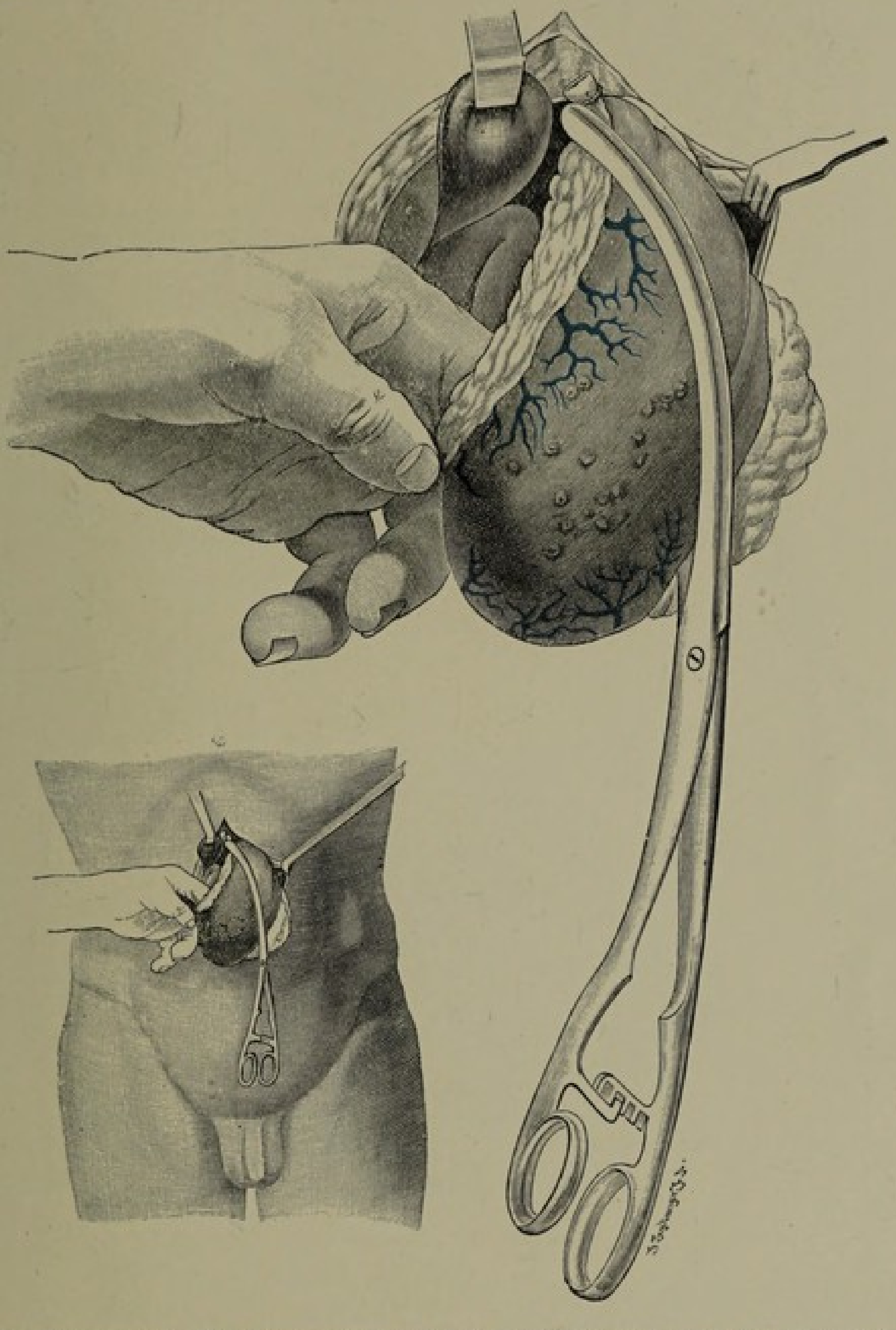


FIG. 343 —Pylorectomy. The lesser curvature has been freed beyond where the glands extend, the coronary artery has been ligatured, and a pair of crushing-forceps applied (only one pair of forceps is here shown). The edge of the liver is hooked upwards, and the pylorus and first part of the duodenum exposed.

The finger is then inserted behind the lesser omentum internal to the point where the peritoneum and vessels have been divided along the upper border of the duodenum, and the gastrohepatic omentum is divided so that the glands lying along the lesser curvature are below the line of division, and all the vessels are tied. This

division is carried as far as the glands extend. Beyond this point the coronary artery with its accompanying veins is ligatured and cut across close to the lesser curvature.

Provided now that it is not adherent to the colon or the posterior abdominal wall, the stomach can be lifted up and the resection begun. Two large crushing-

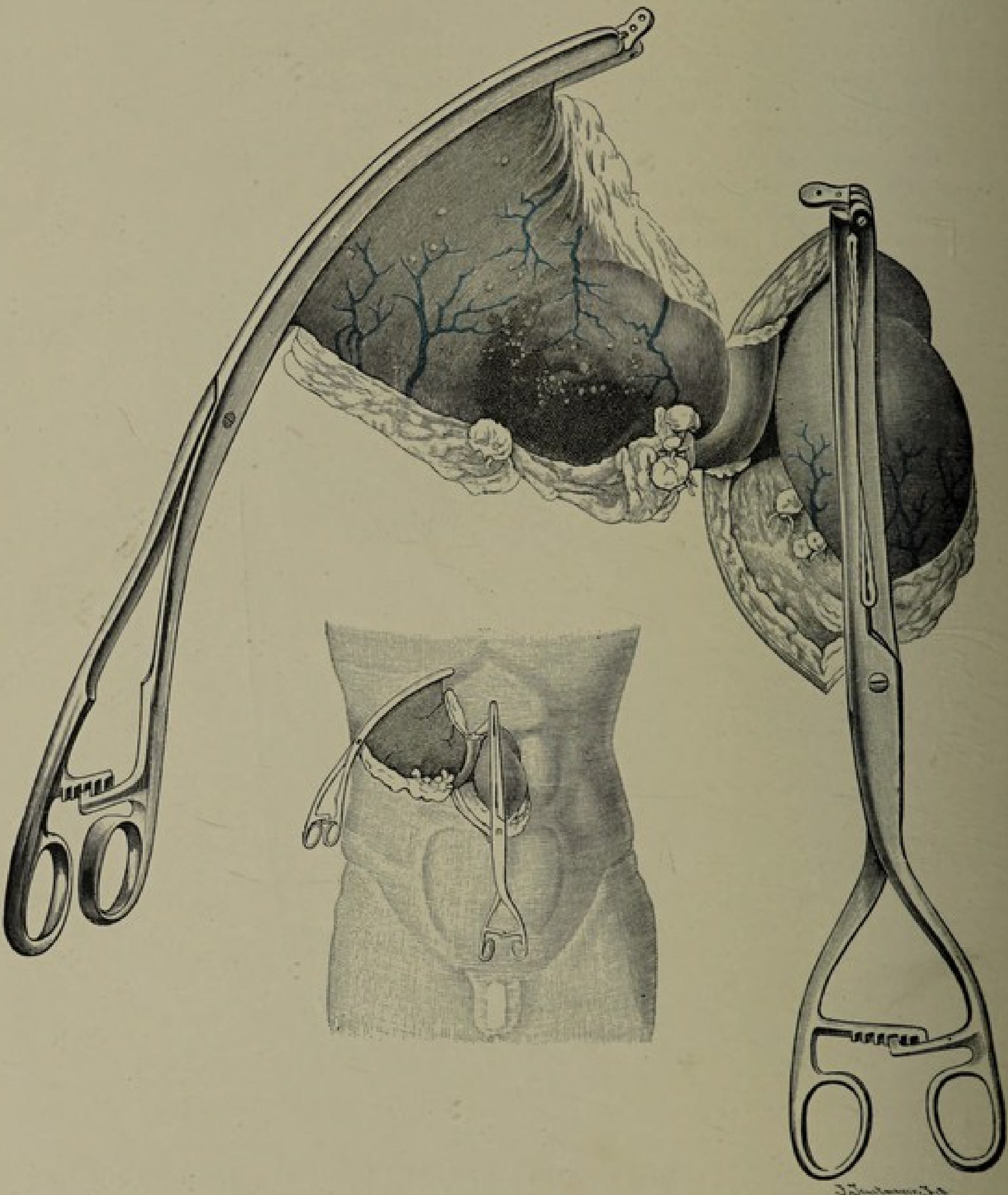


FIG. 344.—Pylorectomy. The stomach is here shown divided between two pairs of crushing-forceps, and the pyloric portion turned over to the right.

forceps (see Fig. 344) are then placed on the stomach close together, two fingers'-breadth beyond where there is any induration, and, after a roll of gauze has been placed underneath it, the stomach is cut across flush with the forceps on the upper healthy portion. The cut surfaces are cleansed with lysol and alcohol, while the

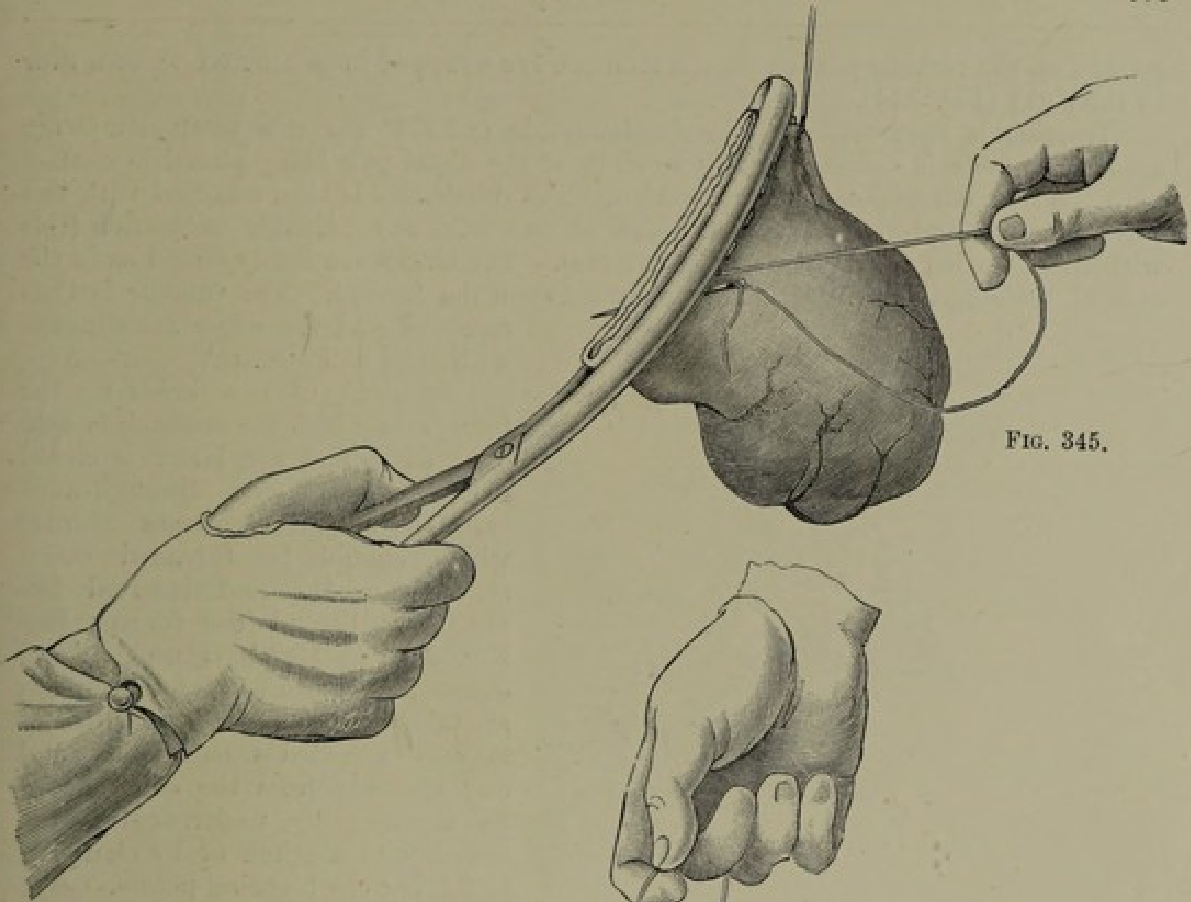


Fig. 345.

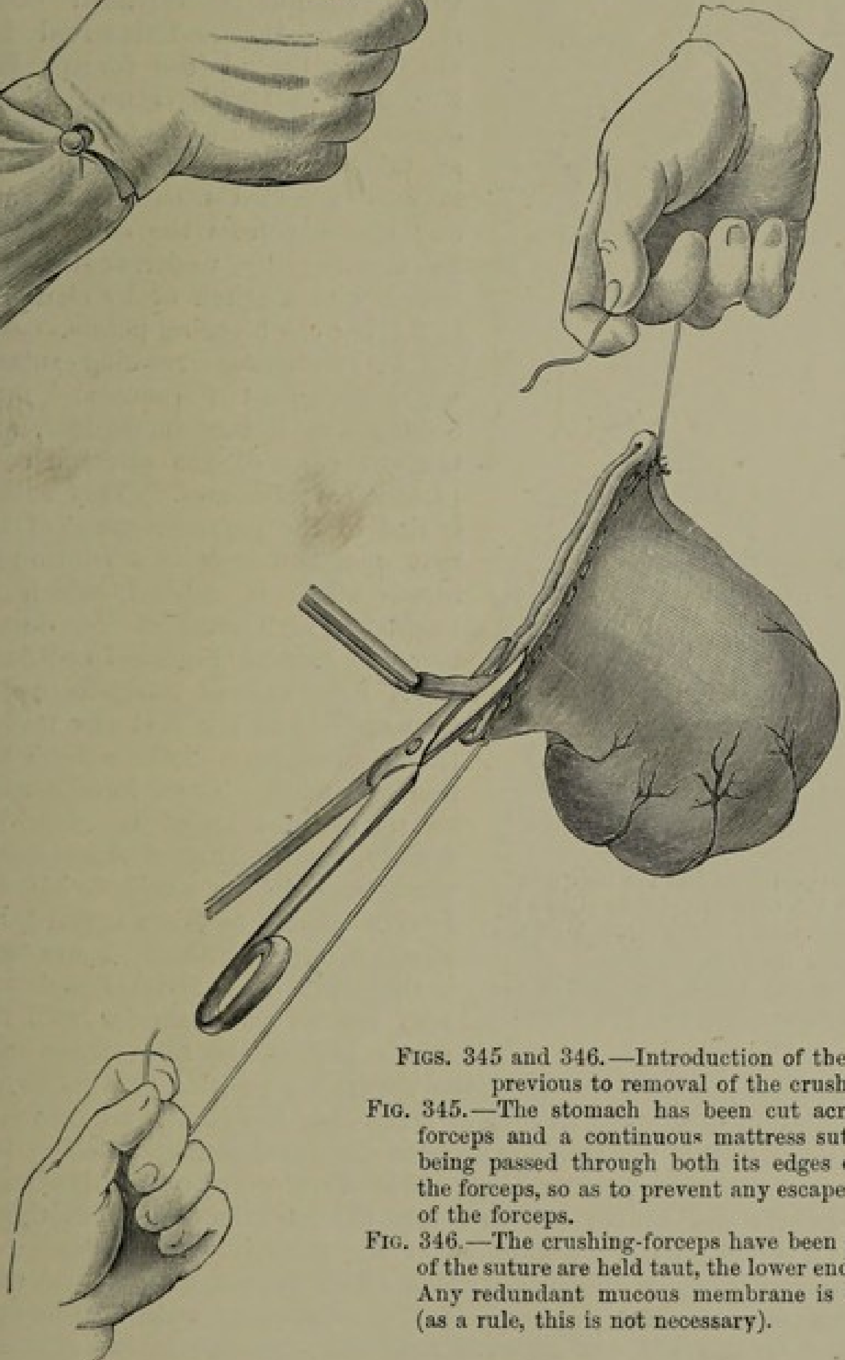


Fig. 346.

Figs. 345 and 346.—Introduction of the "occlusion suture" previous to removal of the crushing-forceps.

Fig. 345.—The stomach has been cut across close to the upper forceps and a continuous mattress suture (straight needle) is being passed through both its edges on the proximal side of the forceps, so as to prevent any escape of contents on removal of the forceps.

Fig. 346.—The crushing-forceps have been taken off, and the ends of the suture are held taut, the lower end being not yet knotted. Any redundant mucous membrane is cut away with scissors (as a rule, this is not necessary).

forceps on the tumour portion of the stomach are wrapped in gauze and thrown over to the right (Fig. 344).

Traction is then made on the duodenum in order to see that when clamps are applied to it it is sufficiently free to allow of the distal pair being placed in contact with the stomach without causing tension. The duodenum is then clamped with two pairs of crushing-forceps at a part which is free from any palpable induration (this without exception stops short at the pylorus). The blades are firmly closed as in the case of the stomach, and it is cut across between the forceps. The tumour is then removed and the edges are cleansed with lysol and alcohol.

Fig. 347.

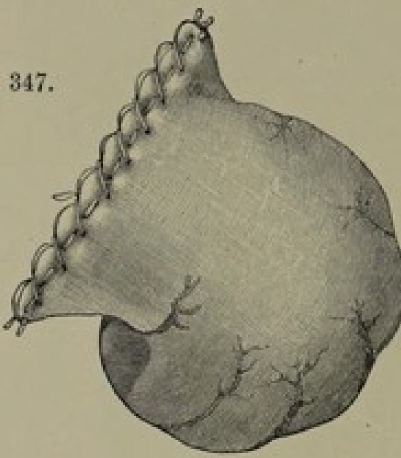
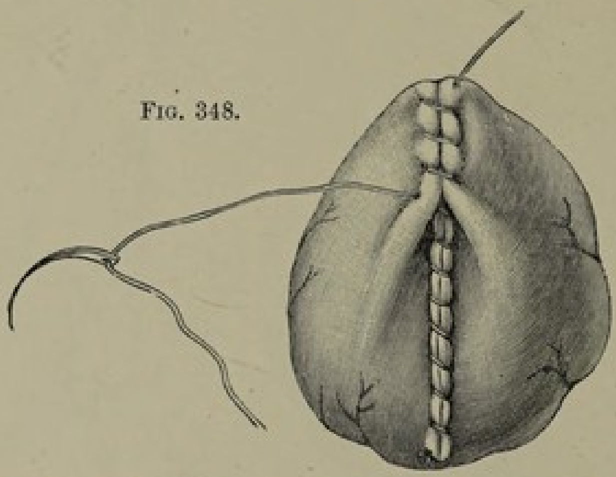


Fig. 348.



Figs. 347 and 348.—"Occlusion" of the stomach.
Fig. 347.—The stomach has been completely closed by a second continuous suture passing through all the coats and applied over the first.
Fig. 348 illustrates how the above two sutures are inverted by a continuous serous muscular suture.

An assistant now holds up the forceps in which the stomach is held (Fig. 345), and the latter is closed with a continuous through-and-through suture (mattress suture) which should be threaded on a straight needle, and inserted immediately behind the forceps (see Fig. 345) ($\frac{1}{2}$ Gely's suture). After drawing the suture tight the forceps are taken off. The projecting tissues may be trimmed with scissors, and any bleeding from the edge should be arrested by underrunning the vessel with a stitch or by clamping and tying the bleeding points.

A continuous running-suture, which includes the serous and muscular coats, is now introduced, and the cut edge of the stomach completely covered over. This suture is tied to the commencement of the first one, and over it a continuous serous stitch is applied, which invaginates both ends of the deeper layers of sutures (Figs. 347 and 348).

A light pair of clamp-forceps is next applied to the posterior wall of the stomach some distance from the line of suture. These forceps must on no account be of the crushing variety, for bruising of the stomach must be carefully avoided. If the forceps cannot be easily applied, the stomach can be held either in one or both hands of a reliable assistant, who rotates the posterior wall forwards and at the same time holds it in contact with the duodenum, so that the latter occupies a position parallel to and 2 inches from the occlusion suture and as near as possible to the greater curvature.

The posterior inferior wall of the stomach and the duodenal stump which is still closed by the forceps are placed in position (Fig. 349). The forceps on the duodenum form an excellent handle and enable one to rotate the posterior wall forward, and hold it accurately in position for the introduction of the posterior continuous serous suture. This is inserted without difficulty with a small curved needle, and as it holds the duodenum and stomach in contact, the subsequent stitching is comparatively easy. The forceps are not removed until the posterior serous suture is

completed, and not until the bowel has been lightly clamped lower down (not crushing-forceps) or shut off by lightly tying a thick suture round it. It is often sufficient if the assistant presses the duodenum against the stomach. The stomach is then

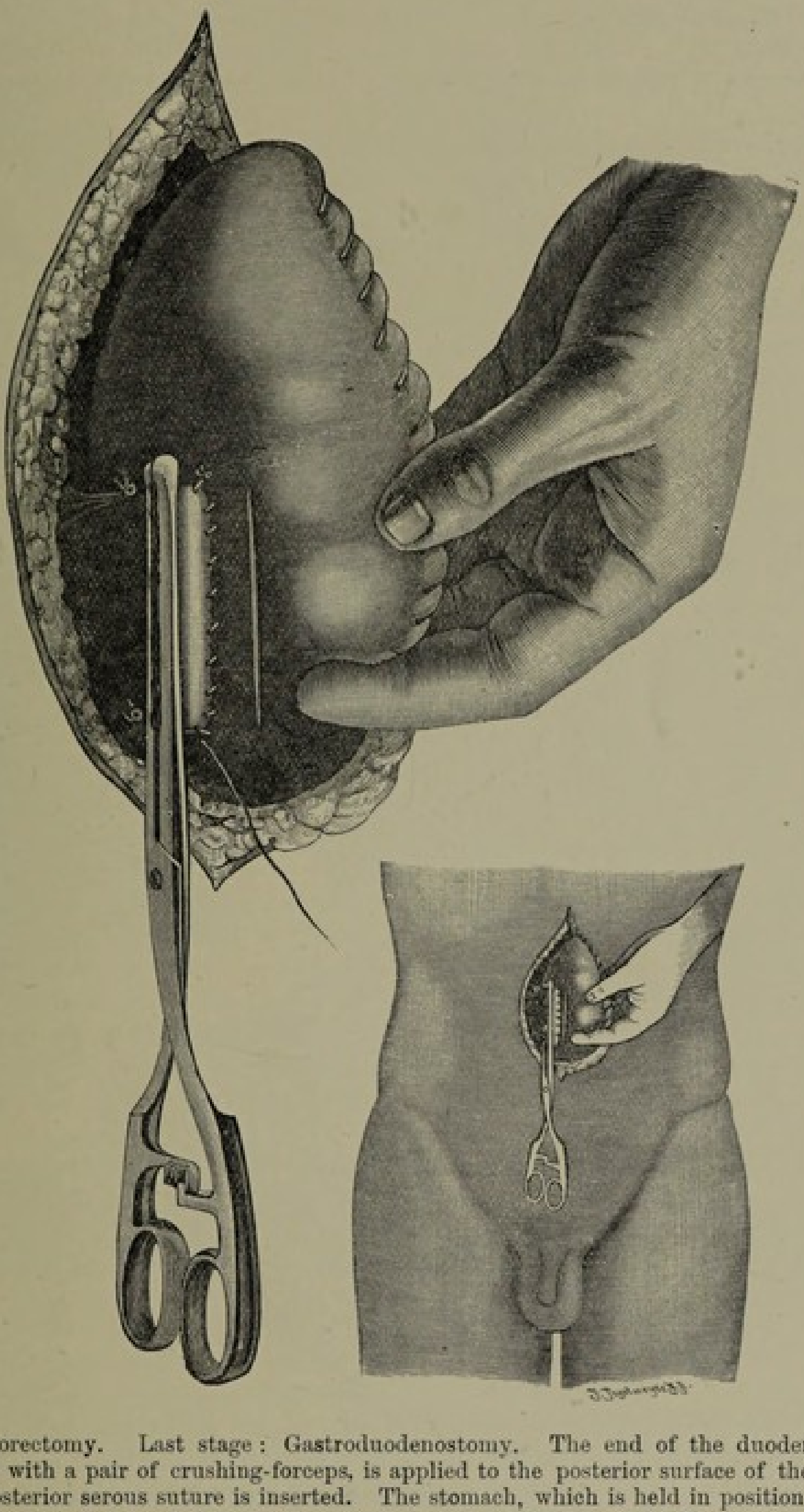


FIG. 349.—Pylorectomy. Last stage: Gastroduodenostomy. The end of the duodenum, which is closed with a pair of crushing-forceps, is applied to the posterior surface of the stomach, and the posterior serous suture is inserted. The stomach, which is held in position and closed by an assistant, is incised close to the greater curvature, the length of the incision corresponding to the breadth of the duodenum. The ligatured ends of the vessels along the upper and lower borders of the duodenum are seen immediately behind the forceps.

incised for a length equivalent to the breadth of the duodenum and at a distance of about a fifth of an inch from the posterior serous suture. Any large vessels, chiefly veins in the submucous tissue, are tied, and the edges united to the duodenum all

round with a continuous through-and-through suture. Care must be taken that the mucous membrane is in accurate apposition.

The introduction of the anterior serous suture presents no difficulty, and the

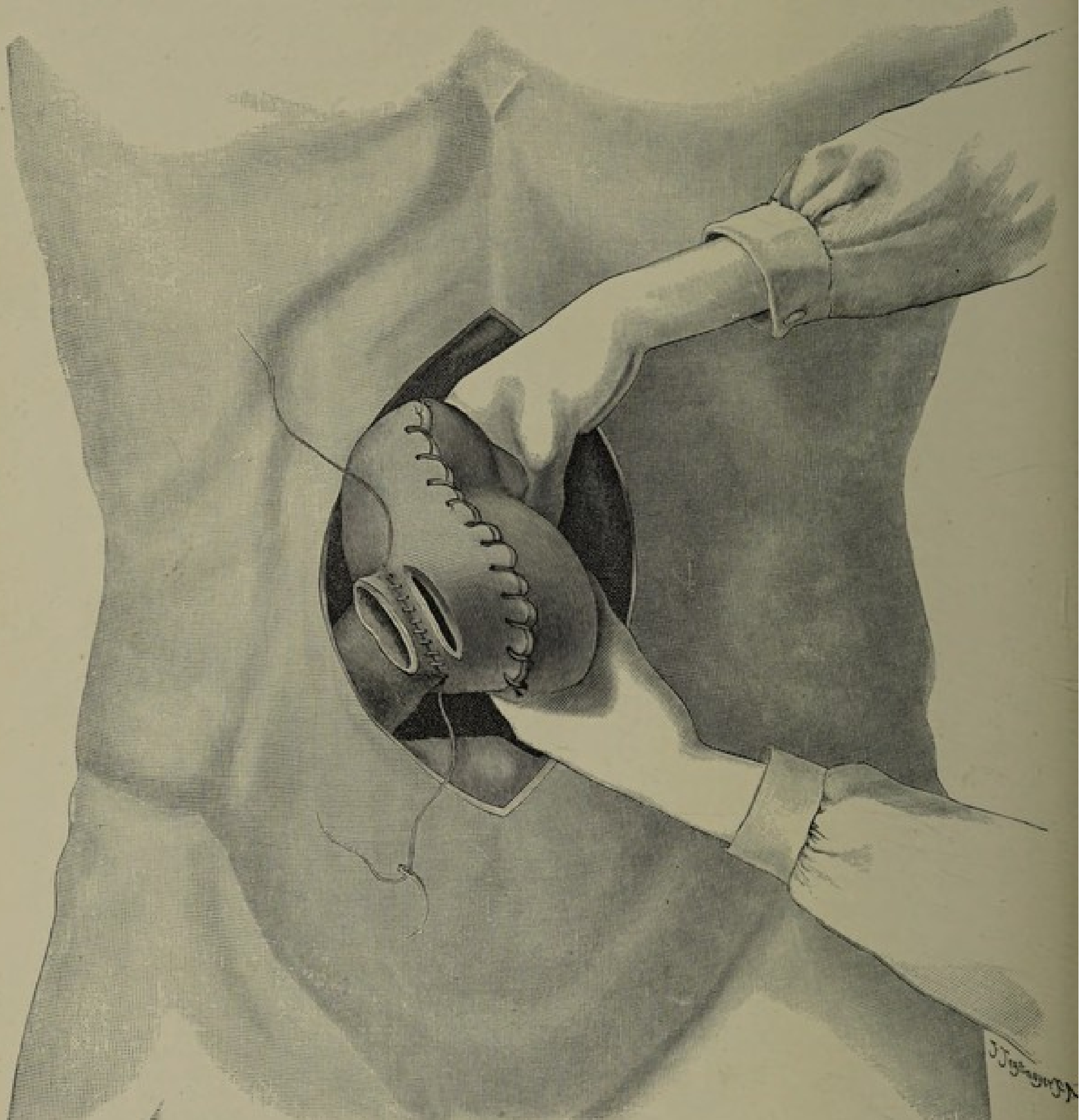


FIG. 350.—Resection of the pylorus. The stomach has been closed, and the duodenum is applied to its posterior wall. The posterior continuous serous suture has been inserted, and an incision corresponding to the lumen of the duodenum has been made in the stomach. The forceps have been removed from the duodenum to show deep suture.

anastomosis is completed by tying the anterior to the end of the posterior serous suture; it is assumed the material used is silk, which may be very fine if of good quality.[1]

[1] We again draw special attention to the fact that we absolutely reject Murphy's button for our

134. Pylorectomy with Gastro-jejunostomy. Billroth employs this operation in exceptional cases where the original Billroth method cannot be carried out, *i.e.* the insertion of the duodenum into the lower corner of the divided stomach. At the Congress of the Deutsche Gesellschaft für Chirurgie in 1887 we drew attention to the advantages of completely closing the stomach and implanting the duodenum into a separate opening and recommended it as a routine method. At that time we had gastro-jejunostomy in view, but we are convinced that it is not so effective as gastro-duodenostomy.

Despite its by no means brilliant results, gastro-jejunostomy has come to be widely employed in conjunction with gastrectomy in the Billroth II. operation. The reason for this is that gastro-jejunostomy is more easily performed, but the disadvantages, particularly in regard to the vicious circle, of a simple lateral anastomosis are still present.

Even a mild degree of vicious circle has here the disadvantage that the security of the suture by which the duodenum is closed is threatened by the upper part of the intestine becoming overloaded. This is the reason why, to use Brunner's words, this suture has become the *partie honteuse* in the Billroth II. operation, and why v. Mikulicz, one of the most successful abdominal surgeons, has come to the conclusion that of the two methods Billroth I. still gives the better results.

As we have already stated, gastroduodenostomy was always possible in our last series of cases. He who therefore adheres to the more convenient gastro-jejunostomy from unwarranted theoretical reasons is, in our opinion, bound to perform the operation in such a way that the possibility of a vicious circle is excluded, *i.e.* with the addition of Braun's entero-anastomosis or Roux's Y-operation.

The Billroth II. method requires no special description—it is performed according to the rules laid down in the previous section. Both the stomach and the duodenum are completely closed. The occlusion of the duodenum requires special care, for it is here that accidents most often occur. To ensure that it is securely closed the duodenum has to be separated for as great an extent as is required for implantation into the stomach, and in this respect the method presents no advantages over gastroduodenostomy.

After the occlusion of the stomach and duodenum has been completed, gastro-jejunostomy is performed, and to be entirely satisfactory the latter must be combined with one or other of the methods mentioned above, *i.e.* either Braun's entero-anastomosis or Roux's Y-operation. It is therefore seen that instead of the stomach or intestine being twice surtured as in our operation, four sutures have to be inserted, two occluding and two anastomosing. To avoid this some surgeons have had recourse to performing the operation in two stages—a not altogether pleasant experience for the patient.

135. Pylorectomy by the Rydygier-Billroth Method, No. I. This is the original method introduced by Billroth, with which the first successful resection of the stomach was accomplished. In it the tumour is excised, the duodenum implanted into the lower part of the cut edges of the stomach and the upper part closed. The weak spot of the operation is the point where the occluding suture of the upper portion of the stomach wound joins the anastomosing suture lower down, for it is difficult to obtain secure closure without causing tension. The method, therefore, has now been abandoned by the majority of surgeons.

136. Pylorectomy after Henle and Mikulicz, and after Rydygier. The Henle-Mikulicz method is analogous to the Rydygier-Billroth or Billroth I. operation, with this difference, viz. that a loop of jejunum instead of the duodenum is implanted into the lower part of the divided stomach. It may be employed in cases where the

gastroduodenostomy. If one looks at Kümmel's statistics (published by Ringel) relating to specially difficult cases, where fifteen died out of twenty-four, it is seen that Kocher's method gave the best results, but only in the cases in which Murphy's button was not used. Zoege von Manteuffel (*vide* W. Fick, Langenbeck's *Archiv*, Bd. 54) has only lost one case out of six operated on by our method, and speaks well of it. Hochenegg (*vide* Porges, *Wiener klin. Wochenschr.*, 1897) has not lost any cases out of four pylorectomies, and credits Kocher's methods with the excellent results he has obtained.

condition of the duodenum renders it unsuitable for gastroduodenostomy—in our opinion a very exceptional occurrence.

Rydygier's operation is categorical. He divides the jejunum 12 to 16 inches below the duodeno-jejunal flexure as in gastroenterostomy, inserts the upper end into the intestine six inches lower down and the lower end into the greater curvature. The operation is therefore a combination of the principle of Roux's Y-method with the Billroth II., and in this connection is worthy of much more consideration than the Henle-Mikulicz operation.

Rydygier, however, loses sight of the best feature in the Billroth II. operation when he proposes (in his second operation) to fix the efferent gut in the lower end of the divided stomach; and certainly few surgeons will approve of a complicated procedure such as refraining from immediate resection of the pyloric portion, but suturing it in the abdominal wound in order to feed the patient by passing a tube through this "fistula" into the duodenum, and only completing the resection at some later time.

The best features in Billroth's second and Rydygier's second method can be retained by first performing gastroenterostomy by the Y-method (gastroenterostomy by our method with a Braun's anastomosis is equally good), and at a later operation resecting and closing the stomach and intestine. Rydygier himself states that patients are often unwilling to submit to a second operation, and we maintain that the difficulty of dealing with the duodenal stump is not surmounted by this method any more than by Billroth's second method.[1]

137. Irregular and Partial Circular Gastrectomy. An irregular or circular gastrectomy may be indicated when the tumour is situated away from the pylorus, *e.g.* on the lesser curvature, or the posterior wall. If, in such a case, partial resection is undertaken, it is advisable to begin with the separation of the chain of glands along the greater and lesser curvatures and with division of both omenta. One or two pairs of clamps are then applied to shut off the rest of the stomach from the portion to be excised, and after carefully packing with gauze in order to prevent any soiling of the peritoneum, the stomach is cut across wide of the tumour, the serous coat being first divided all round with the knife, after which the tumour is cut away with scissors, keeping sufficiently far from the edge of the ulcer. Forceps are applied to the bleeding points, but it is not necessary to ligature them, as the hæmorrhage is arrested when the sutures are inserted. The projecting mucous membrane is first closed with a catgut stitch, after which the muscular and serous coats are united with a continuous suture of fine silk, and lastly the serous coat is sutured.

When a circular resection is undertaken, it is often necessary to make an additional incision in the gastric wall before the proximal and distal portions of the stomach can be securely united with three layers of sutures.

Cancer rarely affects the stomach elsewhere than at the pylorus. Comparatively recently, however, we have encountered two cases in which this was otherwise. Such cases are distinguished clinically by the absence of signs of pyloric obstruction or dilatation of the stomach, and beyond a sensation of fullness in the stomach, pain, disturbance of digestion and emaciation, the condition gives rise to few symptoms. These subjective phenomena may often only exist for some weeks or months, although objective changes characteristic of carcinoma (diminution of hydrochloric acid, etc.) are already present.

Simple ulcer, on the other hand, is more often situated at a distance from the pylorus, most commonly on the lesser curvature. We recently excised an ulcer in this position which had given rise to a recurrence of symptoms notwithstanding the fact that anterior gastroenterostomy by the Y-method had been performed some time previously. Although the anastomosis was functionally perfect, a typical ulcer on the lesser curvature was discovered. Recovery in this case was uneventful. As a rule, partial and circular resections run a satisfactory course.

[1] We learn from Kausch's *Gedenkband an Mikulicz* (Jena, bei Fischer, 1907) that Martin, a pupil of the admirable Mikulicz school, saw three deaths occur where Billroth II. had been performed, one because the stitches closing the duodenum did not hold, one from vicious circle, and a third death resulted from vomiting, while, according to Kocher, a fatal local complication occurred in one case.

138. Gastrectomy associated with Resection of the Colon. Although we shall consider the technique of resection of the large intestine in a later chapter, we might mention here that till recently the presence of adhesions between the stomach, colon, and mesocolon, was regarded as a most unfavourable complication to the performance of gastrectomy, while if the tumour is adherent to the pancreas and liver, resection, as a rule, has to be abandoned altogether as the chance of obtaining a radical cure is so slight.

Formerly, the great risk of removing a tumour which was adherent to the mesocolon lay in the onset of gangrene of the colon, which was manifested by symptoms of peritonitis developing about the end of the first week, the patient, after having at first made good progress, getting suddenly worse. This grave complication no longer need be feared. We are now able to judge of the vitality of the bowel by observing whether there is pulsation in its vessels. Wherever pulsation in the vessels cannot be found, the portion of the colon involved must be resected.

But notwithstanding this assistance, the mortality is still high. In no less than three of the four fatal cases mentioned in our third series of pylorectomies, simultaneous resection of the colon had been performed. On the other hand, two patients recovered after a similar operation.

What, therefore, can we do to diminish the dangers of a radical operation in those cases where the colon is involved? Whatever measures we adopt, the risks can only be partially diminished, for we are dealing with patients with advanced disease, who are already much reduced, and who, naturally, have to face an extensive operation.

Serious local complications can be prevented. In dealing with resection of the large intestine we shall consider the reasons why the results are worse than after resection of small intestine or stomach. The contents of the colon are so highly infective that the slightest escape sets up an infection of the surrounding tissues, while the stitches are so readily infected from the interior of the bowel, that, notwithstanding two or three layers of sutures, the closure may not be reliable.

We consider the only remedy for this is to close both ends of the large intestine with occluding sutures, and conduct off the contents of the gut by anastomosing a terminal loop of the small intestine with the large intestine at a suitable distance from the seat of the resection. This allows one to remove (1) as much of the colon as has a doubtful vitality, without any fear of causing necrosis from defective blood-supply, while at the same time (2) the junction of the intestines is relieved from the risk of mechanical and chemical injury from pressure of fæces. We refer the reader to the description of ileo-colostomy, which is described in the treatment of ileo-cæcal tumours (see p. 631), and which is an operation free from all risk.

The large intestine is resected as far as the interference with the mesocolon seems to have affected its blood-supply. The bowel is crushed with two strong compression-forceps and a ligature applied in the groove left by the one instrument. It is then divided close to the other pair of forceps with the thermo-cautery, which completely destroys the mucous membrane of the stump. The stump is then covered in with a suture passed through serous and muscular coats, and lastly the closure is completed with a serous stitch.

A loop of ileum near its termination is then drawn out and a lateral anastomosis made with the pelvic colon, using clamps in the manner to be described later. The ileum may be cut across low down, the cæcal end occluded, and the other end inserted into the pelvic or descending colon.

139. Gastrectomy with Resection of the Cardia. First of all, Mikulicz, and then Micheli, Marwedel, and Aesthower, showed how to obtain sufficient access in operations on the cardia, where careful suturing is essential. Marwedel's[1] operation deserves most commendation. In it an oblique incision is made along the costal margin, analogous to that described for exposure of the bile-ducts. The 7th and possibly also the 6th ribs are divided at the junction of their costal cartilages, and a flap consisting of skin and muscle is reflected upwards as far as the costo-chondral junction of the 7th, 8th, and 9th ribs, the cartilages of which are divided with the knife. By turning up the costal arch as a flap, good access is in this way obtained.

[1] *Centralbl. f. Chir.*, Aug. 1903.

We are convinced that, as was mentioned in connection with operations on the bile-ducts, it is frequently possible by merely bending the costal arch forcibly upwards to fracture the ribs at the junction of their cartilages. This is a much simpler procedure and provides excellent access.

Further, the researches of Biondi, Levy, and Krukenberg have proved of essential service, in regard to the technique of excision of the deeply-placed cardiac end of the stomach. According to Krukenberg, it is essential to free the œsophagus at its opening in the diaphragm, and to pull down 3-4 inches into the abdominal cavity (his experiments were performed on medium-sized dogs). Division of the peritoneum is essential. It is an undoubted advantage to procure a long intra-abdominal portion of œsophagus, because the point at which it is inserted into the stomach can be further invaginated, and the serous coat of the latter stitched higher up on the œsophagus, after the manner of Kader's gastrostomy.

From an operation which we undertook on the 21st November 1905, and from subsequent experiments on the cadaver, we recommend the following procedure :—

The abdomen is opened by a mesial incision, extending from the sternum to the umbilicus, exposing above the sternal attachment of the 6th and 7th costal cartilages. A second incision is carried outwards from the junction of the middle and lower thirds of the wound to meet the left costal margin at the junction of the 7th and 8th cartilage, and is then prolonged over the 7th cartilage obliquely upwards and outwards as far as the 6th rib, which is exposed subperiosteally and cut across, care being taken not to injure the pleura. The 7th and 8th cartilages are similarly divided at their junction with the ribs, and the ribs drawn upwards. At the upper end of the mesial incision the sternal attachments of the 6th and 7th cartilages are divided, after separating the perichondrium. The costal margin can now be turned up as a flap along with the skin and muscles, and access got to the under surface of the diaphragm.

This preliminary operation greatly facilitates access to the œsophageal foramen. By raising the left lobe of the liver, the left end of the coronary ligament (left lateral ligament) which passes from the diaphragm on to the cardia and œsophagus, is put on the stretch, and divided at the cardia, after which the peritoneum is incised all round as close as possible to the junction of the œsophagus with the stomach. In this way the vagus nerves are preserved.

A finger can now be hooked round the œsophagus and 2½ inches or more of the latter gently pulled down, force being avoided, as the muscular coat of the œsophagus readily tears. The vagus nerves can be easily drawn forwards if required. If the peritoneum round the end of the œsophagus is not divided, the diaphragm is not pulled down with it, while the pleura only follows it slightly as is shown by examination from the pleural cavity.

Two pairs of strong clamp-forceps[1] are then applied to the œsophagus close together immediately above the cancerous cardia, the portion in the grip of the upper forceps is ligatured, and the œsophagus cut across above the lower pair. The muscular coat of the œsophagus is now closed with stitches, and a Murphy's button passed by Sauerbruch's method into the blind end of the œsophagus from the mouth, a clamp being subsequently applied above it. Excision of the cardia is now performed in the same way as we described under resection of the pylorus, using large crushing-forceps and securely closing the stomach. The female half of a Murphy's button is then inserted into the stomach through a small special opening (which is closed immediately after), and is made to project against a portion of the fundus of the stomach which can be conveniently approximated to the œsophagus. A small incision is then made over it and the cylinder allowed to protrude.[2] In the same way the male portion in the lower end of the œsophagus is pushed through a small incision in the wall of the œsophagus above the constricting suture and the two halves of the button are united.

From what we have said regarding the first Billroth operation, we condemn inserting the œsophagus into the divided edge of the stomach by sutures (a method

[1] Crushing-forceps must be avoided here, since they cut through the friable œsophageal wall.

[2] Sometimes the incision can be made at first at the place where the button is to be fixed into the stomach wall.

which Levy has employed), but adhere to the principle, first laid down by us at the Surgical Congress in 1887, that the œsophagus, like the intestine, should be inserted into a special opening in the stomach.

No successful case of resection of the cardia has as yet been recorded, the operation seems to have been first performed on man by Mikulicz and Bernays.

We see no reason, however, why as good results should not be obtained after it as after total excision, if due regard be paid to contraindications. It follows, however, that it must be more rarely indicated, since at the time when operation is considered, the growth in the cardia has often spread to the œsophagus, or the primary focus may have originally been in the œsophagus.

According to Levy, Krehl has proved that the vagi may be divided in front of and behind the cardia without doing any harm.

(b) Total Gastrectomy

Since the last edition of this work was published, Boeckel[1] and Ito and Asahara[2] have collected the recorded cases of total and partial excision of the stomach. According to Ito and Asahara 108 cases have been reported.

Boeckel's list comprises 46 cases. The majority, however, must only be regarded as extensive resections, and were every surgeon to record extensive resections as total gastrectomies it is easily seen that the number of the latter would be considerably augmented. In Boeckel's own case of complete gastrectomy it was found at the autopsy six months later that there was a "new" stomach measuring 4 inches along its lesser curvature and 8 inches along its greater curvature.

Of these 46 total and "subtotal" gastrectomies, 39·1 per cent died, leaving 28 patients, in 21 of which the subsequent history has been traced. Eleven died from recurrence, 6 cases (two of which were not malignant) are still alive, while 4 have lived for more than four years. Of the malignant cases, those operated on by Ricard, Ribera, Brooks Brigham, and Maydl are still alive.

As regards the history of the operation, Ito and Asahara, from their knowledge of the literature on the subject, give Czerny the credit of having proved experimentally (Scriba and Kaiser) that total excision of the stomach is possible. One of the dogs used for experiments was carefully studied by Ogata (Ludwig), who showed that its digestion was in no way inferior to that of a healthy dog. This was, of course, a case of subtotal excision.

Carwallo and Pachon only once succeeded in performing a complete excision in a cat, Grohe once in a dog, while Monari and Filippi's animals all died. In 1880 Albert recommended total excision in man, and Nicoladoni suggested substituting part of the transverse colon for the stomach.

In 1883 Cormor first attempted total excision in man with a fatal result, but in 1897 Schlatter performed the first successful case, which, however, was subsequently shown to be subtotal.

140. Technique of Total Gastrectomy. A surgeon may feel justly proud if he has excised the stomach successfully, for it is an operation which demands a very skilful technique. The condition of the cardia is of vital importance, and the success of the operation largely depends on whether a portion of the cardiac end can be preserved or not.

The operation is not dangerous provided that the peritoneum covering the abdominal portion of the œsophagus can be preserved, and that, after clamping the latter immediately below the diaphragm there is sufficient room between the upper clamp and that on the stomach to allow of the application of two pairs of crushing-forceps. Only in this way can the cardiac end of the stomach be securely closed and infection prevented, while at the same time the tissue to be sutured is—thanks to the peritoneum—highly resistant and capable of rapid healing. To put it shortly, subtotal resection is a comparatively safe operation, but even when the greatest

[1] *De l'ablation de l'estomac*, Paris, 1903.
[2] Ito and Asahara, *Deutsche Zeitschr. f. Chir.* Bd. 80, 1905.

care is exercised genuine total excision often fails, because the slightest strain on the œsophagus will cause the stitches to cut through where it has no serous coat. When the disease involves the cardia itself the peritoneum must be divided at a higher level and a portion of the œsophagus pulled down through the diaphragm into the abdomen.

The condition of the œsophagus and the adjacent cardiac portion of the stomach is therefore the critical factor as regards success, and careful attention must be given to this point before undertaking the operation. It is much less important what part of the intestine is united to the œsophagus and cardia (whether duodenum or upper jejunum), the essential thing is that the anastomosis should be made without causing tension.[1]

It is interesting to observe how few objections have been brought against utilising the duodenum in these circumstances, while our method of partial gastrectomy has been severely criticised. Although the difficulties are greater in the former case, the majority of surgeons see no objection to uniting the duodenum to the œsophagus. Mobilisation of the duodenum materially facilitates the operation, and may well be employed in these cases with advantage.

(c) Total Gastrectomy with Œsophago-Duodenostomy

We give the following description of an operation as performed for diffuse cancer of the stomach necessitating also resection of the colon.

The operation was performed on 9th June 1899, with the assistance of Dr. Albert Kocher, and in the presence of numerous doctors and students.

After the abdomen was opened, the large tumour, which had been felt before operation, presented in the wound, and we saw at once that it was firmly adherent to the colon and transverse mesocolon, so that their removal had also to be considered. We therefore made a careful examination to ascertain whether excision should be undertaken or not.

As usual, the growth at the pylorus was sharply defined from the duodenum. There were no adhesions with the liver, but the stomach was firmly bound down to the spleen, so that dragging on the stomach pulled forward the spleen. The tumour moved freely in front of the spine. In order to secure a better view the incision was prolonged upwards to the xiphisternum, and we were then able, by passing a hand over the fundus of the stomach, to grip the œsophagus. The stomach was densely infiltrated up to the œsophagus, and here the disease was as sharply defined as at the pylorus. There were large adherent masses of hard glands felt along the greater curvature, but there were no nodules on the peritoneum. To enable us to draw the stomach farther out of the wound we clamped the adherent part of the transverse colon on either side with powerful forceps, and divided it with the thermo-cautery, so that a piece of transverse colon 5 inches long was left attached to the stomach. The duodenum, after being carefully isolated, was divided between two strong clamps, the divided ends being cleansed with lysol. The stomach could now be drawn farther out and the adhesions to the spleen separated, the vessels being divided between two ligatures.

We had some difficulty in separating the stomach posteriorly, as the transverse mesocolon had to be very cautiously separated as it passed over the pancreas, but this was successfully done after some large vessels were divided and ligatured. The upper part of the fundus of the stomach was quite free, and, after dividing the small omentum along the lesser curvature, we were able to isolate the œsophagus sufficiently to be able to apply two clamps close together and to cut between them.

With a little trouble the forceps on the duodenum were approximated to those on the œsophagus, and while they were held in position the serous suture was inserted posteriorly, and then, after shutting off the surrounding part with gauze tampons, we carefully removed the forceps. A continuous suture of fine silk (double) was then inserted through all the coats, and the edges of the œsophagus and duodenum

[1] Cf. Kelling's careful researches, Langenbeck's *Archiv*, Bd. 75.

were united, while, finally, the anterior serous suture was inserted and tied to the posterior one.

Considerable difficulty was experienced owing to the difference in size of the two lumina; the duodenum was too wide and had to be reduced by sutures to make it fit the lumen of the œsophagus. Lastly, we performed an end-to-end union of the divided colon in the usual way, using fine silk (double).

At the end of the operation, which lasted three hours, the patient was not at all collapsed. A subcutaneous injection of saline ($1\frac{1}{2}$ pint), as well as a coffee enema, was given in this case.

It will be seen from the above description that œsophago-duodenal suture can be accomplished with good prospects of success, if crushing-forceps can be applied both above and below at a point where there is a complete peritoneal covering, and if the forceps can be approximated and a reliable posterior serous suture inserted. Half the battle is gained when the two ends are brought into firm relation with one another.

Before the crushing-forceps are removed escape must be prevented by applying clamps both above and below at a sufficient distance away (3 cm. or more), after which the circular suture through the whole thickness and the anterior serous suture is completed (all with silk). We again mention, as was emphasised in speaking of operations for carcinoma of the cardia, that access is greatly facilitated by Marwedel's method of turning up the costal margin as a flap.

(d) Total Gastrectomy with Œsophago-jejunostomy

If the duodenum cannot be made to reach the œsophagus without tension, a loop of jejunum about 16 inches below the duodeno-jejunal flexure is selected (Schlatter), and an end-to-side anastomosis made by planting the œsophagus into an incision on the convex side of the intestine. Or the intestine may be divided, the lower end anastomosed end to end with the œsophagus, and the upper end inserted into the bowel lower down as in Roux's Y-operation.[1]

Before removing the crushing-forceps off the intestine one should always be careful to pack off the surrounding parts with gauze so that there may be no risk of soiling. Rubber gloves should be worn when inserting the sutures.

With regard to Murphy's button, which was used with success in Brooks' case, it may be employed (1) whenever there is any strain on the œsophagus, or when the introduction of sutures would seem to be too difficult. Brooks thinks it unnecessary to apply a layer of sutures over the Murphy's button. Before the introduction of the button the œsophagus should be securely closed with clamps 3 to 4 cm. higher up. (2) When the serous coat has to be divided, in order to pull down the œsophagus through the diaphragmatic opening into the abdomen. The end of the œsophagus may then be either closed with a ligature over which the muscular coat is stitched, and the button, passed from above, fixed in a small lateral opening; or, the male half of the button may be inserted in the end of the œsophagus, and the anastomosis completed with the female half in the duodenum or jejunum.

It is unnecessary to add to the description of the after-treatment of total and subtotal resection of the stomach given in the fourth edition, as a knowledge of it may be assumed. It does not differ from that for partial gastrectomy except that greater caution must be exercised as regards diet.

Appendix.—Gastroplasty

141. Gastroplasty. In 1898 Albert published a paper with reference to an idea of Nicoladoni regarding the possibility of substituting the transverse colon for the stomach. The middle part of the former attached to its mesocolon was inserted into the gap left after circular resection of the stomach, and the ends of the large intestine were to be reunited. The idea is not unreasonable. The colon can be transplanted

[1] It is interesting that no objection is raised in this case to making an ante-colic anastomosis, a proceeding so often proscribed for gastroenterostomy.

in this fashion and still maintain almost its normal connection with its vessels of supply, and it is not impossible that the great omentum could be used to strengthen and lend security to the line of suture on the stomach by doubling it over the line of junction above and below.

In his experimental work on the stomach with regard to transplantation Reerink refers to Senn's attempts. The latter was the first to recommend the regular employment of omentum for the purpose of lending security to the line of sutures. He also refers to the cases reported by Braun and Bennet in which plugs of omentum were used to close openings in the stomach, and also to Tietze's experiments on plastic operations with the omentum, of which we have already made mention in the introductory part, and to those of Enderlein. Reerink describes an attempt to get union between a piece excised from the transverse colon and the margins of a defect in the stomach. The result was entirely successful as long as the gut remained in undisturbed connection with the mesocolon. The transplanted sections of gut maintained their nutrition and continued to functionate. By other observers ulceration has been seen to occur on the pieces of gut which were transplanted.

Baldassari and Finotti [1] have had very good experimental results in cases of defects of the stomach and intestine from implanting seromuscular flaps from the abdominal wall. The layer of muscle towards the lumen became covered over with mucous membrane and contracted like connective tissue.

142. Gastrostomy. A temporary opening has occasionally to be made in the stomach, *e.g.* in perforation of a gastric ulcer when the patient is *in extremis*. This can be done by simply stitching the edges of the ulcer to the wound (Poisonnier) [2] or again it may be required for the purpose of dilating a stricture of the œsophagus. The formation of a permanent gastric fistula, however, is a much more important operation. It is indicated in cases where the patient cannot be fed by the mouth, *e.g.* in carcinoma of the œsophagus. Patients who are emaciated to a degree, or even moribund at the time of operation, may live for months and be quite able for work after gastrostomy.

It is important that the operation should not be delayed too long, otherwise the results are often not satisfactory. The patient is already poisoned by the absorption from extensive foul ulcers, and is more liable to pneumonia and heart-failure, while there is the risk of peri-œsophageal abscesses suddenly forming and bursting into the pleura, trachea, or aorta.

One advantage of early gastrostomy is that swallowing often improves spontaneously to a remarkable extent, so much so that the patient may consider that he has undergone an "unnecessary" operation. The ulcerated area is given a rest, the dilatation above it disappears, the decomposition as well as the associated inflammatory swelling of the surrounding parts diminishes, and the stricture again becomes permeable.

If it is properly performed, *i.e.* if escape of gastric juice from the fistula is prevented, gastrostomy gives rise to no inconvenience. We used formerly to keep the opening in the stomach closed with sticking plaster, but now we leave in a rubber tube permanently and clamp it with a pair of forceps, for it not infrequently happened that the patient either injured himself by forcibly pushing in the tube, or else failed to get it in at all.

(*a*) *Direct Gastrostomy.* The method which has given us the most satisfactory results is as follows:—A vertical incision is carried from the costal margin downwards over the middle of the left rectus through the skin and the anterior layer of the rectal sheath. We now pass towards the middle line between the rectus and the anterior layer of its sheath, till we reach the inner border, which is then pulled forcibly outwards according to Hacker and Girard's method. The tough posterior wall of the sheath and the peritoneum are then incised for about 2 ins. Two fingers are introduced into the abdomen and the stomach is pulled out, care being taken not to mistake the transverse colon for the latter. Care must also be taken not to suture the stomach too close to the pylorus, as the outflow through it would be hindered. A

[1] *Clinica chir.* Bd. 11.

[2] Poisonnier, *Arch. provinc. de chir.*, 1906, No. 7.

portion of the stomach is drawn out till the greater and lesser curvatures appear, and a sufficient area of the anterior wall, close to the former, is stitched firmly to the

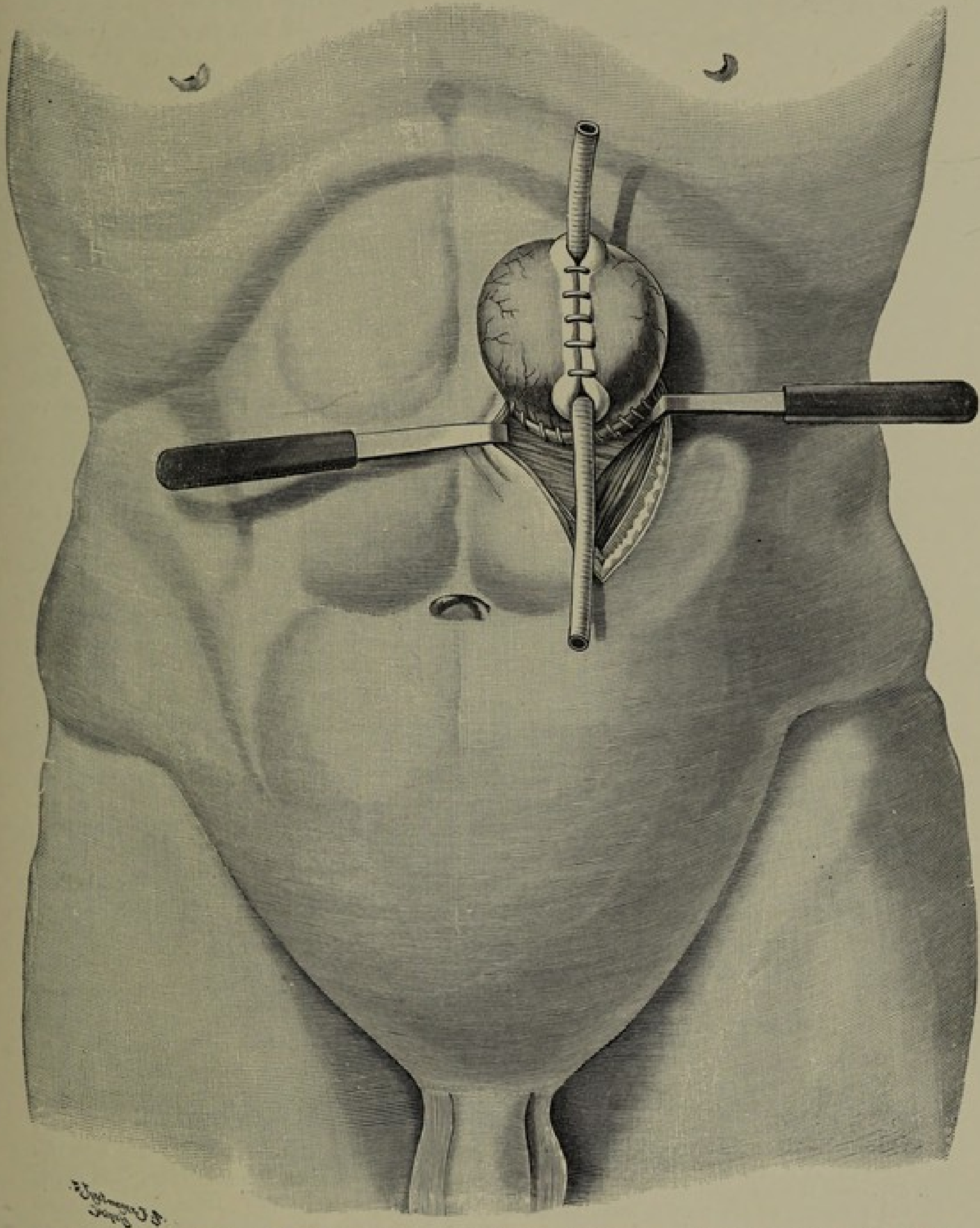


FIG. 351.—Hacker-Frank-Witzel method combined with gastropexy. A vertical incision is carried downwards from the edge of the ribs along the middle of the rectus muscle, which is drawn to the side; the peritoneum and transversalis fascia are stitched to the serous coat of the stomach all round and the stomach is folded and sutured over a drainage tube.

abdominal wound, a continuous silk suture passing through the serous and muscular coats of the stomach, and including the peritoneum and fascia of the abdominal wall. A narrow drainage tube (Witzel) is now laid vertically on the anterior surface of the

stomach wall, and the latter is stitched over it for half an inch by means of a continuous suture, applied in such a way as to include the serosa and a layer of the muscular coat on either side of the tube (Fig. 351). Just below the suture a small opening is made into the stomach, 4 ins. of the tubing is passed into it, and the serous coat is stitched over the part of the tube which is left exposed as it passes through the aperture in the stomach (Fig. 352, *a-c*). The stomach, all round the spot where the tube comes out of its tunnel, is now securely sutured to the skin. The edges of the wound are then stitched together over the stomach protuberance, and a short glass drain is inserted above and below, under the sutured skin wound.

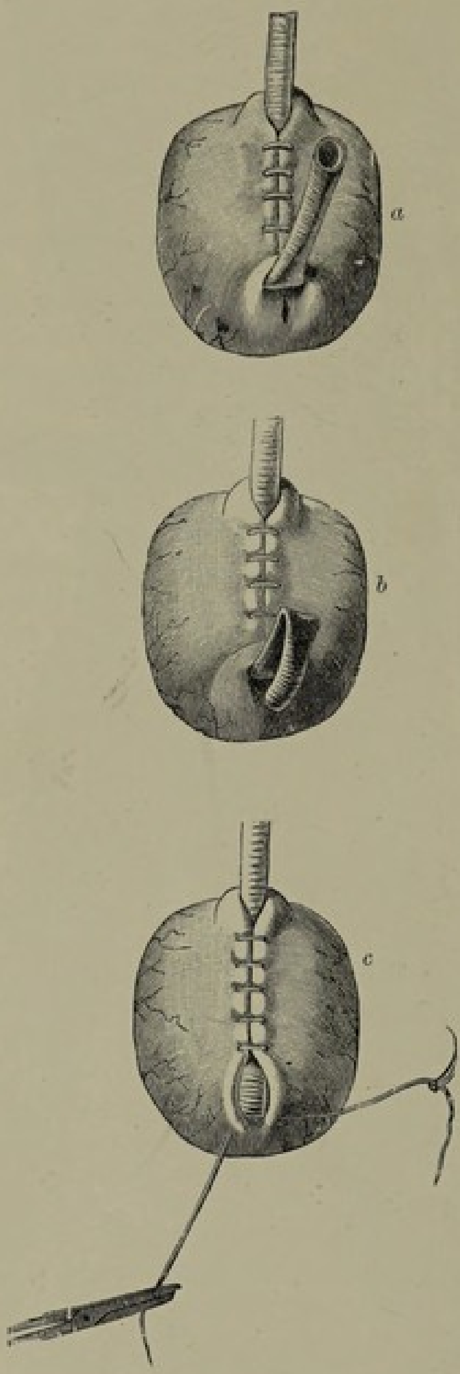


FIG. 352.—*a-c* illustrate the manner in which one extremity of the tube is introduced into the stomach through a small opening, and how the latter is covered over by another folding suture.

Some sterile water is poured through a funnel into the tube to see if the canal is clear. An iodoform gauze and collodion dressing is applied, and the tube is fixed to prevent it from falling out.

By the combination of the methods described by Hacker, Frank, and Witzel an entirely satisfactory result is obtained, as a long narrow canal is formed between the skin surface and the opening into the stomach. It is to some extent kept closed by the rectus abdominis, which lies to one side, and by its tension prevents any escape of gastric contents. The patient can feed himself properly through a narrow catheter, and no dressing is required, except perhaps a piece of elastic plaster. In an autopsy which we performed recently the stomach was found to be firmly adherent by cicatricial tissue to the abdominal wall, while the opening in the stomach, which had contracted, was drawn in and lined by perfectly normal mucous membrane, and was so small that it was difficult to find. It was connected with the opening in the skin by a canal $1\frac{3}{4}$ inches long, which had no mucous lining and was perfectly smooth.

By the addition of Witzel's method of forming an oblique canal in the stomach wall in conjunction with the muscular closure afforded by the rectus abdominis, not only is there no leakage from the fistula, but the closure is sometimes too effective, and some of our patients have been unable to reintroduce the feeding tube when they have pulled it out after leaving hospital.

Fischer and Marwedel constructed an oblique canal, not by making folds in the stomach wall, but by pushing a tube in between the muscular and mucous coats. Barrozzi speaks highly of the method.

Kader and Fontana, abandoning the oblique canal, have endeavoured merely to form a simple canal in place of the valvular fistula, and have sought by this means

to simplify the method of performing gastrostomy. Mikulicz has made extensive use of Kader's method.

We have recently tried this method on several occasions, and, on account of its simplicity, and because, as a rule, it gives a perfectly firm closure, we consider it desirable to illustrate the procedure [1] (Figs. 353 to 354).

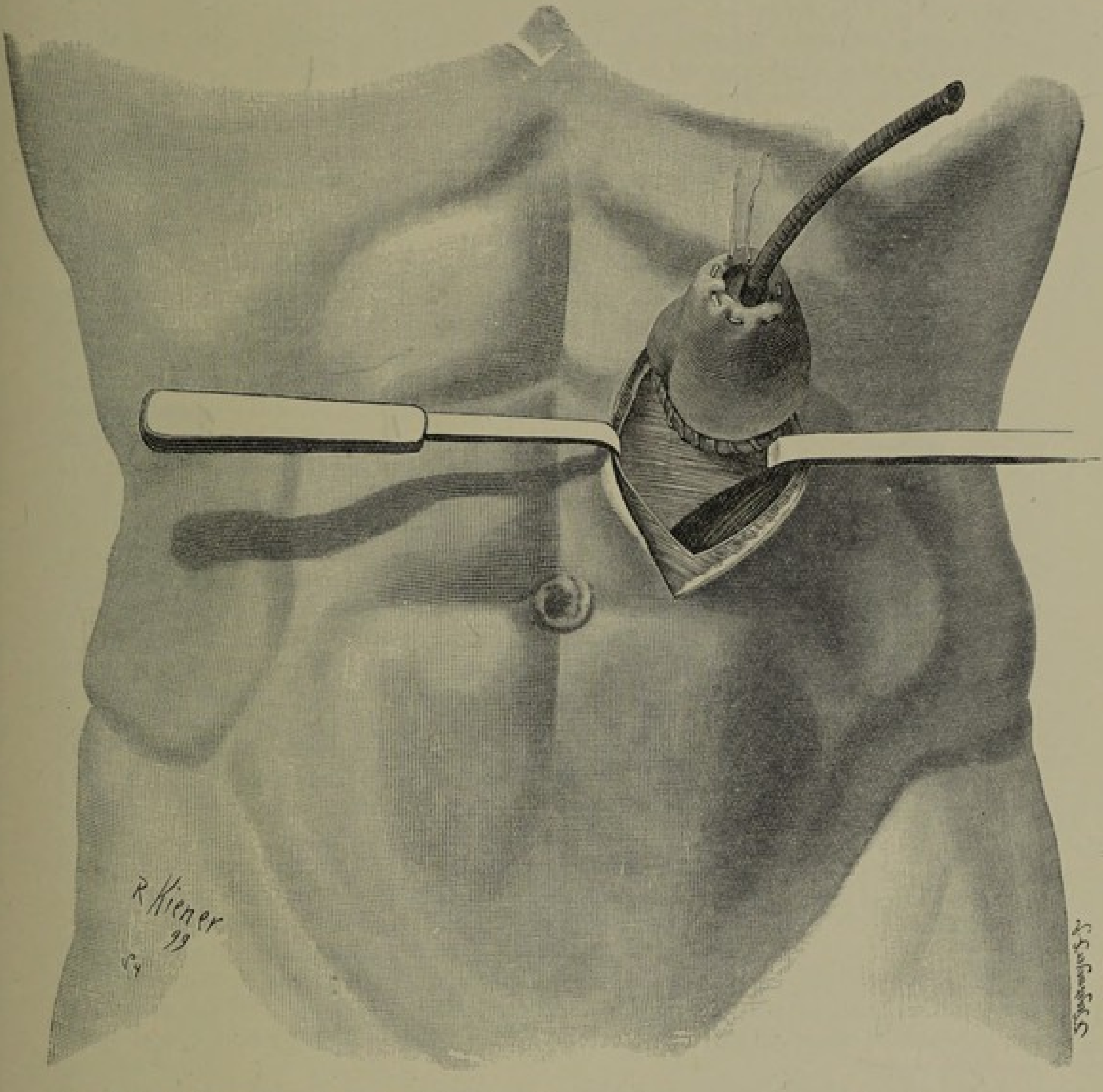


FIG. 353.—Gastrostomy. Kader's method of making a canal. A cone of stomach is drawn out and sutured to the peritoneum and fascia transversalis, the rectus being well retracted outwards. A rubber tube has been introduced at the apex of the cone and fixed with sutures; the tube has then been pushed farther in and a purse-string suture applied, which, however, is not yet drawn tight.

The cone of the stomach which is drawn out is incised at its apex by a fine knife, and in doing this care must be taken to fix the stomach so that the mucous membrane is not invaginated. The edges of the mucous membrane are secured with small hooks, and a tube is introduced and fixed in position by a fine suture, which traverses the whole thickness of the stomach wall.

The apex of the cone is now invaginated by pressing upon the firmly-secured tube,

[1] Lücke has described a similar modification.

and at a distance of 1 cm. a purse-string suture is introduced (Fig. 353) and tightened up around the tube. If it be desired to have a still longer canal, a second suture is introduced after invaginating the previous one, at a distance of about 1 cm., and tightened up around the tube as before.

In this way, as we have endeavoured to show in Fig. 354, a canal 1 or 2 cm. long, in which the tube lies vertically, is formed out of the stomach wall, and is invaginated into its cavity.

The chief difference between this and the method just described is, that there is no question of a rapid removal of the tube, as it is tightly grasped.

In order to ensure against accidents in gastrostomy, one must regard the following points as specially important in the method we have recommended :—

(*a*) The base of the portion of the stomach which is drawn out of the abdomen is to be sutured to the abdominal wall by a continuous circular suture (deep fixation suture) which completely shuts off the abdominal cavity. This is the best means of preventing peritonitis, because it prevents the escape of stomach contents into the abdomen, in case any should flow out between the wall of the stomach and the wound in the skin, or in case the stomach becomes detached from the skin.

Fig. 354.—A longitudinal section of the stomach cone showing how a canal for the rubber tube is formed by a process of invagination.

(*b*) The secure suturing of the drain into the stomach, and of the stomach to the skin wound (superficial fixation suture), in such a way that the contents cannot escape alongside it, and so infect the pocket beneath the skin. This is important because, if a subcutaneous abscess is produced, it may spread to the peritoneum.

(*c*) The satisfactory drainage of the skin wound above and below the portion of the stomach which lies between the superficial and deep fixation sutures. Should there be any escape of stomach contents, the accumulation of any discharge must be prevented.

It does not so much depend upon how the incision through the wall of the stomach is made in order to prevent the subsequent escape of stomach contents: the important object is to make the opening as small as possible. Graser and Golding-Bird have already drawn attention to this point, and have advised that the opening, which is made as small as possible at first, should be subsequently stretched to the necessary size. By making a sufficiently small incision, the prolapse of the movable mucous membrane so closes the opening that nothing escapes ; besides this, it is also of importance that the opening (as Frank has well pointed out) be placed as high as possible in the stomach, and that it be also fixed as high as possible in the abdominal wall, which is just the reverse of what should be done in gastroenterostomy, where the lowest part of the stomach should be chosen.

In carcinoma of the cardiac end of the stomach, gastrostomy is of little use, for the stomach wall is apt to tear and the ulcerated mucous membrane does not derive the chief benefit of the operation, namely protection from every form of chemical irritation. In such cases v. Eiselsberg's jejunostomy (*vide infra*) is preferable, but it is here especially that a modification of gastroenterostomy lately introduced by Tavel[1] may be used with advantage.

(*b*) *Tavel's Jejuno-gastrostomy.*[2] The skin incision is placed lower down than for direct gastrostomy. Tavel places the centre of his left paramedian incision at the level of the umbilicus.

A loop of jejunum which has a long mesentery is selected and a portion of it is

[1] *Archives provinciales de chirurgie*, June 1906 ; *vide* also Dissertation by Dr. Th. Jeanneret, Bern, 1907.

[2] Prof. Tavel has been good enough to communicate his latest method of procedure to us.

excised. The excised portion is clamped so that its mesenteric attachment is in the middle and not at one end of the blades of the forceps.

The continuity of the gut from which the portion has been excised is restored by approximating and suturing the two ends. The isolated loop is brought out through the mesocolon and omentum (gastrocolic ligament) in front of the stomach and the anal end inserted into the stomach, while the oral end is brought out through a special opening as high up as possible in the abdominal wall.

Tavel affirms that the fistula is kept absolutely closed by the normal peristalsis, and that in coughing or even vomiting the stomach will empty itself through the œsophagus sooner than through the connecting piece of jejunum.

(*c*) *Roux's Œsophago-jejuno-gastrostomy.* Roux[1] has extended the principle of Tavel's operation in a very interesting direction. In a patient with an impermeable œsophageal stricture he isolated a long portion of the intestine, and passed it right up under the skin into the neck, with the object of uniting it with the œsophagus in this region and forming a new œsophagus.

Roux points out that the vessels supplying the jejunum are distributed on a far more regular plan than those which supply the bowel lower down, especially the ileum. In the case of the jejunum, there are numerous short vasa recta given off the last arterial arch, while spaces between the vessels which go to form the latter make it easy to divide the mesentery extensively without damaging the circulation in the intestine.

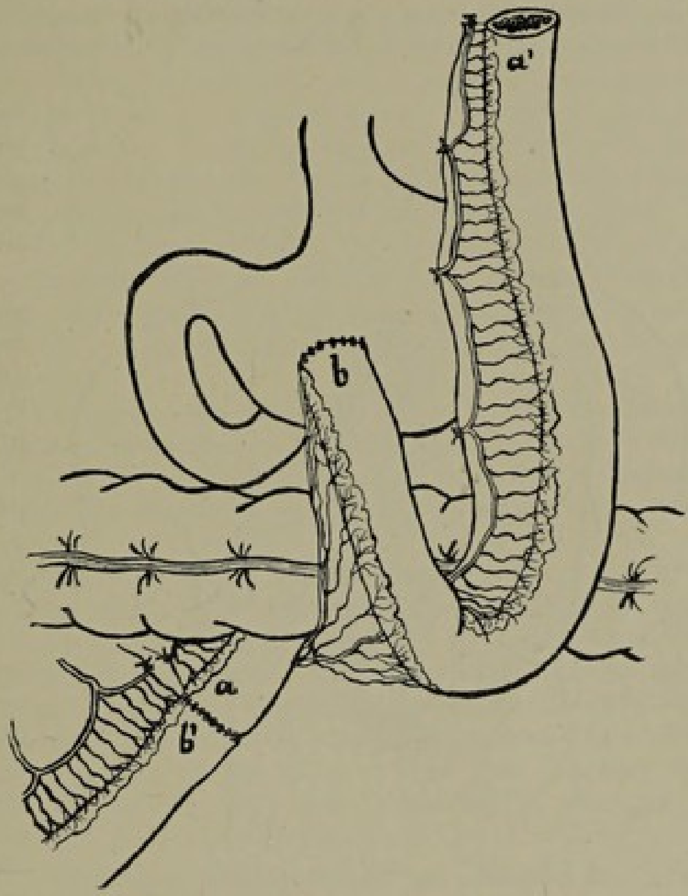


FIG. 355.—Reproduction of a sketch by Roux to illustrate œsophago-jejuno-gastrostomy. The continuity of the intestine, from which the loop has been resected, is restored. The anal end of the isolated loop is inserted into the stomach, the oral end is pulled upwards. Note the situation of the ligatures on the mesenteric vessels.

He found that by ligaturing four or five of these afferent vessels and at the same time preserving the peripheral arch the vitality of the gut was maintained by the vasa recta quite satisfactorily. In this way he was able to isolate a long enough portion of jejunum and to insert its anal end into the stomach near the lesser curvature in front of the transverse colon.

A longitudinal incision is then made below the suprasternal notch and a long pair of Richelot's forceps passed under the skin so as to make a subcutaneous channel through which the oral end of the gut wrapped in gauze is pulled and fixed to the edges of the wound with sutures. A stomach tube is then passed from above into the stomach and fixed in position, after which the ends of the divided jejunum were united with a Murphy's button. To enable the transplanted piece of bowel to be pulled through the wound, the sheath and to some extent the muscle fibres of the rectus were notched. The main wound is completely closed.

Fig. 356 illustrates the appearance after the operation. The closure of the gut

[1] *Semaine médicale*, January 1907.

is automatic and complete, and when food is put into it, it is rapidly carried down to the stomach by the peristalsis of the bowel.

We would point out that the idea of œsophago-jejunostomy (*infra*) had been previously put forward by Wullstein,[1] who, on the strength of experimental observations, suggested bringing a portion of intestine up in front of the thorax and uniting it by a plastic operation to the œsophagus, after the latter had been exposed in the neck. Roux's suggestion is, however, the simplest. We attempted the operation in an old man with cancer of the cardia, but had to resort to jejunostomy as the blood-supply of the isolated gut failed.

Appendix. Adhering to our principle only to describe those operations which we can recommend from our own experience, we refrain from giving a description of Bircher's gastroplication for dilatation of the stomach, and of gastropexy, introduced by Rovsing, for gastroptosis. Gastro-enterostomy gives such excellent results in dilatation and ptosis that apart from theoretical considerations we give it the preference from our own experience and that of others.

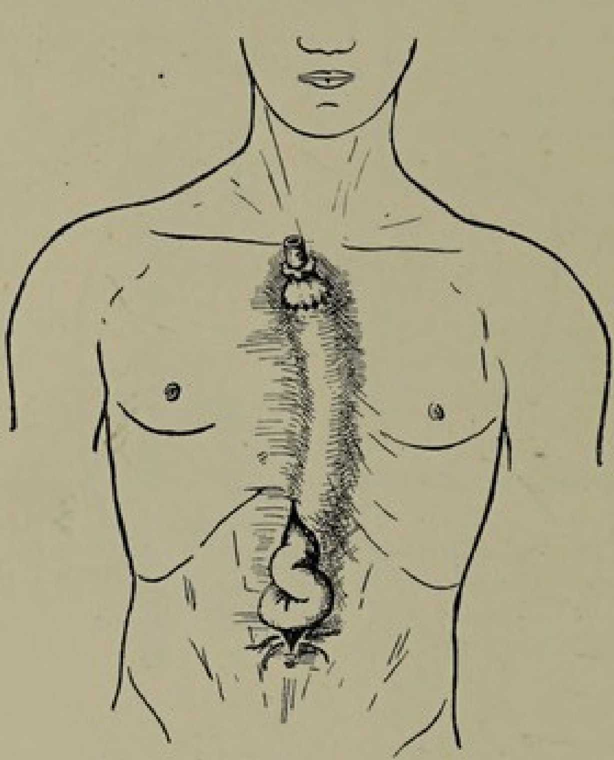


FIG. 356 represents the appearances after œsophago-jejuno-gastrostomy. (From a sketch by Roux in the *Semaine médicale*, Jan. 1907.)

Gastro-gastrostomy for hour-glass stomach requires no special description as it is so rarely indicated, and because the procedure is the same as that described for gastrectomy. When it is not possible, gastroenterostomy should be performed.

(h) Surgery of the Intestines

143. General Remarks on Intestinal Surgery. The technique, as well as the results of operations on the intestine, differ according to the portion of gut affected. The surgery of the duodenum has already been dealt with partly under diseases of the bile-ducts and of the stomach, but it will also have to be considered in connection with diseases of the small intestine.

In considering the rest of the intestine it will be convenient to treat separately the vermiform appendix, the small intestine, and the large intestine, as the prognosis and treatment of disease in each of these situations is widely different, and depends chiefly on the altered quality of the content, as well as the ease with which it can pass through small openings and defects in stitching.

In this connection the vermiform appendix is by far the most favourable, as its contents are very scanty, and unless perforation occurs at its base in the course of a gangrenous appendicitis or as the result of accidental injury, the amount of fæcal escape is very slight. It possesses a strong peristaltic current, which in virtue of its direction, and provided it is not destroyed, acts against the escape of the colonic contents in those cases where a rupture has taken place, a point to which sufficient attention has not been drawn.

The difference as regards prognosis in the large and small intestine mainly depends on the altered character of their contents, for in the case of the latter the contents undergo a very active process of decomposition, and the slightest escape is sufficient to set up infection of the surrounding parts.

[1] *Deutsche med. Wochenschr.*, 1904, No. 20.

Sutures, moreover, are more readily infected and are therefore more liable to give way in the large than in the small intestine. The latter, therefore, lends itself far better to operative manipulations, suture, resection, short-circuit, etc., than the former. Even the most experienced surgeons often find that the sutures of the large intestine are insecure and give way.

Success in all intestinal operations is mainly dependent on the security of the intestinal sutures, especially in enterostomy, in all forms of anastomosis either simple or for short-circuiting, and in all operations where resection and suture or gut are required, *e.g.* in simple resection and plastic resections where one portion of intestine is substituted for another or for a hollow viscus, such as the bladder.

We shall consider intestinal surgery on these lines and deal with the features peculiar to each.

144. Enterostomy. Under the term enterostomy, *i.e.* making an opening in the intestine, are included such operations as appendicostomy, duodeno-, jejuno-, ileo-stomy, or colo-stomy. It is undertaken chiefly for the purpose of emptying the bowel, and may be either temporary to prevent the risk of stagnation of infectious contents, or to provide a permanent escape when the gut is obstructed lower down.

But in addition to affording relief in obstruction of the bowels (generally low down in the colon) enterostomy is employed for the purpose of administering nourishment when food cannot be taken by the mouth, and occasionally it is used for the exhibition of drugs. In these cases the opening is made high up in the intestine (duodenum or jejunum).

(*a*) *Temporary Enterotomy.* In temporary enterostomy, or to use the better term, enterotomy, the opening is closed immediately after the intestinal contents have been emptied. It is of great value both in mechanical ileus and in the dynamic type where the stagnation is caused by impaired peristalsis, consequent on over-distension and circulatory disturbances.

It is less often employed in infective enteritis, although with the exception of acute obstruction there is no condition which more urgently calls for the bowel being emptied, as the decomposition is very active and gives rise to rapid toxæmia. While the stomach can be readily emptied and washed out with a tube, the ordinary measures for emptying the bowels are often unsatisfactory or contraindicated. Enterotomy, by getting rid of the intestinal contents, therefore, achieves the same good results in severe toxæmia that lavage of the stomach does and is often the means of saving the patient's life. This is especially true in peritonitis where for a longer period provision has as a rule to be made for emptying the intestine than is required in the case of temporary stasis or infective enteritis. (See the following section.)

The technique of enterotomy is very simple. A coil of intestine is pulled out, fixed in the wound with a loop of thread which is passed through the mesentery close to the bowel, and secured with artery-forceps. The bowel is opened by a transverse incision on its convex surface, and a double flanged glass tube is tied in, to which is connected a rubber tube to carry away the fluid contents from the wound.

If enterotomy has to be performed in the course of a laparotomy, *e.g.* in a case of ileus, the bowel should be emptied both from above and below towards the opening, which should be, as a rule, as low down as possible.

The whole length of the small intestine can be thoroughly emptied, and if necessary can also be washed out with salt solution. Dahlgren has introduced a double roller by which the bowel can be "milked." We find it easier, however, to manipulate the bowel with the hands protected with rubber gloves than with instruments. Moynihan employs a glass tube 8 inches long which he inserts into the intestine, and after fixing it in position with a rubber band, 6 or 7 feet of gut are pulled over the tube and emptied. Finally the gut is picked up, and the small incision closed with a double row of sutures, after which the intestine is thoroughly cleansed with saline and replaced.

(*b*) *Permanent Enterostomy.* If provision has to be made for emptying the intestine repeatedly, the opening must be made so as to allow the intestinal

contents to escape for a longer or shorter period. This can be obtained in two ways, depending on whether the opening is to be allowed to close after a short interval or whether it is to remain open permanently.

A permanent opening in the small intestine is as a rule only indicated in cases of high-seated obstruction, *e.g.* in cancer of the stomach, to allow of the patient being fed. The technique of the operation will be described in the sections dealing with duodenostomy and jejunostomy. By stitching the mucous membrane to the skin, so that the mucous membrane projects like the lips, a permanent opening is obtained which functions well. Such a permanent opening is most frequently indicated in the large intestine (*vide* Colostomy).

On the other hand, an opening in the small intestine is generally of a temporary nature and is often resorted to in cases of ileus and peritonitis for the purpose of draining away the infective intestinal contents.[1] Some years ago in an article on ileus we drew attention to the toxæmia that follows the absorption of decomposing intestinal contents, and to the serious effect of distension on the intestinal wall.

It is generally recognised now that absorption of the decomposing stagnant fæces is the most serious feature of ileus and peritonitis, and that the toxæmic collapse is most rapidly relieved by emptying the intestines. Enterotomy or enterostomy is now universally employed in obstruction of the bowels in addition to laparotomy, or enterostomy alone may be all the patient can survive.

It is only recently that enterostomy has been extensively employed in the treatment of peritonitis. Some surgeons, notably Heidenhain,[2] Haffter,[3] and Lennander are strongly in favour of making more than one opening, and Payr, Lund, Moskowicz, Escher, and Hofmeister have recorded very good results with multiple enterostomy. As we have already mentioned, the opening is often used in order to stimulate the peristalsis by an injection of concentrated solution of Karlsbad salts (Busch), atropin in doses of 1 mg. ($\frac{1}{64}$ gr.) (according to Dahlgren, repeated four times), or physostigmin doses up to 1 decimg. ($\frac{1}{600}$ gr.).

Technique of Enterostomy, avoiding a Permanent Fistula. Enterostomy has often to be undertaken in patients already suffering from toxic collapse, the result of neglected ileus or peritonitis. It must therefore be performed as rapidly and in as simple a manner as possible under local anæsthesia (novocain and adrenalin).

The bowel should be opened at a point where the distension is most marked, if possible low down in the ileum. The skin and aponeurosis are incised, the muscles (internal oblique and transversalis) split with a blunt dissector, and after a second injection of novocain under the fascia transversalis the peritoneum is opened. One has then to determine whether the intestines are too adherent to the abdominal wall to allow of their being pulled out.

(1) *Enterostomy when the Gut is adherent, and the Intestinal Wall is friable.*—When a loop of bowel cannot be brought out, the edges of the wound, particularly the divided muscles, should be rubbed over with xeroform powder, and the parietal peritoneum and deep fascia (fascia transversalis) stitched to the serous and muscular coats of the bowel with a continuous suture (*vide* Fig. 357). A fine curved needle, and the thinnest silk must be used for this purpose, as if there is much tension, gas and fluid contents may escape even through very small stitch holes.

After the bowel is securely stitched to the abdominal wall it is punctured with a small knife. Gas at first escapes freely, followed by the fluid contents, which should be washed away with saline lotion (the bowel itself is not washed out). The surrounding parts are best protected by covering them with a large sheet of gutta-percha tissue which can be made to adhere firmly by pressure with warm gauze

[1] Posner and Lewin (*Deutsch. med. Wochenschr.*, February 1895) have given experimental proofs of the importance of autoinfection from the intestine. Twenty-four hours after tying the rectum in rabbits they found the B. coli in the blood of the heart, peritoneum, kidneys, and urine. Similarly Genersich of Mikulicz's clinic (*Beitr. z. klin. Chir.*, 1903) has recorded experiments on ligature of the intestine, in which there were produced excessive meteorism and decomposition of intestinal contents, damage to the intestinal wall, absorption of toxins, and rapid escape of the colon bacillus. Magnus has directly demonstrated intestinal poisons.

[2] Busch, *Deutsche Zeitschr. f. Chir.*, 1904.

[3] *Deutsche Zeitschr. f. Chir.* Bd. 74.

compresses. The intestinal contents are then led away into a bowl by folding over the edges of the rubber sheet.[1]

When the intestine has collapsed after being emptied, deep sutures should be inserted at both extremities and in the middle of the incision, if there is any doubt that the suture is not secure. A small drainage tube is then inserted in the opening and the wound packed with iodoform gauze.

(2) *Enterostomy when the Bowel is free and can be pulled out of the Abdomen.*—If it is found that, when the peritoneum is opened, the bowel can be brought out of the wound, and that its walls are not friable, the operation is carried out on different lines to that just described. Here the intestinal contents are led off without coming in contact with the wound at all, and for this purpose either Paul or Mixter's tube is used by preference in England and America.

After the peritoneum has been opened a distended loop is pulled out, emptied by milking back its contents, and clamped, gauze compresses being carefully packed under the clamp to protect the wound from soiling. A small incision is then made into the gut on its convex side, a glass tube is tied in with fine silk (Fig. 358) and the edges of the incision are disinfected with lysol and alcohol. The forceps are now taken off and the bowel is emptied : if desired, it may be washed out before the loop is replaced inside the abdomen. The gut, in which the tube is, is then replaced, and stitched to the parietal peritoneum and fascia with two sero-muscular stitches.

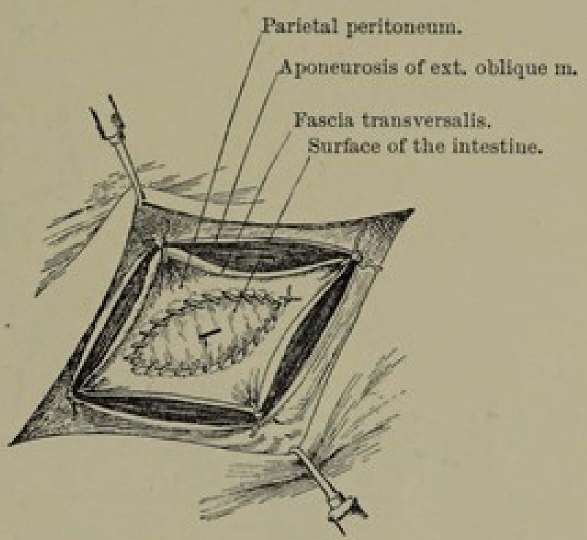


Fig. 357.—Formation of a fæcal fistula.

Before the gut is opened a purse-string suture should be inserted, which when tightened keeps the tube in position, while the ends of this suture may also be fixed to the abdominal wall. Iodoform gauze is packed all round the glass tube, and the intestinal contents are led off with a rubber tube. Adhesions form in a few days (*i.e.* before the sutures cut their way out and the tube becomes loose) and the wound is protected by granulations.

One can be more certain of the opening ultimately closing by making an oblique fistula according to Witzel's method. To do this, a rubber tube is applied along the wall of the gut and fixed there with stitches. The one end of the tube enters the gut while the other is brought out through the wound in the manner described for gastrostomy.

An oblique fistula heals spontaneously soon after the tube is taken out. The bowel round the tube should be stitched to the under surface of the peritoneum in the same way as when Paul's tube is utilised.

Patients who come to the table cyanosed, with cold extremities and with a small rapid pulse, are quite unable to stand any shock, absorption of poisons, severe pain, an increase of the abdominal hyperæmia, or any action of toxins. They often recover in a marvellous manner under enterostomy, subcutaneous saline injections, and nutrient enemata.

Enterostomy is also of advantage in the collapse due to ileus and peritonitis, when an attempt to remove the original cause by laparotomy would only hasten a fatal issue.[2]

[1] We consider this adhesive rubber tissue better than Heidenhain's cloth covered with zinc paste which Busch recommends.

[2] Cf. the excellent work of W. Braun (*Beitr. z. klin. Chir.*, 1904) which is based on Krause's large experience.

(c) *Permanent Enterostomy.* While temporary enterotomy as well as enterostomy in the vast majority of cases is performed in the ileum, as ileostomy, and occasionally as jejunostomy and colostomy, a permanent opening, on the other hand, is most commonly made in the jejunum and colon, the upper portion of the intestinal canal being utilised for the administration of nourishment, the lower portion, when a permanent exit for intestinal contents is intended. The different forms must therefore be kept separate.

145. Duodenostomy. The method of exposing the bile-duct or the duct of

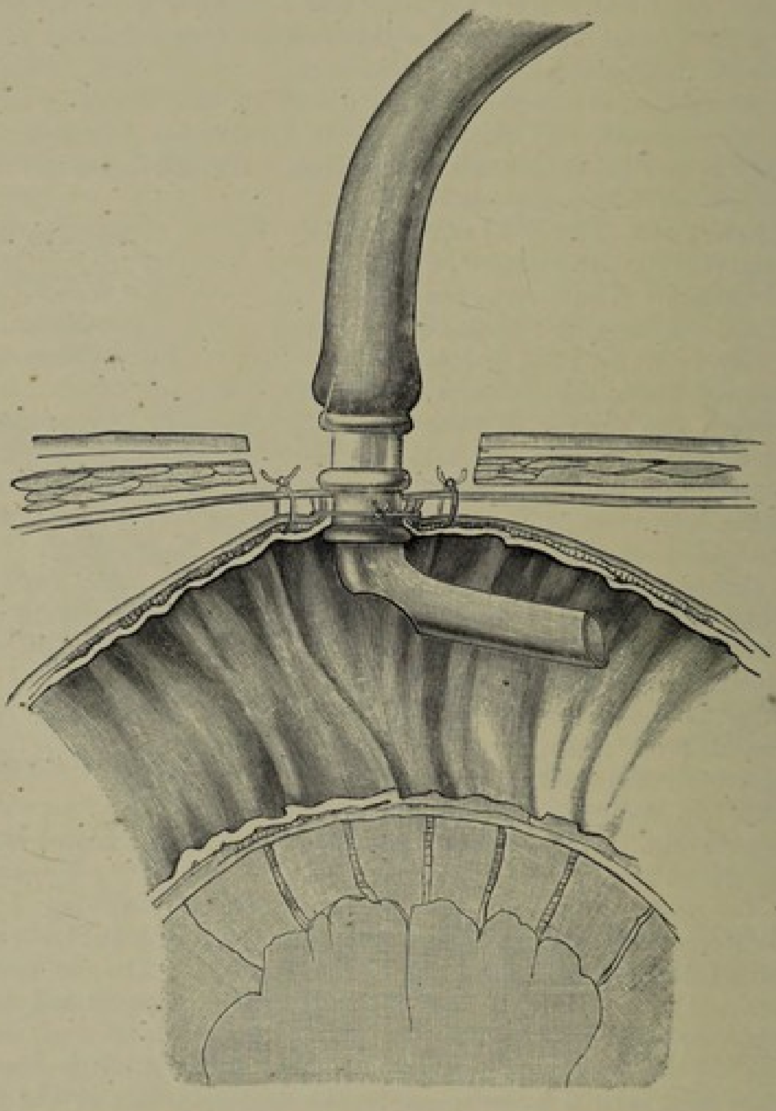


Fig. 358.—Enterostomy in small intestines. The figure illustrates, in section, the manner in which the glass tube is fixed in the intestine, and how the bowel is united to the fasciæ with sero-muscular stitches. The external wound is not closed.

Wirsung through the duodenum has been described under the surgery of the bile-ducts and pancreas. The idea of making a permanent opening in the duodenum was first suggested and carried out by Braun, while Langenbeck performed the first successful case. Hartmann recommends it instead of jejunostomy.

There is no doubt that the operation is greatly simplified by mobilising the duodenum, for the bowel can then be brought up and fixed to the abdominal wall without tension, a procedure which, without mobilisation, may be very difficult. A somewhat larger incision is required than that for jejunostomy, and since the introduction of Maydl's modification of jejunostomy, in which the bile and

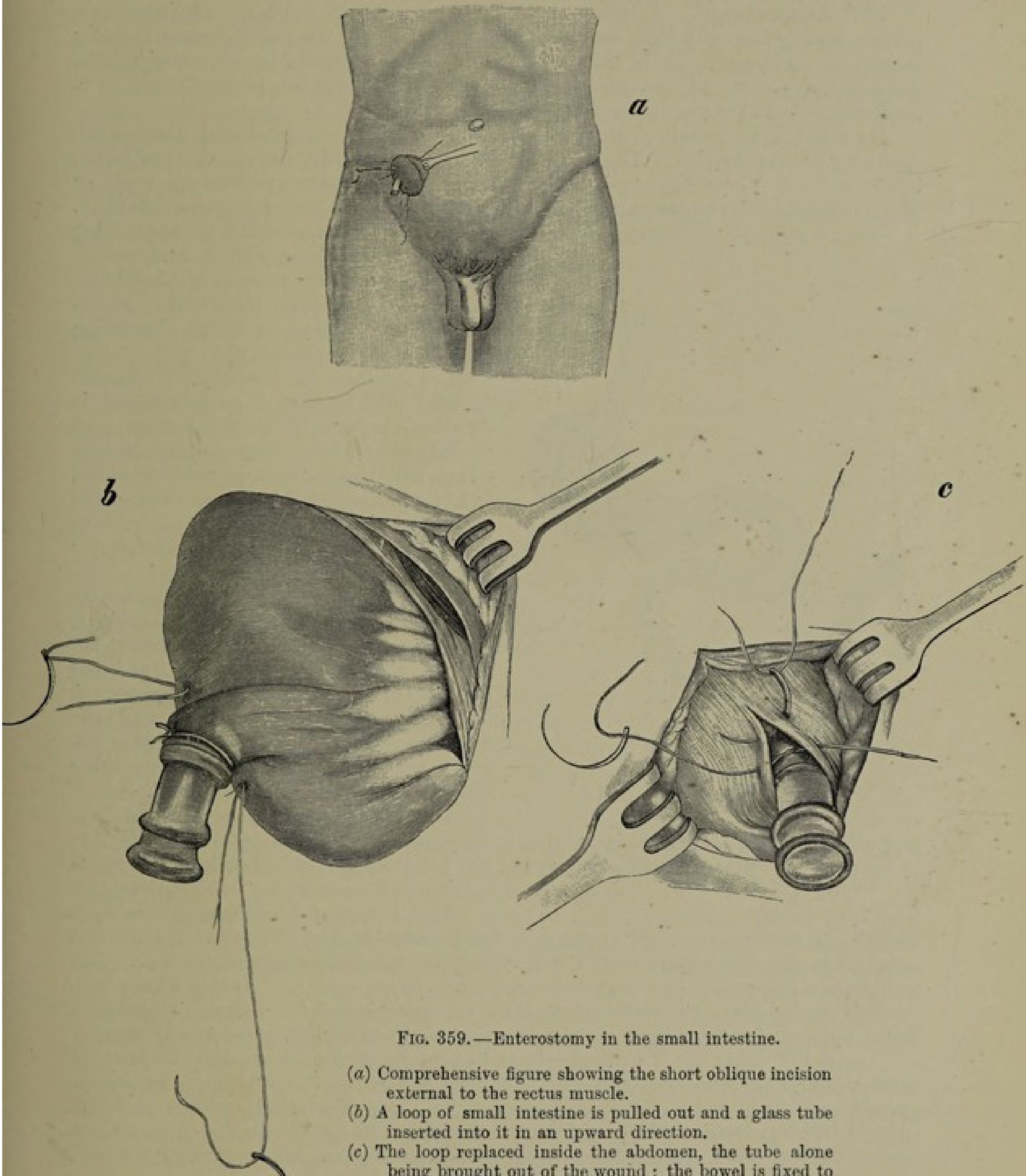


FIG. 359.—Enterostomy in the small intestine.

(a) Comprehensive figure showing the short oblique incision external to the rectus muscle.
(b) A loop of small intestine is pulled out and a glass tube inserted into it in an upward direction.
(c) The loop replaced inside the abdomen, the tube alone being brought out of the wound ; the bowel is fixed to the parietal peritoneum and fascia transversalis with one or two stitches.

pancreatic secretion is led away from the wound with certainty, the advantages of duodenostomy have disappeared. The description of the technique of duodenostomy can therefore be omitted.

146. Jejunostomy. Jejunostomy may be employed in cases of inoperable pyloric obstruction in which owing to the extent of the disease gastroenterostomy cannot be performed. It is also indicated in diffuse inoperable carcinoma of the stomach, carcinoma of the cardia, in the case of a shrunken stomach, and as a preliminary to an extensive resection.[1]

Its object is to permit of the ingestion of food and to v. Eiselsberg belongs the credit for its introduction. The operation has been materially improved since Maydl introduced his Y-method based on Roux's pattern of gastro-enterostomy, and by Mayo Robson's short-circuit method analogous to Braun's method of gastroenterostomy.

Tavel's method of jejuno-gastrostomy marks a real advance, for by implanting the intestine properly with its oral end in the abdominal wall there is absolutely no danger of escape of intestinal contents nor of the permanent fistula becoming obnoxious to the patient.

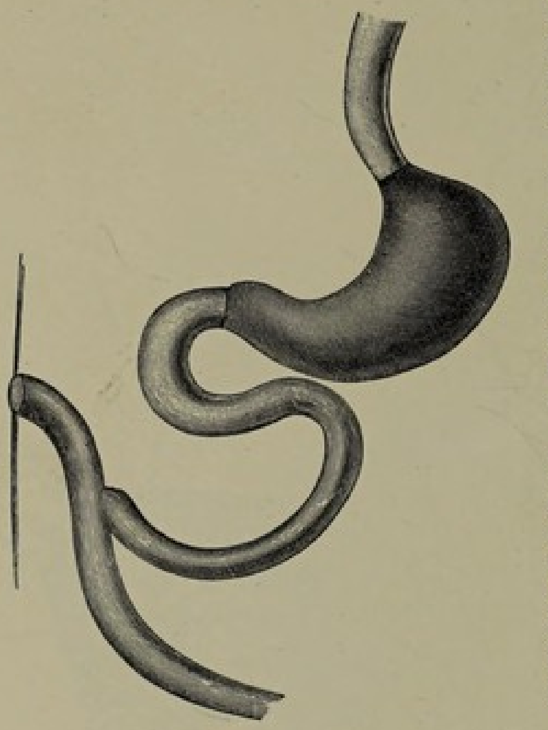


Fig. 360.—Sketch illustrating Maydl's Y-jejunostomy for the treatment of diffuse inoperable carcinoma of the stomach.

The intestine can be fixed in the abdominal wall so that a large opening is obtained through which the patient may be fed, without the least leakage, beyond a little intestinal mucus, provided the oral end of the divided jejunum is fixed in the abdominal wall and the anal end let into the gut 4 to 6 inches below the enterostomy opening, as indicated in Fig. 360.

The technique is as follows:—An incision is made to the left of the umbilicus, the skin and sheath of the rectus are divided, the muscle is displaced, and the peritoneum opened. The commencement of the jejunum is identified, and the intestine divided 8 to 10 inches lower between two crushing-forceps in the manner described in resection of the bowel.

The mesentery is then divided and the upper end of the gut implanted into the intestine 4 to 6 inches lower down as in gastroenterostomy by the Y-method.

The lower end of the gut is next pulled out through a special opening in the peritoneum and the rectus muscle, and stitched to the skin with sutures which include the whole thickness of its wall. The opening in the peritoneum and fascia need not be so small as to constrict the gut, as the muscle fibres are sufficient to keep the opening closed, no special contrivance being required for the purpose as the direction of the peristalsis prevents any escape.

Instead of using the Y-method, Mayo Robson short-circuits the loop of jejunum with a lateral anastomosis. Experience will show whether this application of entero-anastomosis (which in any case must not be made too small) affords sufficient security against leakage of bile and pancreatic juice. *Mutatis mutandis*, the technique corresponds to that described for Braun's anastomosis (see Gastroenterostomy with entero-anastomosis).

Except when there is a prospect of being able to close the jejunal fistula later on, there is no object in making a lateral opening, either by the method described in temporary enterostomy (using Paul or Mixter's tube), or by Witzel's method (oblique fistula), or by invagination according to Kelling's plan.

[1] For this preliminary operation proposed by Cackorie *vide* Friedrich's Diss., Kiel, 1904.

In contrast to the relatively small opening provided by the lateral operation, the "lip-like" fistula obtained by the other method has the advantage that it is large enough to allow the patient to feed himself in comfort with a large tube after he has chewed the food, as Trendelenburg advises in the case of gastrostomy.

147. Colostomy. Colostomy is almost exclusively employed in order to provide escape for the intestinal contents above an obstruction, and consists in the formation of an artificial anus. The conditions in which one may be called upon to open the intestine differ greatly, and their bearing on the technique of the operation has not received sufficient attention, *e.g.* whether the bowel is opened and stitched to the abdominal wall for the purpose of administering food, or in order to provide an outlet for the fæces.[1]

In the former case the essential feature consists in suturing the oral end of the divided bowel, *i.e.* the upper end of the efferent or lower portion to the skin. The risk of the wound becoming contaminated is thus very slight owing to the downward peristalsis of the bowel, and beyond a little mucus nothing escapes. But on the other hand, when the object is to get rid of the contents of the intestine, exactly the opposite has to be done, and the anal end, *i.e.* the lower end of the afferent or upper portion, is brought up into the wound, while every care must be taken to prevent soiling.

In making an artificial anus (and a fæcal fistula) the treatment of the lower portion of the bowel is of no great importance as the contents of this portion are automatically kept back in the intestine and carried away from the wound. But it is a different matter when the oral end of the lower portion of gut is sutured in the wound to provide for artificial feeding, as here one has to convey the contents of the upper portion away from the wound into the gut lower down.

The trouble always arises from the afferent gut, rarely, if at all, from the efferent, so that the first consideration is always how to keep the intestinal contents away from the wound. As shown for jejunostomy, this can be satisfactorily done by Braun's lateral anastomosis, or by draining the upper gut into the lower by Roux's Y-method, in all cases where the bowel below is free or can be made free by the removal of a tumour or stenosis.

These two methods are applicable to the colon also when colostomy is undertaken for operable cancer of the large intestine. Painful experience, however, has taught surgeons that there is a difference in the application of these methods to the large and small intestines. The contents of the large intestine accumulate much more readily above an obstruction and cause damage to the wall of the bowel, and are also incomparably more septic than the contents of the small intestine, hence complications can only be prevented by taking the utmost care to provide free escape. We shall return to this difference again in the chapter on intestinal resection, and proceed to the precautionary measures to be taken in simple colostomy.

There is another difference between simple colostomy, *i.e.* an artificial anus, and the formation of a fæcal fistula in the small intestine. The latter is generally only a temporary measure, and one has to consider how it is to be closed when no longer required. In opening the large intestine, on the other hand, one is often dealing with the formation of a permanent fistula, and here our efforts must be directed towards providing a competent sphincter which will keep the opening closed and prevent a continuous escape of intestinal contents.

Technique of Colostomy.—In describing the operation we shall not consider any half measures in making either a permanent or temporary artificial anus (the latter, for instance, as a preliminary to excision of the rectum). We regard as half measures all methods in which intestinal contents can pass down into the lower portion of gut, as in the event of an operation being undertaken on the lower portion of bowel subsequently requiring the introduction of sutures, the stitches are in danger of

[1] In the former edition we tried to point out this difference even by the nomenclature, since we suggested the termination -stomy; for instance, that the term "cæcostomy" be retained for cases where the cæcum is opened in colitis for the injection of fluids and therapeutic agents, and that the term "coloprocty" be used when it is intended to drain the contents of the colon.

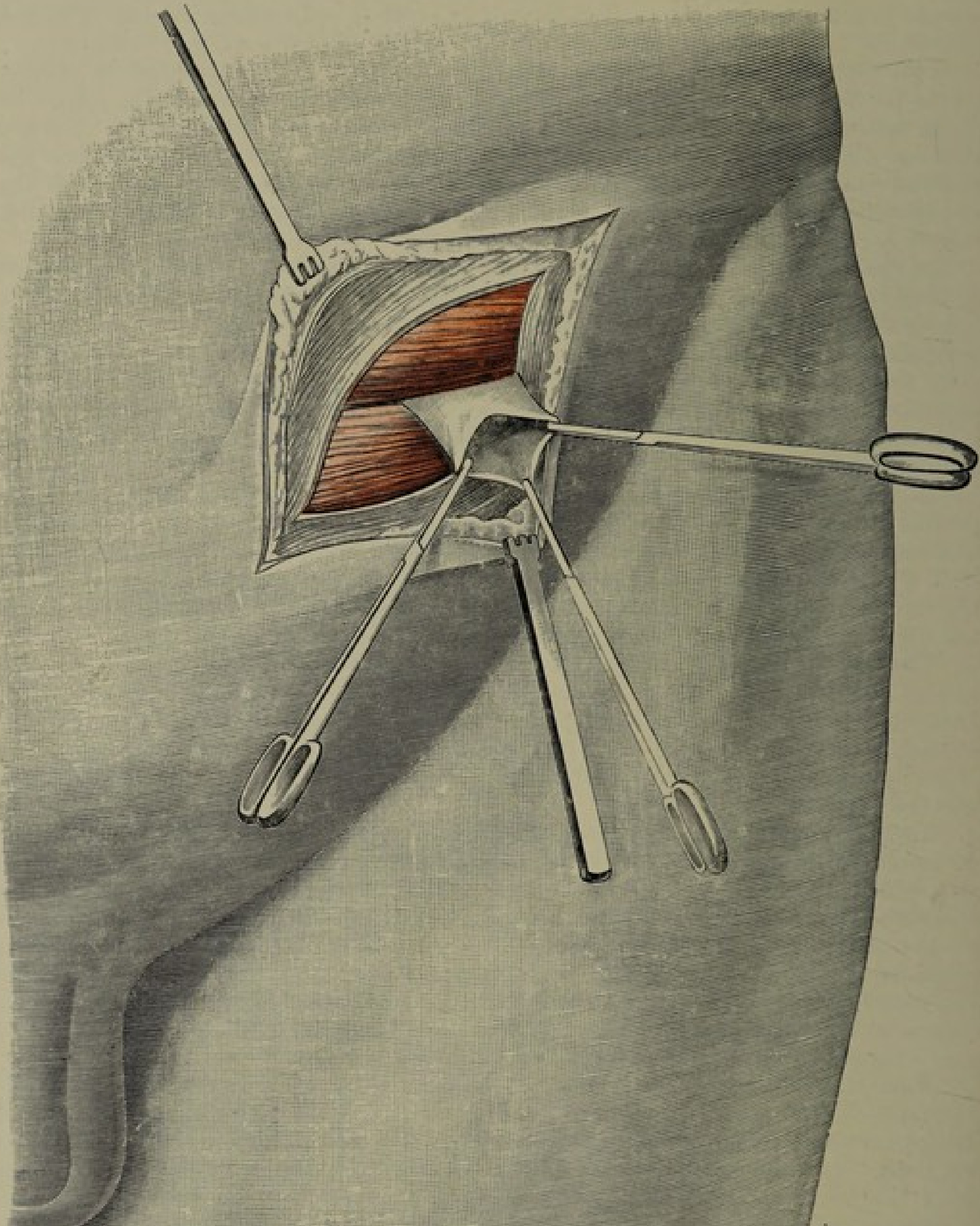


FIG. 361.—Formation of a temporary artificial anus in the left iliac region; skin, superficial fascia, and fascia musc. obliqui externi are divided in an oblique direction, the deep abdominal muscles (obliquus internus in figure) are only separated. The parietal peritoneum has been drawn out between the deeper abdominal muscles and opened.

becoming infected from contact with the intestinal contents, and unless the fæces are entirely kept away ulcers situated lower down do not get a chance of healing. A lateral opening is only to be made when a loop cannot be pulled out, as happens in the case of the cæcum (cæcotomy), and when the pelvic colon is firmly bound down by adhesions. Mosetig[1] has devised an operation in which a valve is formed below the opening, which deserves consideration on account of its simplicity. He ties a ligature lightly round the intestine and stitches the projecting walls above and below

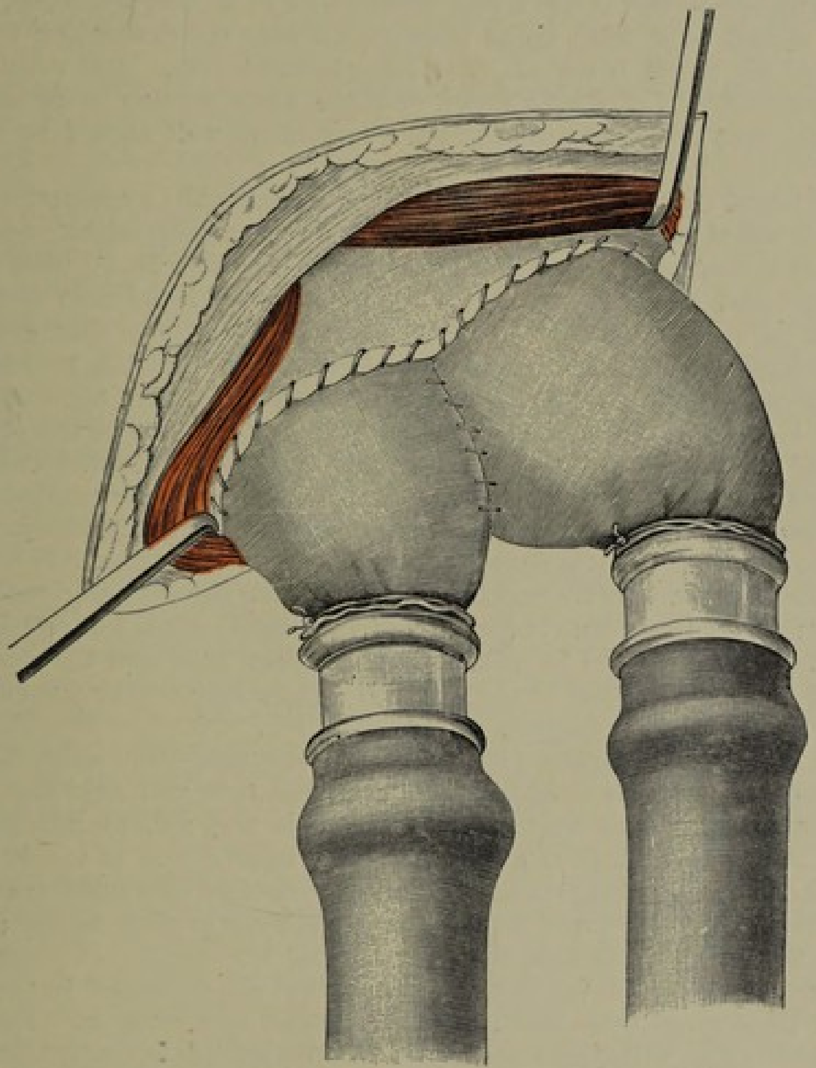


FIG. 362.—Enterostomy. Formation of artificial anus in the pelvic colon (Moynihan). The parietal peritoneum and fascia transversalis are stitched to the bowel with sero-muscular stitches. Two glass tubes are tied into the bowel.

this to one another, thus forming a diaphragm which, according to experiments by Silbermark and Domeny, remains permanent.

Lateral colostomy requires no special description. A circular area of the wall of the bowel is stitched to the peritoneum and fascia with sutures which include the serous and muscular coats. Before the bowel is opened, it is better to wait for one or two days. After it is opened the edges are fixed to the skin with 4 to 6 sutures which include the whole thickness of the bowel wall (*vide* Technique of Jejunostomy).

The routine operation of colostomy is performed as follows:—Local anæsthesia with novocain and adrenalin. An incision is made through the skin, fascia, and aponeurosis of the external oblique two fingers'-breadth above Poupart's ligament,

[1] Cf. Silbermark and Domeny, *Deutsche Zeitschrift f. Chir.* Bd. 78.

and the same distance internal to the anterior superior iliac spine. The internal oblique and transversalis are split with two blunt dissectors and held apart with suitable retractors, the fascia transversalis and peritoneum are incised for a distance of about 2 inches, and the pelvic colon, which is readily found in the iliac fossa, is brought out of the wound. If it cannot be pulled out owing to its mesentery being short, it may be mobilised by dividing the peritoneum and avoiding the vessels. It is then stitched to the parietal peritoneum and transversalis fascia, the stitches being passed through its serous and muscular coats.

If it is proposed to excise the bowel lower down at a later operation, the portion brought out should be as high up as possible, *i.e.* near the descending colon, so that the mobility of the bowel below may not be interfered with. But when there is no radical operation in view at a later stage, or if the whole portion below the opening is to be removed, then the loop stitched to the abdominal wall should be as low down as possible.

After the bowel has been emptied between the fingers the mesentery of the pelvic loop is put on the stretch and a small slit is made in an interval between the vessels, through which a strip of iodoform gauze is pulled and tied round both limbs of the loop, the upper end being loosely tied while that on the lower end is pulled tight. Below this a clamp is applied. The convexity of the loop is then grasped with a pair of crushing-forceps which include the bowel as far as the mesentery, and a Paul's tube is inserted through an opening in the summit of the constricted loop and tied in, so as to prevent escape alongside it. The crushing-forceps are then removed, and round the groove left in the descending limb a ligature is passed and firmly tied. A second ligature is also passed round the groove on the upper portion of intestine and is tied round the glass tube after the latter has been pushed farther into the bowel.

In this way the intestine is closed above and below the tube. The convexity of the loop is now cut away (after packing all round with gauze wrung out of lysol), as much of the mucous membrane being excised as possible while the rest is disinfected with alcohol. A rubber tube is attached to the glass tube and the contents of the bowel are led away. The tube round which the gauze loop is tied prevents retraction of the gut till adhesions are formed.

No harm results if the ligature on the lower end comes off in a day or two, owing to accumulation of fæces, as irrigation with a double tube will soon remove it. One should, however, make sure beforehand if there is any risk of infectious material collecting in the lower portion of gut. It is only interruption of the downward flow which can hinder the spontaneous action of the peristaltic movements, otherwise this is quite sufficient to prevent any leakage from the lower portion of the gut into the wound, with the exception of some harmless mucus.

When accumulation of fæces in the lower portion of gut cannot be prevented, it is advisable to tie a glass tube into it as well, instead of closing it. The use of two glass tubes does away with the necessity of completing the operation in two stages. This, however, is highly desirable when a lateral opening is made in the gut, since in this case it is very difficult to prevent the wound from being soiled.

By bringing out the bowel between the fibres of muscle an amount of control over the opening is obtained. Witzel brings the rectum through the gluteal muscle, and v. Hacker, as already mentioned in connection with jejunostomy, utilises the rectus for the purpose. Hoffman drew attention to the fact that by making the track obliquely through the abdominal wall a colotomy opening is effectively kept closed. He brings the gut out through the abdominal wall at a little distance from the wound.

When the bowel is brought out through the abdominal muscles in the manner we have advised the opening is sufficiently controlled and phlegmonous cellulitis of the wound is prevented. As the muscle fibres are simply separated without interfering with its nerve-supply, they contract sufficiently closely round the gut to keep the opening shut. More secure closure may be effected by a pad and spring, which can easily be obtained with a properly-fitting belt.

148. Appendicostomy. It is not uncommon to find after perityphlitis that a fistula persists which will not close spontaneously, and which is peculiar in that one

can pass a long probe down it into the bowel without any fæcal escape beyond a very little slightly purulent mucus. These fistulæ have been proved by operation to be due to a perforation of the vermiform process when the latter was adherent to the abdominal wall—in other words, spontaneous appendicostomy had been performed.

It follows, therefore, that if the appendix is opened artificially and sutured into the abdominal wall, considerable advantages are presented over cæcostomy. Weir[1] first suggested appendicostomy. No escape of intestinal contents takes place through the fistula, because the strong peristalsis is directed towards the bowel; but by inserting a tube gas can be allowed to escape, or fluids can be injected either for the purpose of nourishment or as medical agents for the treatment of affections of the large intestine.

Appendicostomy has been suggested as a substitute for cæcostomy, especially in the treatment of ulcerative or membranous colitis. It is, of course, essential that the appendix itself is not diseased, and that it is long enough and sufficiently free to allow of its tip being fixed in the abdominal wall. It is then cut across and the edges stitched to the skin. It is an operation free from danger, provided the appendix retains its peristaltic function. When it cannot be performed, recourse must be had to lateral cæcostomy.

149. Entero-anastomosis and Intestinal Occlusion. One of the most important operations in intestinal surgery, and one which has even a more extensive field of usefulness than Wölfler's gastroenterostomy, consists in uniting two portions of intestine so that the contents of the upper will empty into the lower without passing through the intermediate or short-circuited loop. Wölfler is responsible for its development and use, although the idea had already been suggested by Maisonneuve. According to Haberer[2] Billroth performed the operation first, and v. Hacker had the first successful case.

Although to a certain extent a portion of bowel is always functionally isolated in every anastomosis, the term "occlusion" is used in a limited sense to imply that the intermediate portion is completely shut out, one or both ends opening on the surface so that it is no longer connected with the ordinary circulation of fæces.

According to Haberer, Senn first suggested unilateral, and Salzer total isolation of bowel, while Hochenegg first performed the operation successfully. According to Hartmann, on the other hand, Trendelenburg had the first case.

For the sake of precision we speak also of total occlusion. The difference is an important one. When the gut is not isolated in the stricter sense of the term, we are dealing merely with a lateral or side-to-side anastomosis. But when, on the contrary, occlusion is performed, we mean that the intestine above and below is united either laterally after closing both ends, or directly by end-to-end anastomosis, or that only one end is closed while the other is utilised for an end-to-side anastomosis.

The anastomosis between the ileum and colon is the one most commonly performed. v. Eiselsberg, who has had the greatest experience, employed lateral anastomosis for this purpose in 40 out of 52 cases with 13 deaths. Lateral anastomosis is the simplest method of putting a diseased portion of intestine at rest, and we have found that in very extensive tuberculosis of the cæcum and large intestine, a complete cure can be got without real isolation. We were able to prove the truth of this positively in a case where a subsequent laparotomy was found necessary.

We therefore regard lateral anastomosis of healthy intestine above and below the disease as an excellent operation in cases of tuberculosis of the bowel, where removal of the diseased portion is difficult and dangerous. It is also of great use in inoperable carcinoma, particularly in the neighbourhood of the cæcum, the hepatic or splenic flexures. The patients may recover their working capacity for months or years. But, as we shall show later, unexpected radical cures may be obtained by resection even when the disease is very wide-spread, so that one must always attempt to perform this operation. Lateral anastomosis is also of value in cases of stenosis due to other

[1] *Vide* M. Gil, *Revista di med. pract.*, Madrid, 1906.
[2] Haberer, *Archiv f. klin. Chir.* Bd. 72.

causes, *e.g.* syphilitic or inflammatory. When there is acute obstruction and a large accumulation of fæces above the obstruction, it is essential to empty the bowel by enterotomy before making the anastomosis. In cases also where the function of the intestine is impaired by peritonitis, it is occasionally possible to anastomose a contractile portion of intestine above directly with the colon. Friedrich [1] successfully short-circuited 13 feet of small intestine.

In cases of ileus, where the patient is in a very poor general condition at the time of operation, anastomosis is a very important preliminary or introductory to a later radical operation, especially in malignant cases where an acute ileus may often be the first indication of the trouble.

Anastomosis with total occlusion of the bowel may further be undertaken in the treatment of intestinal fistulæ—more especially pyo-stercoraceous fistulæ where excision cannot be employed. The principal disadvantage of total isolation in contrast to simple lateral anastomosis, is the necessity for an artificial opening in the isolated portion of the bowel. Complete closure of both ends of the isolated portion has been found inadmissible in pathological cases. Not only are external fistulæ cured in this way, but also those opening into the bladder or vagina.

Intestinal isolation is again indicated in obstinate cases of colitis, and in idiopathic dilatation of the large intestine with obstipation and congenital hypertrophy of the colon. The operation by choice is here ileo-sigmoid anastomosis, between the lower ileum (about 12 to 20 ins. above the ileo-cæcal valve) and the pelvic colon. v. Beck has had excellent results in five cases of diffuse colitis by short-circuiting the whole of the colon "as a more or less rudimentary structure, which is of no great significance for the nourishment of the patient."

Lastly, the isolation of healthy gut has been undertaken in order to replace other hollow viscera, *e.g.* the bladder in extroversion, the intestine after extensive removal of very fixed portions (in the large intestine and rectum) and also the stomach. It has also been employed to establish a communication between the stomach and the abdominal wall (Tavel's jejunogastrostomy) and even to replace the œsophagus (Roux).

150. Technique of Lateral Anastomosis. The diagram of Braun's entero-anastomosis in the section on gastroenterostomy (p. 576) may serve as the type of the method of procedure. Certain rules, however, must be observed in the performance of an anastomosis:

(1) There must be no strain on the intestine entering into the anastomosis. The most movable portions should also be selected. In the small intestine, this corresponds to the lower ileum, at a little distance from the cæcum. Immediately above the ileo-cæcal junction the mesentery is shorter. In the large intestine the transverse and the pelvic colon have the longest mesentery and are less likely to be stretched.

(2) Though not essential, it is desirable that the bowel should occupy an isoperistaltic position, but an antiperistaltic position is possible. The bowel must not be twisted.

(3) Very congested or over-distended portions of the intestine must not be joined without a previous enterotomy, or, as in the large intestine, without an enterostomy having been performed some time previously above the proposed site of the sutures.

The operation is performed as follows:—The selected portions of gut are emptied, approximated in an isoperistaltic position, and clamped. The posterior serous suture should be about 2 inches long, and the incision into the gut about $1\frac{1}{2}$ inches long and $\frac{1}{5}$ inch from the suture, after which the edges are united all round with a continuous suture including the whole thickness of the intestinal wall. Before inserting the anterior serous suture the clamps are taken off, the parts cleansed with lysol, and fresh packing inserted.

Mechanical contrivances such as Murphy's button, and the modifications used by Jaboulay and v. Beule, Senn's absorbable bone plates and similar plates used by Baracz, Landerer, and Alessandri are all inferior to suture. They are less reliable and do not give so rapid or perfect a result. The same applies to the use of M'Graw's

[1] *Med. Klinik*, 1905, No. 2.

elastic ligature,[1] which, although it is simple and easy to apply (as we mentioned under gastroenterostomy), is apt to be followed by contraction of the opening.

151. Entero-anastomosis with Unilateral or Bilateral Occlusion of the Gut. At the sixteenth French Congress of Surgery (Paris, 1903), H. Hartmann gave a very complete description of the various methods in which short-circuiting may be performed. His diagrams, which we reproduce here, need no further description.

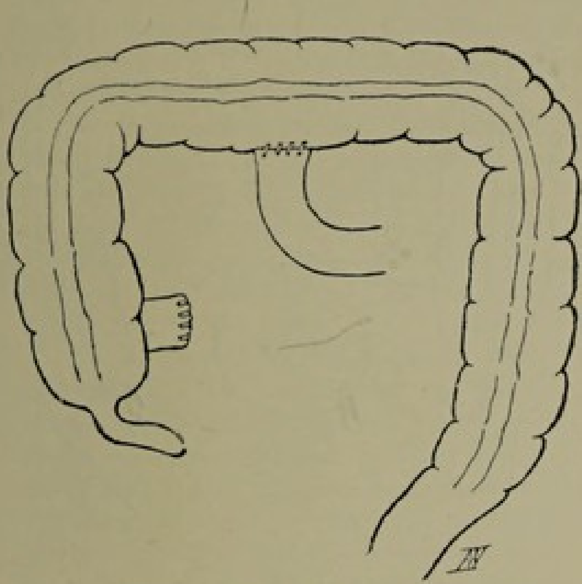


FIG. 363.—Unilateral occlusion with end-to-end anastomosis.

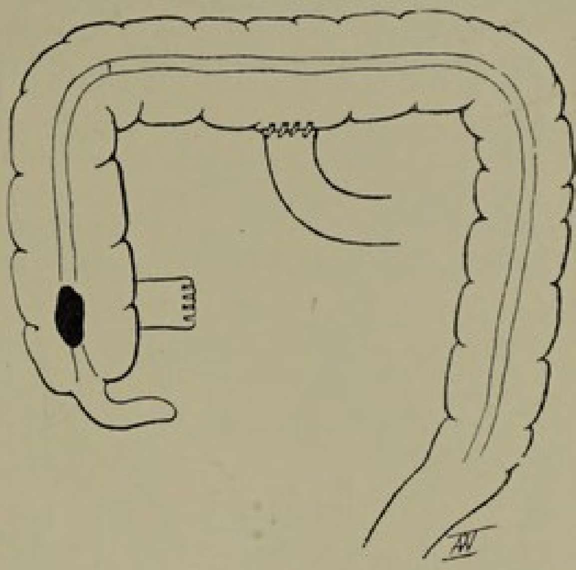


FIG. 364.—Same as Fig. 363, but with formation of fæcal fistula in the occluded bowel.

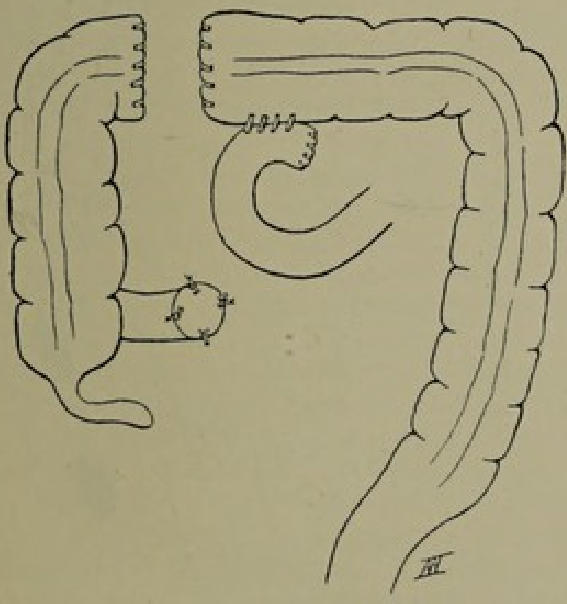


FIG. 365.—Unilateral occlusion with lateral anastomosis and enterostomy of the occluded bowel.

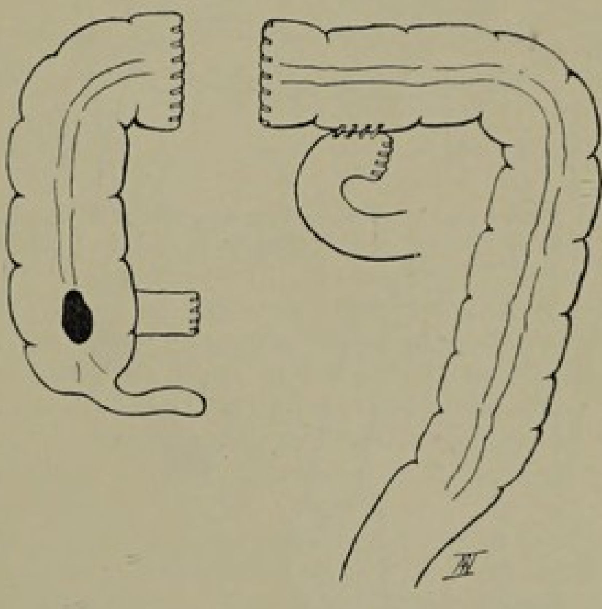


FIG. 366.—Same as 365, but with formation of fæcal fistula.

Hartmann very properly points out that the term "intestinal occlusion" should only be used when the continuity of the gut is broken by division in one or two places.

Technique.—As a rule the abdomen is opened in the middle line, but occasionally an oblique lateral incision is more suitable. In selecting the portions of intestine for

[1] *Journ. of Michigan State Soc.*, Aug. 1904.

the anastomosis, great care must be taken to ascertain that the one segment is above and the other below the obstruction. If there is any doubt, then a lateral anastomosis only may be made.

The gut above the obstruction is clamped with two pairs of crushing-forceps, placed

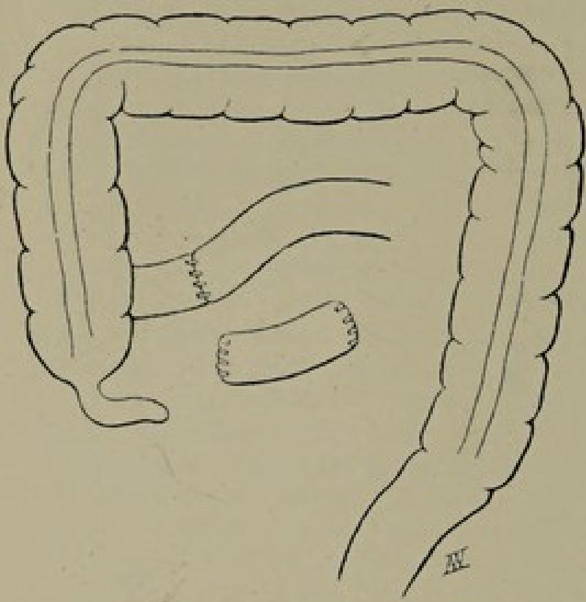


FIG. 367.—Bilateral occlusion with end-to-end anastomosis. Closure of occluded bowel.

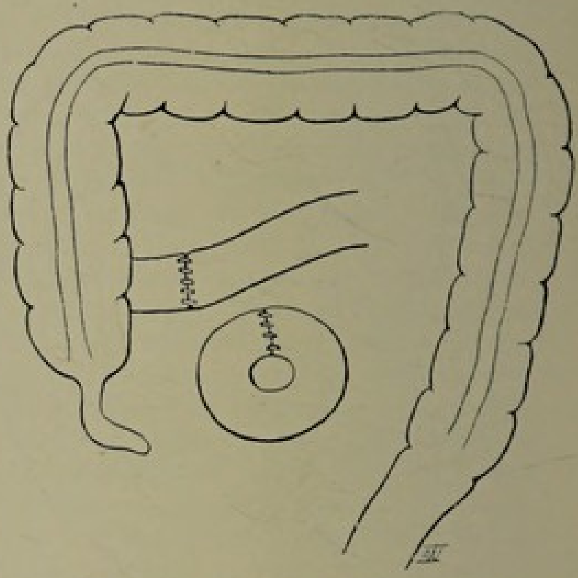


FIG. 368.—Same as Fig. 367. A different method, however, of closing the occluded bowel.

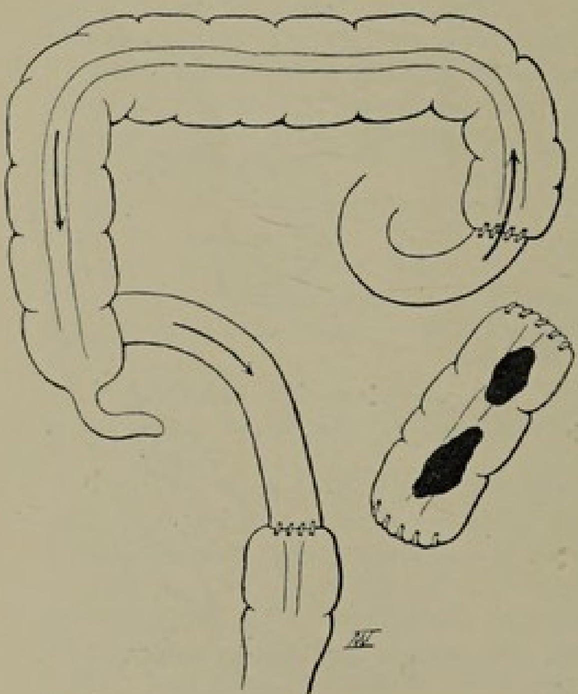


FIG. 369.—Bilateral occlusion, reversed end-to-end anastomosis, formation of fæcal fistulæ in occluded bowel.

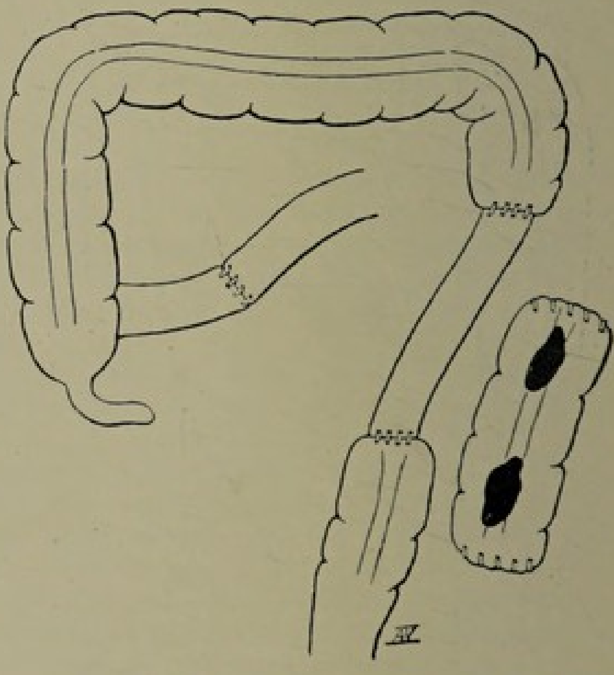


FIG. 370.—Bilateral exclusion as in Fig. 369. Continuity restored by enteroplasty.

about an inch and a half apart and is cut across (see Section 153). The forceps on the upper end are left on, while those on the lower end are taken off and the crushed portion of bowel is tied with a silk ligature. The division of the bowel should be flush with the forceps on the upper end. The ligatured stump is pulled out, and the mucous

membrane cauterized and invaginated with two rows of sero-muscular sutures, after which the stump is dropped back into the abdomen.

When the obstruction is complete, the end of the gut should not be closed, but should be brought out through a special opening in the abdominal wall (Fig. 365), at a distance from the main incision, and stitched there as described under enterostomy (see p. 613). The upper end of the gut, which is still closed with the forceps, is then inserted directly into the bowel below the obstruction. The forceps are useful in bringing the parts into apposition. In the large intestine a longitudinal band is to be selected. Fig. 363 illustrates the method of unilateral isolation with end-to-side anastomosis.

In this normal process the contents of the isolated portion are carried down by the peristalsis, without requiring the formation of an external fistula. The theoretical fear that the isolated portion becomes filled from below by a back flow of intestinal contents is groundless, provided the outlet downwards is free. It is therefore wrong to divide the gut below the isolated loop and close up both ends (Fig. 365), merely to be able to make a lateral anastomosis lower down.

Salzer's total isolation (Figs. 365 and 366) is only indicated in cases where much accumulation is anticipated in the occluded portion from discharge from the ulcer or backward pressure of fæces from the lower portion of the gut. According to Hartmann, Lance has demonstrated a backward intestinal flow in nine out of fifteen cases where unilateral exclusion was practised. Hochenegg and Eiselsberg maintain that both ends of the excluded portion should be brought to the surface so that it may be irrigated and kept clean. Hartmann knows of only two cases (Wiesinger's and Kammerer's) where occlusion of the isolated portion led to cure, and then only after fistulæ had formed and continued for some time.

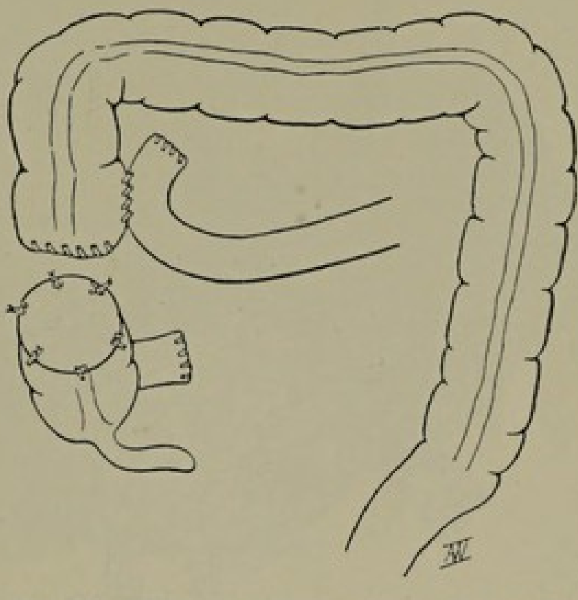


FIG. 371.—Bilateral occlusion, side-to-side anastomosis, formation of artificial anus in occluded bowel.

In very difficult cases where the large intestine above the obstruction is too distended to permit of its being implanted lower down, one may occasionally attempt a recurrent anastomosis (Fig. 369), *i.e.* cut across the ileum and insert its proximal end into the colon above the obstruction, and the distal end into the pelvic colon, the fæces thus passing, by way of a portion of ileum, from the large intestine into the rectum. Or one may interpose a piece of ileum between the two ends of the large intestine by an enteroplastic operation (Fig. 370).

In occlusion, as in resection of gut, it is important not to leave any openings or bridges in the mesentery. The divided edges of the mesentery should in every case be stitched either to mesentery or to omentum, so as to obliterate any opening through which internal strangulation might occur.

152. Intestinal Resection.—*General Remarks.* In considering the indications, methods, and prognosis of intestinal resection, we shall deal with the different portions of the intestine separately. Statements which hold good for resection of small intestine, apply only slightly to resection of the ileocæcal region, and not at all to resection of the large intestine. Resection of the small intestine, ileocæcal region, and large intestine must be considered separately, as there is little that is common to all these forms.

Resection of the intestine has become an exceedingly important and comparatively frequent surgical operation, and by its proper performance the surgeon is able to

preserve many lives which would be otherwise lost. It is absolutely necessary that, besides attending to the obvious necessity for asepsis, the definite steps in the technique of the operation must be adhered to.

By observing these rules large portions of the bowel may be removed. We have performed a considerable number of very extensive intestinal resections, the most extensive being the removal of 7 feet of small intestine, and in another case 5½ feet. Both patients made an uninterrupted recovery.

In Maydl's clinic, Kukula has recorded two cases of resection of more than 6½ feet of intestine, and has drawn attention to experiments by Monari and Trzebicky in which as much as seven-eighths of the small intestine was removed from animals without injury. Kukula believes that as much as half of the human small

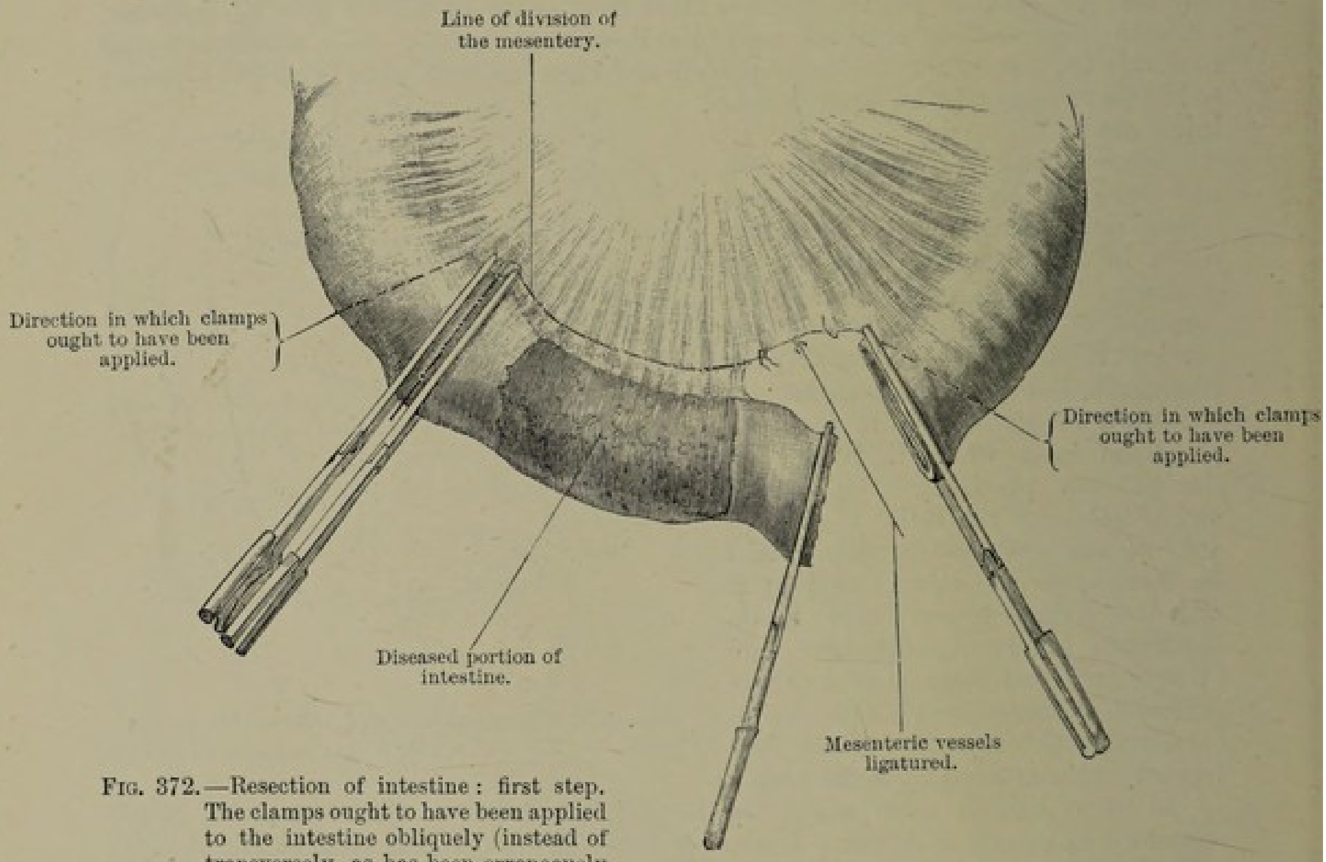


FIG. 372.—Resection of intestine: first step. The clamps ought to have been applied to the intestine obliquely (instead of transversely, as has been erroneously indicated) to ensure a good blood-supply. The intestine has been cut across between two of the forceps, and between the other two the line of section is indicated by an interrupted line. The line of division of the mesentery is shown, part of it having been divided and its vessels ligatured.

intestine may be removed without doing harm, and of the large intestine as much as may be desired. Roux reports the case of a patient who survived with a small intestine only 5 feet long, and with only half the length of the large intestine.

R. Park[1] has published a case in which he successfully removed 9 feet of small intestine, and records twelve recoveries in sixteen cases, one over 6 feet, a second over 9 feet, and a third over 10 feet. According to Schlatter[2] after such extensive resections the diet has to be very carefully selected on account of the great loss of albumen and fat.

It is important to know that such very extensive resections can be performed without harm and with uninterrupted recovery, because the first rule in intestinal as in stomach resections is this: *only to suture together wound edges which are thoroughly well nourished.* Before the sutures are introduced one must be absolutely

[1] *Arch. internat. de chir.* t. 1. [2] *Beitr. z. klin. Chir.* Bd. 49.

certain that plenty of blood is flowing to and from the mesentery at the ends of the intestine which are to be united.

The best and only sure method of ascertaining this is to examine the pulsation in the arteries: the only certain test of a satisfactory blood-supply in the uninjured gut is the presence in the arteries of pulsation, which can be felt right up to the intestine itself. In the case of collapsed patients, however, the pulsation is not always easily felt. If there be any doubt another piece of gut should be resected before the parts are sutured together.

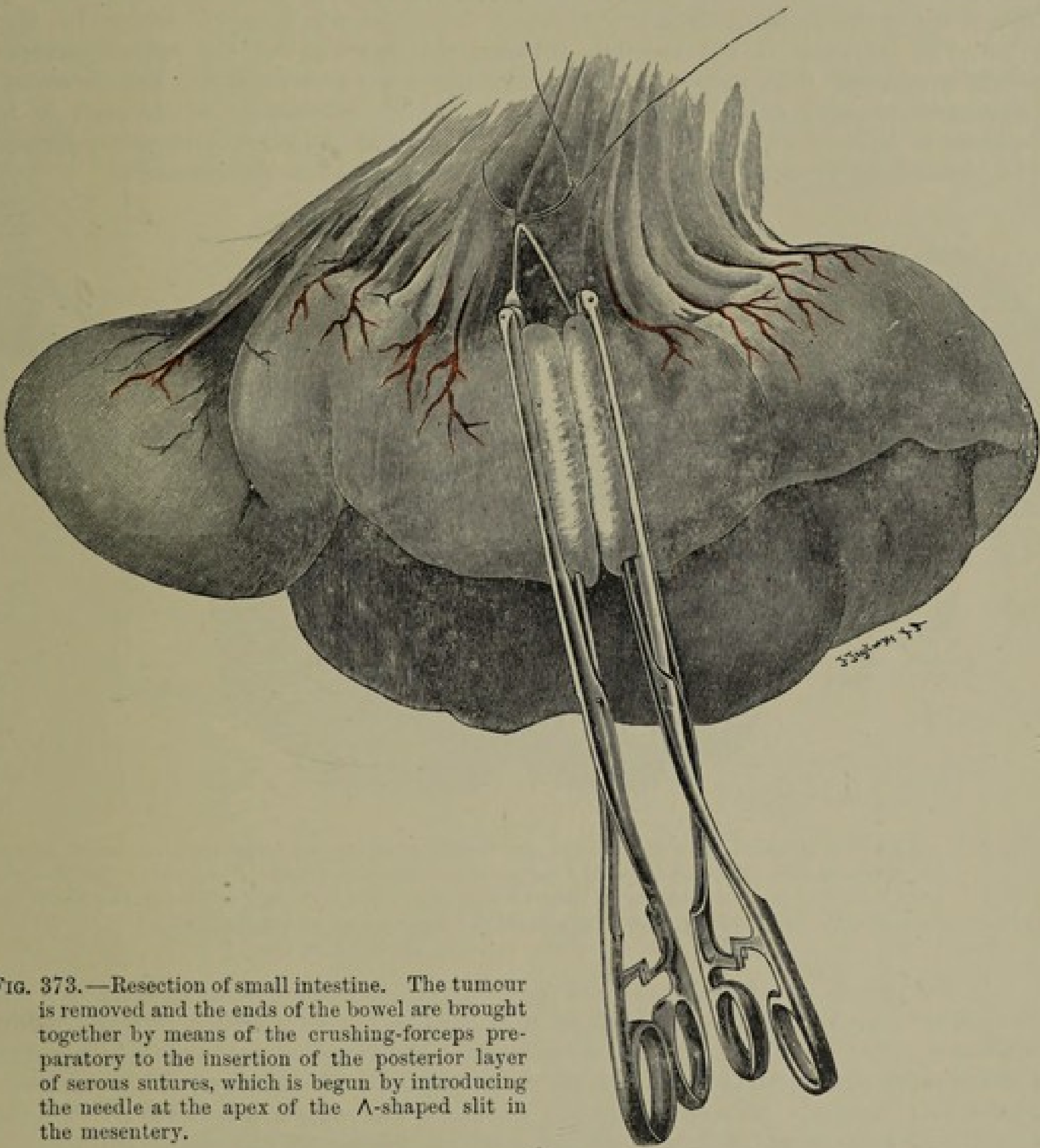


FIG. 373.—Resection of small intestine. The tumour is removed and the ends of the bowel are brought together by means of the crushing-forceps preparatory to the insertion of the posterior layer of serous sutures, which is begun by introducing the needle at the apex of the Λ-shaped slit in the mesentery.

153. Resection of Small Intestine. Resection of the small intestine is now so safe an operation, provided the technique is good, that one has no hesitation—*e.g.* in gangrenous hernia—in aiming at primary union and restoring the continuity of the bowel by suture immediately after removal of the gangrenous portion. It is only in cases where the patient is in a state of extreme collapse that an exception to this rule is made.

The following points must be attended to, if the operation is to be successful:—

1. The piece of intestine to be resected is to be drawn well out of the abdominal cavity, so that the operation may be performed extra-peritoneally and leisurely. The

loop of intestine which is pulled out is shut off from the peritoneal cavity by aseptic tampons.

2. Two crushing-forceps are applied close together to the part of the intestine where the section is to be made (Fig. 372), a part being chosen where the wound edges will be well nourished. These forceps are not to be applied exactly at right angles to the long axis of the intestine (as has been erroneously represented in Fig. 372), but somewhat obliquely, as indicated by the dotted line in the same figure, so that more intestine is removed from the convexity than from the mesenteric side. The transverse vessels which run towards the convexity are thus more likely to escape injury, up to the point of division.

3. The intestine is cut through between the forceps, and the cut surfaces are carefully mopped with moist lysol swabs (1 per cent) and alcohol. The mesentery (transverse or pelvic colon) is then divided *along its attachment to the part of the intestine to be removed*, the vessels being seized, one after another, with artery-forceps. The intervening piece of intestine with forceps on each end is thus removed.

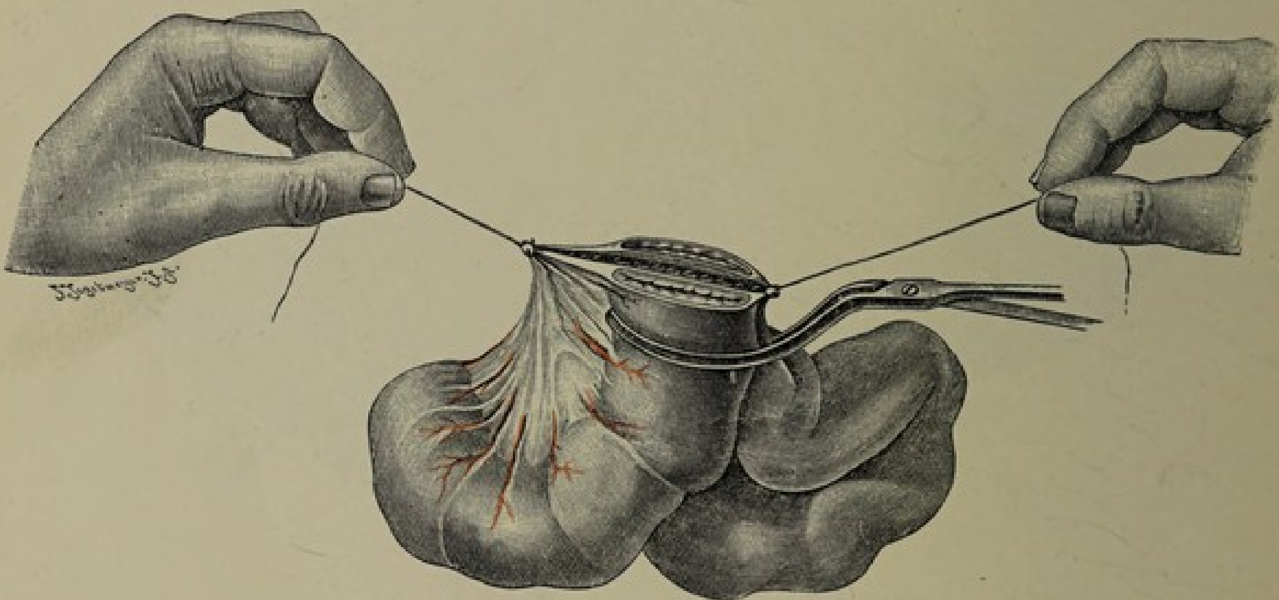


FIG. 374.—Resection of small intestine. After the insertion of the posterior layer of serous sutures the crushing-forceps are removed and an intestinal clamp applied. The ends of the posterior serous sutures are held on the stretch, so that after thorough disinfection of the bowel the deep circular continuous suture (through all the layers) may be inserted.

4. The intestine is then sutured, the crushing-forceps being used as handles by which the posterior serous surfaces are brought in apposition for the insertion of a continuous silk suture (*vide* Fig. 373). An intestinal clamp is then applied as is shown in Fig. 374, and the crushing-forceps are removed, after cleansing the divided ends with small gauze swabs and carefully protecting against soiling. The edges are then stitched all round and invaginated with a continuous suture taking up the whole thickness of the walls. The ends of the first loop having been knotted, the one is left long enough to tie with, while the other, to which the needle is attached, is used to bring the edges of the gut into uninterrupted and firm contact by means of a simple continuous glover's suture carried right round the circumference to the starting-point, where it is knotted with the end which has been left long. The intestine is thus firmly and securely closed. The line of suture is cleansed with lysol swabs, any ragged mucous membrane is removed, and the protruded intestine washed with warm sterilised salt solution, while the surrounding cloths shut off the peritoneal cavity.

5. The cloths are now changed and the anterior serous suture is inserted with the finest possible needle, and fine but strong silk. The suture penetrates only the

serous and a part of the muscular coats in such a way that the former are inverted and brought into broad position (Lembert suture). The double suture (indicated in longitudinal section in Fig. 375) was first described by Czerny, and then by us without knowing that he had employed it

The first loop of the Lembert suture is knotted and then carried uninterruptedly right round the intestine, and knotted with the initial end which is left long. The line of suture is again disinfected with lysol, which is then washed off by a warm sterilised salt solution. The towels having been removed, the intestine is replaced in the abdomen, the edges of the wound being raised up forcibly by hooks, and care taken not to use any force. The abdominal wall is closed with a double row of sutures.

If the intestine is distended with flatus and fluid contents, it should be opened

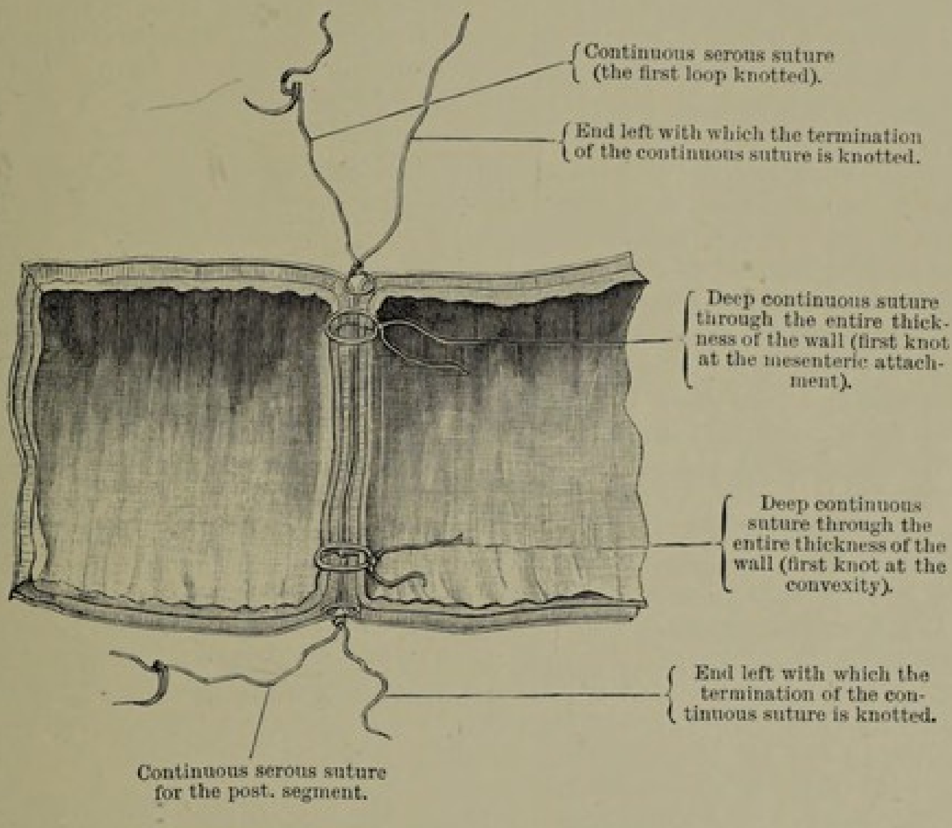


FIG. 375.—Intestinal suturing, to demonstrate the double row of sutures. The posterior half of the gut is cut longitudinally. The view is from within.

above the line of suture by a transverse incision 4 to 5 mm. in length, and the contents removed by pressure and allowed to flow into a small glass dish, after which the opening is stitched up. The part is again cleansed as above described and the reduction of the intestine effected.

We maintain that continuous sutures are alone permissible in enteroraphy, and fine silk is to be exclusively employed.

The circular method of suturing the gut is always safest, if the bowel can be brought out of the abdominal cavity. There is, then, no reason to substitute any other method in place of it. When, however, the circular suture cannot be inserted with absolute confidence because the parts are not fully exposed to view, some method of simplifying the procedure may be sought. The most valuable means we have of effecting this is by using a Murphy's button. Other methods, such as those described by Maundsell and recommended by Ullmann, are also reliable. In this method the upper end of the gut is invaginated, and the invaginated end is brought out through a lateral longitudinal incision higher up. The lower end is pushed

through the invaginated upper end so that both can be ligatured over a turnip bobbin and drawn back again.

With regard to suture of the intestine Chlumsky has made some very interesting experiments. He has shown that sutures give a much more efficient mechanical union than Murphy's button; and further, that the suture is more reliable on the first day and shortly after the operation than on the days immediately following. The firmness of the union only begins to increase again from the fifth day onwards, and reaches its original strength on the seventh day. He demonstrates that end-to-end anastomosis is firmer than lateral anastomosis. From these experiments it may be concluded that, as far as firmness of the line of suture is concerned, it is permissible to give a purgative on the first day, unless there be some definite contraindication present, such as suspected ulceration of the intestine. It is often desirable to be able to empty the gut at once. On the four next days much greater caution must be exercised.

Katzenstein has attempted to take advantage of the characteristic action of glutenkasein on the serous membrane in order to give greater firmness to the external sutures; such applications, however, unfortunately predispose to the formation of adhesions. A solution of Lugol has been used in Mikulicz's clinic for a similar purpose.

In cases in which the end-to-end method of uniting the gut cannot comfortably and safely be employed, it is often necessary to close one or both of the intestinal ends and to perform a lateral anastomosis.

The circular method of closing the intestine has been greatly simplified by Doyen. He applies a pair of crushing-forceps (after the principle described in resection of the stomach), removes the forceps, and ligatures the compressed part. A running purse-string suture is applied over this (the advantage of this has been pointed out by de Quervain and confirmed by Haegler) and the ligature invaginated. One or two rows of serous sutures are then introduced to still further unite the peritoneal surface. The further procedures are the same as under lateral entero-anastomosis above described.

We have recently got Dr. Fricker (in conjunction with Dr. Albert Kocher) to perform a series of experiments to demonstrate the advantage of extending Doyen's method to the operation of uniting two pieces of intestine end-to-end as well as to the operation of intestinal anastomosis. Compression-forceps are applied to the ends of the intestine, and a simple through and through "mattress suture" (with wire thread) is inserted behind the forceps, just as is done in resecting the stomach. The ends are not tied, but are held taut. By this means the gut is temporarily closed without the use of clamps, and by bringing together the threads used in closing it the two ends of the intestine can be brought into exact apposition, and continuous sutures can be put in as above described. The temporary "mattress sutures" are then simply drawn out and the continuous Lembert suture is introduced. By adopting this plan the escape of intestinal contents is prevented. The method is of use in cases where one cannot properly protect the surrounding parts from soiling with the contents of the intestine by simple removal of the compression-forceps and application of a clamp-forceps.

154. Ileo-cæcal Resection. End-to-end suture of the small intestine is a very safe operation, but occasionally in the case of a stricture it may be difficult, owing to the inequality in the size of the gut above and below. In anastomosing the small to the large intestine this difficulty is even more marked, and end-to-end anastomosis is only possible when the lumen of the ileum has become chronically enlarged above an obstruction while there is contraction of the colon below it.

In all other cases the principle laid down for resection of the stomach must be followed. The bowel with the larger lumen must be closed with occluding sutures and the smaller inserted into it laterally, *i.e.* in resecting the ileo-cæcal region the end of the small intestine is to be inserted into the large intestine by an end-to-side anastomosis.

The advantage of this procedure, which has been already proved in resection of the small intestine, is that the suturing is much easier when the bowel can be readily

reached and brought outside the abdomen. In ileo-cæcal resection, when much bowel is removed, it is better not to insert the ileum into the ascending colon but into the more movable transverse colon.[1]

It is quite unnecessary as a routine procedure to follow Friedrich's advice[2] and remove the whole of the ascending colon, including the hepatic flexure, and make the division through the transverse colon. We have often performed this ileo-transversostomy (a short but bad term) for one or other of the following indications, viz. (1) because a more secure anastomosis could be made with the transverse than seemed possible with the ascending colon, or (2) because we could not be sure that the colon up to its transverse portion was free of disease, or (3) to be able thoroughly to remove the glands lying in the mesocolon.

In tuberculous tumours of the ileo-cæcal region the excision of the ascending colon may be rendered difficult owing to the shrunken condition of the gut from pericolitis, but we have positive evidence that tuberculous affections of this sort can be cured by the simple process of short-circuiting (ileo-transversostomy). When one is dealing with a healthy ascending colon, by division of the peritoneum on its outer aspect it can be freed along with the hepatic flexure in a few minutes, after which the peritoneum is divided along the inner border of the colon, the vessels are secured, and the lumbar glands exposed. Friedrich has had three uneventful recoveries in four such cases. We regard Friedrich's communication as important, as it shows how readily the colon can, if necessary, be excised, and more especially its fixed portions, viz. the hepatic and splenic flexures. Apart from the fact that it ensures complete removal of the disease, the chief feature of Friedrich's operation consists in the implantation of the small into the large intestine, by which means the fluid contents of the narrow small intestine are conveyed into the wide large intestine. The anastomosis may either be an end-to-side or a lateral one (Roux).[3] Both are equally safe.

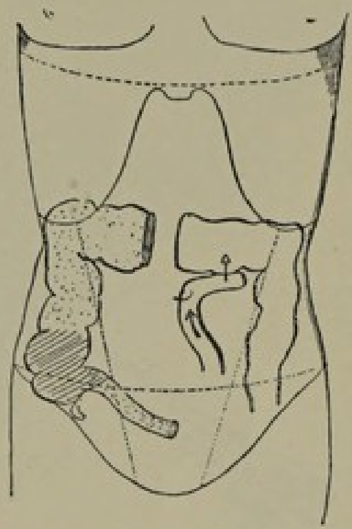


FIG. 376.—To illustrate the principle of resection of the colon for carcinoma of the ileo-cæcal region (after Friedrich).

Campiche, who has collected 202 cases of tuberculosis of the cæcum, shows that with end-to-side anastomosis there were 81 per cent of cures and with lateral anastomosis 88 per cent. This merely proves that, as in the case of the stomach, end-to-side anastomosis requires rather more practice, for with lateral anastomosis a larger incision can be made, and even if the sutures are not quite accurate, supporting sutures can be added and still leave a sufficiently wide opening of communication. In our opinion the former method is the simpler, and, provided the technique is good, it is quite as safe as lateral anastomosis.

It should be a rule that the operation is performed in one stage, not in two or three stages, as is required in other parts of the large intestine. Of Babes'[4] ten cases by the one-stage operation, all recovered. He rightly maintains, that the administration of the anæsthetic plays an important part, especially when the patient is debilitated as a result of ileus. He gives morphia $\frac{1}{4}$ gr., and makes the incision with local anæsthesia (we always use novocain and adrenalin) and only employs a short ether anæsthesia while opening the peritoneum. No anæsthetic is given during the separation or stitching of the intestine, and the anæsthesia is only resumed when the skin is being stitched.

Technique of Ileo-colic Resection.—An oblique incision, similar to that recommended in difficult cases of appendicitis, is made close to the outer border of the rectus, but

[1] Cf. also Scudder, *Boston Med. and Surg. Journal*, November 1904, where very good illustrations of this method are given.

[2] *Archives internat. de chir.* Gand, 1905.

[3] *Deutsche Zeitschr. f. Chir.* Bd. 80.

[4] Langenbeck's *Archiv*, Bd. 80.

without opening the rectus sheath, the centre of the incision being placed midway between the umbilicus and the anterior superior spine of the ilium. By prolonging the wound upwards to the costal margin if necessary access can be got to the hepatic flexure and the transverse colon. The gridiron method of splitting the muscles is only to be used in the case of a circumscribed movable tumour of the cæcum.

The skin, linea semilunaris, transversalis fascia, and peritoneum are divided. If local anæsthesia is used, a fresh injection of novocain should be given before dividing the peritoneum. The edges of the wound are then retracted, and the tumour freed and brought out by dividing any peritoneal bands or adhesions which tack it down to the iliac fossa. The peritoneum on the outer side of the colon must be freely divided before it can be sufficiently lifted up and healthy bowel exposed above and below the growth.

The ascending colon is pulled well forward, isolated, and clamped with two pairs of crushing-forceps placed about $\frac{3}{4}$ of an inch apart. The distal pair is removed and the bowel tied with a strong ligature in the groove where it has been crushed. A gauze swab wrung out of lysol is placed beneath it and the intestine is cut across close

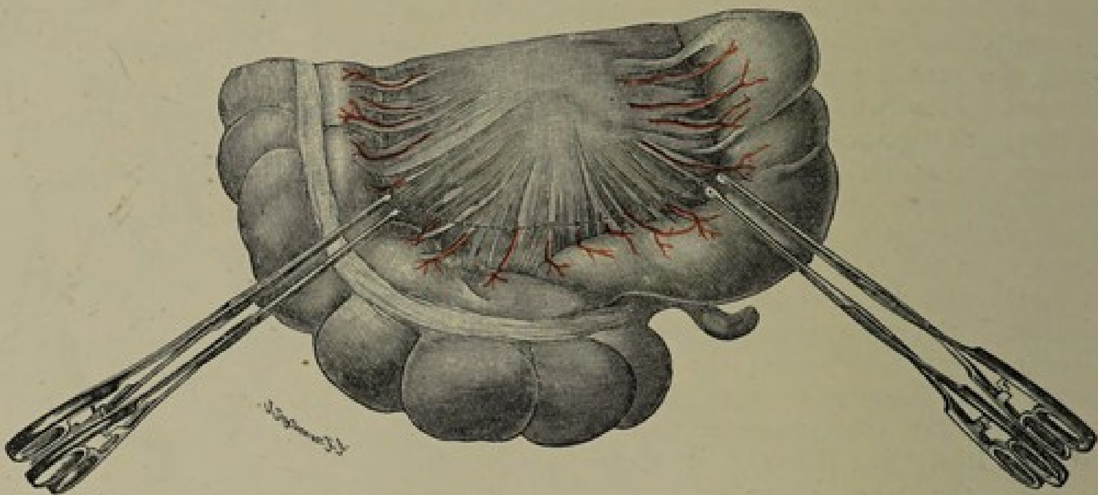


FIG. 377.—Ileo-cæcal resection. Stage 1 : Cæcum, ascending colon, and ileum have been exposed and two pairs of crushing-forceps applied above and below. The division of the mesentery is indicated by a dotted line. The forceps on the large intestine are here represented as too near, as it would not be possible to pass a ligature round the groove left by the removal of the distal forceps.

to the proximal pair of forceps; the redundant tissue is removed and the crushed end swabbed with alcohol. The mucous membrane of the peripheral stump is destroyed and swabbed with lysol. By using the proximal pair of forceps as a handle, the mesentery on the inner side of the bowel is divided, under-running the vessels with an aneurysm needle and ligaturing them firmly in sections. If the mesentery is thick, it should be crushed before it is divided. The distal ends of the vessels are then caught up with artery-forceps.

If there are any enlarged glands in the mesentery, they are to be removed, but if none are found, the division of the mesentery should be as near the gut as possible, to avoid tying the ileo-colic artery which supplies the ascending colon, an accident which would necessitate a further or entire removal of the ascending colon.

The mesentery of the small intestine is also divided close to the gut, and as the mesentery of the lowest portion of the ileum is so short, it is advisable not to utilise it, but rather select a portion higher up, which can be readily brought up to the ascending or the transverse colon without tension. As before, the intestine is divided between two crushing-forceps after which the diseased ileo-cæcum is removed.

The ileum is then anastomosed to the colon, but first of all one must make sure that the blood-supply to the ends of the gut, which are still grasped by the crushing-

forceps, is good, by noting the pulsation in the arteries; and secondly, that the ileum can be approximated to the ascending colon sufficiently well to allow of their being sutured. If this cannot be done, the transverse colon must be pulled down and the ileum inserted into it.

As Fig. 378 shows, the end of the large intestine is carefully closed with a layer of sero-muscular sutures, over which a layer of serous sutures is inserted.

The end of the small intestine is then applied to the large intestine and its posterior serous coat fixed by a line of serous sutures to a longitudinal muscular band. Both portions of gut are then emptied and clamped, the colon is opened by a longitudinal incision in the muscular band, and the crushing-forceps are removed off the small intestine. A suture including all the layers is next inserted in the ordinary way, and the serous coat is sutured over it.

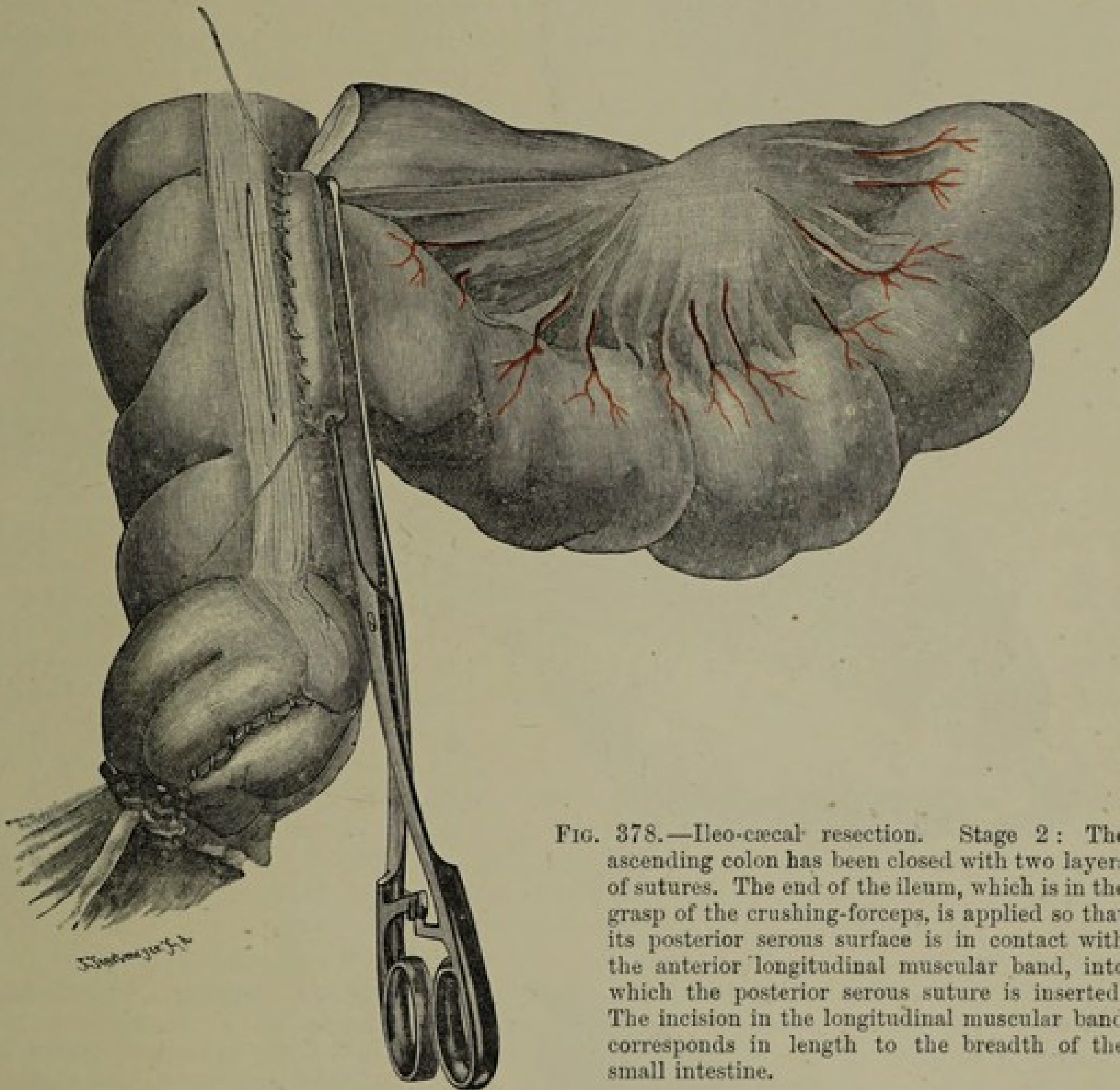


Fig. 378.—Ileo-cæcal resection. Stage 2: The ascending colon has been closed with two layers of sutures. The end of the ileum, which is in the grasp of the crushing-forceps, is applied so that its posterior serous surface is in contact with the anterior longitudinal muscular band, into which the posterior serous suture is inserted. The incision in the longitudinal muscular band corresponds in length to the breadth of the small intestine.

If possible, the raw surfaces on the abdominal wall are covered over with peritoneum, and the free edge of the mesentery stitched to the peritoneum. If the operation has been carefully performed and there has been no soiling of the peritoneum, a single glass drain is passed down to the site of the anastomosis and the wound is closed in layers. It is advisable also to insert two short drainage tubes into the wound as abscesses of the abdominal wall readily occur, from even the slightest contact with intestinal contents.

155. Resection of the Large Intestine. Resection within the limits of the colon must be regarded quite differently from resection of the small intestine and even of the ileo-cæcal region. In the case of the small intestine the contents are fluid and can

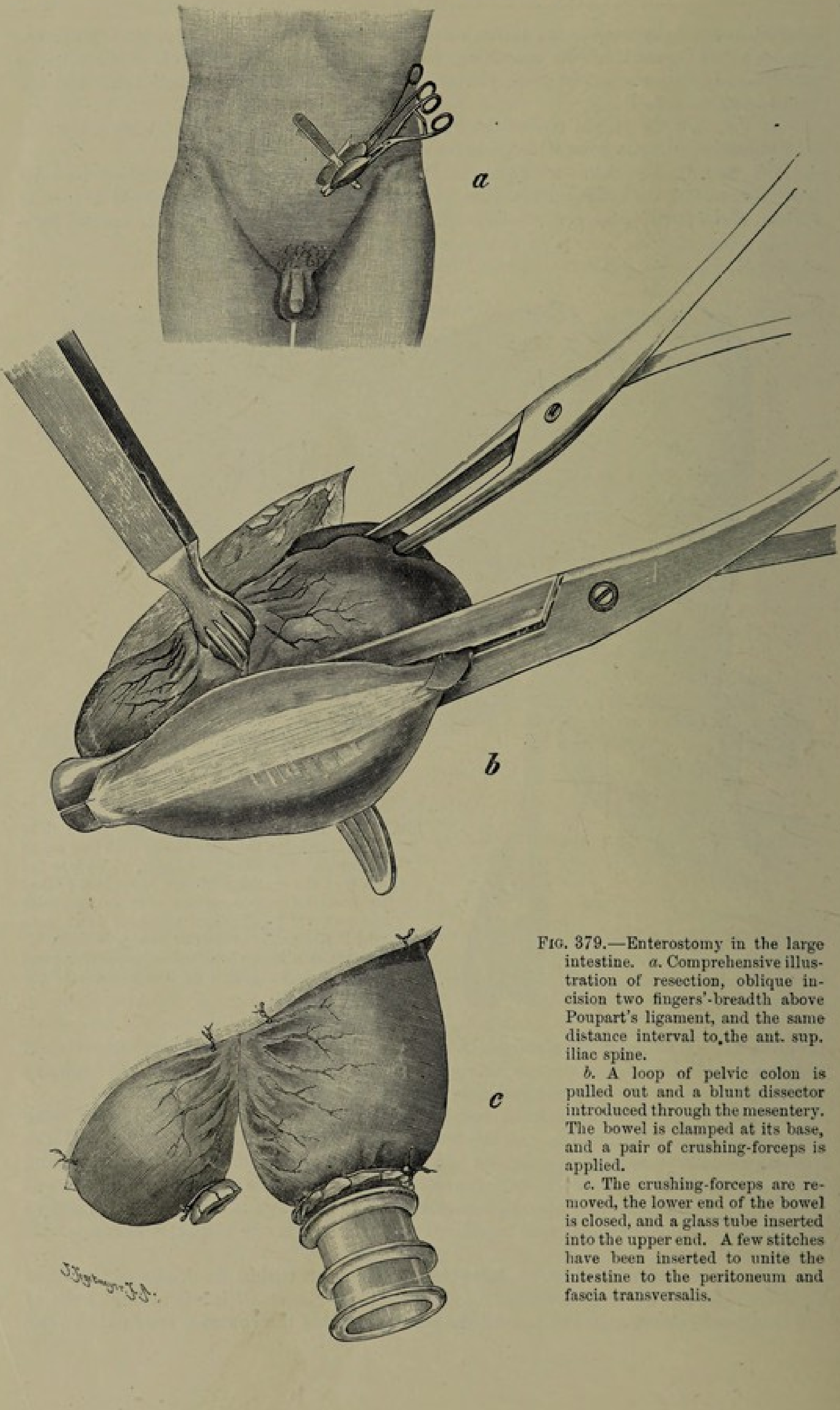


FIG. 379.—Enterostomy in the large intestine. *a*. Comprehensive illustration of resection, oblique incision two fingers'-breadth above Poupart's ligament, and the same distance interval to the ant. sup. iliac spine.

b. A loop of pelvic colon is pulled out and a blunt dissector introduced through the mesentery. The bowel is clamped at its base, and a pair of crushing-forceps is applied.

c. The crushing-forceps are removed, the lower end of the bowel is closed, and a glass tube inserted into the upper end. A few stitches have been inserted to unite the intestine to the peritoneum and fascia transversalis.

therefore be readily propelled onwards by the peristalsis through the sutured portion, even when the lumen of the latter has been rather diminished, and its power of contracting temporarily interfered with.

With the contents of the colon, however, it is different, for when they come in contact with the portion that is sutured, their progress is apt to be arrested owing to temporary obstruction and diminished peristalsis. They exert a prejudicial action on the sutures and may give rise to local ulceration, cutting out of the stitches, and perforation.

Accidents of this sort may occur even after thorough purgation and accurate stitching, and they can be made good only by most careful observation and by prompt and energetic treatment. The sutured gut must be brought to the surface, an artificial anus made, and the peritoneum cleansed as thoroughly as possible to prevent the onset of acute general peritonitis. Even in cases which do not go so far as perforation, fæcal abscess or peritonitis, the occurrence of an infective necrosis of the mucous membrane is sufficient to set up septic metastatic conditions (more especially pneumonia in old people) to which they rapidly succumb from heart failure and diarrhœa.

The trouble from the sutures can be avoided with certainty if we conduct the fæces away from the bowel above the resection. To do this an artificial anus must be made, not a fæcal fistula, so that the whole of the intestinal contents are led away through the opening, and the lower portion is thrown out of use. Or, one may anastomose the small intestine with the large intestine below the site of suture by ileo-colostomy, ileo-sigmoidostomy or ileo-proctostomy. Or, finally, the whole of the lower portion of gut may be excised and the upper portion implanted in the abdominal wall or even into the anus.

It makes a great difference whether resection of the large intestine is undertaken when the patient is suffering from obstruction or ileus, with a fæcal collection above the obstruction, or whether the bowel has been thoroughly emptied for a week or a fortnight before. In the latter case we have often been able to resect the large intestine without making an artificial anus above the site of suture, and as a rule with success, but in such cases both ends of the gut must be pulled well out of the wound, carefully approximated, and a large communication made between them. Even then the sutures occasionally give way.

The same care must be taken in making a lateral anastomosis, *i.e.* when both ends of the bowel are occluded and a large communication is made through the opposed longitudinal muscular bands. This method is in many cases to be preferred in the large intestine. In the case of the small intestine we attach no special importance to lateral anastomosis, while we consider end-to-side anastomosis between large and small intestine just as good as, and more simple than, lateral anastomosis.

The methods by which the above conditions can be carried out are very varied. The steps of the operation, viz. (1) safe removal of fæces, (2) isolation of the diseased portion of bowel, (3) removal of the disease, and (4) suture of the gut, may be combined in several ways, especially as one may operate in one or in several stages. The individual features of each case as well as the resistance of the patient must be considered before deciding whether to operate in one, two, or three stages.

In neglected ileus where the condition of the patient is already very serious, it is often as well to attend to the first point only—namely, the emptying of the gut—and wait till the patient's strength has been restored by the administration of fluid and nourishment, and till the danger of perforation of distension ulcers is past. These ulcers [1] are particularly liable to occur in the large intestine. The first stage of the operation is therefore limited in these cases to making an artificial anus above the obstruction, as described under "Enterostomy."

When the patient's general condition is less serious, and will allow of further operative interference, an attempt should be made to convey the contents of the ileum into the large intestine below the obstruction, while the resection of the gut is reserved for a later date. Thus, for tumours of the cæcum, ileo-transversostomy is performed, and ileo-sigmoidostomy for disease elsewhere in the colon. End-to-side

[1] See our article on "Ileus" in *Grenzgebiete d. Med. u. Chir.*

ileo-colostomy is the only reliable method preparatory to subsequent resection of gut.

Lastly, when the patient's condition is good, one has to decide whether the entire operation may not be performed in one stage. This should only be attempted in special cases; in the majority of cases one is compelled to operate in at least two stages.

According to Anschutz,[1] Oskar Bloch first proposed the two-stage operation, and Mikulicz developed it in the form of merely bringing out the gut. Many surgeons (*e.g.* Rotter,[2] who has had great experience in this branch of surgery) have proved that the mortality has diminished greatly since the adoption of Mikulicz's method. Schloffer[3] developed and recommended resection in three stages, the steps of which consist in colostomy, resection and suture of the bowel, and closure of the fistula.

Operation in one stage is only possible when a permanent artificial anus has been made. It can be employed, for instance, in malignant disease of the pelvic colon,

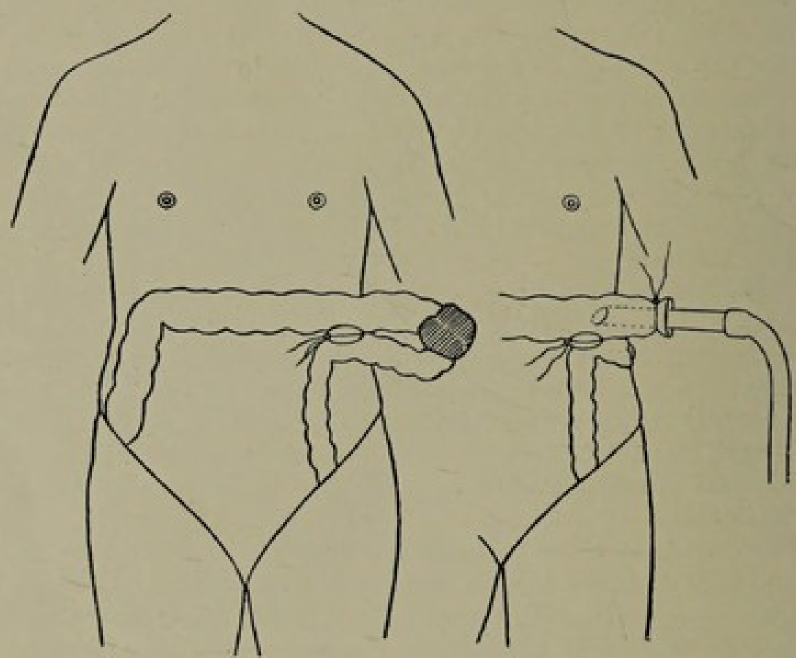


FIG. 380.—Resection of large intestine with M'Graw's elastic ligature. In the figure to the left the tumour is shown pulled outside the abdomen and the anastomosis made with the elastic ligature. In the figure to the right the tumour is removed, the lower end of the bowel closed and replaced just inside the abdomen, while a glass tube is tied into the upper end.

and occasionally of the descending colon up to the transverse colon, if the entire portion of gut down to the anus is excised (cf. section on excision of the rectum). Thus Kümmel and de Quervain have divided the transverse colon above the obstruction and inserted it into the anus, after excising the whole of the intervening bowel. If the patient's strength is well maintained, it is not necessary to do this in two stages.

The same holds good in ileo-colostomy. There is no reason why the ileum low down should not be implanted into the ascending, transverse, or pelvic colon, and why the whole of the short-circuited gut should not be excised in one stage, provided that the patient can stand it, as the possibility of fæcal stagnation is excluded. It is only when the patient's condition is not sufficiently good that the operation must be done in two stages.

[1] *Gedenkband für Mikulicz,* loc. cit.

[2] Rotter had a mortality of 55 per cent by operation in one stage (twenty-five cases). Mikulicz has reduced the mortality from 49 per cent to 10 per cent by the method of operating in stages.

[3] *Beitr. z. klin. Chir.* Bd. 38.

When the operation is done in two or three stages, it depends on the method adopted and the condition of the patient whether only a few days or a month should elapse between the first and the subsequent stages. M'Graw[1] has devised a method in which the whole operation is completed in four or five days. Like Mikulicz, he brings the tumour out of the wound after separating it, but he then makes an anastomosis between the afferent and efferent limbs of the gut with his elastic ligature, and closes and replaces the lower end before he stitches the intestine to the edges of the wound. The tumour is cut away and a large glass tube tied into the upper end. After four or five days the elastic ligature cuts its way through, and the fæces are passed per anum. The glass tube is then removed and the upper end of the gut closed and replaced.

Technique of Resection of the large Intestine.[2] We have excised a comparatively large number of tumours of the large intestine, and our results as regards radical cure even in advanced cases have been satisfactory, the patients having enjoyed good health for many years.[3] Apart from the cæcum, which is a very common situation for tumours (for the treatment of which see previous section), carcinoma of the pelvic colon demands special attention. At the same time, carcinoma not uncommonly occurs in the hepatic and splenic flexures and in the transverse colon. Malignant tumours of the pelvic colon are as a rule small and of the scirrhus type, whereas those elsewhere in the large intestine often attain a large size (one or double closed fist), and their removal may present great difficulty.

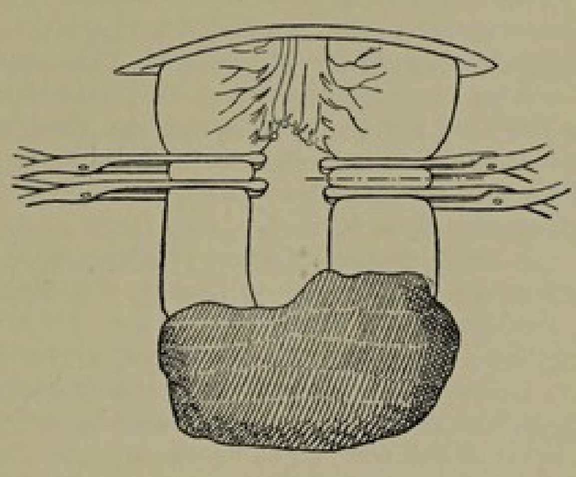


Fig. 381.—Resection of large intestine. The tumour is drawn well out, and two pairs of crushing-forceps are applied to the bowel above and below after the mesentery has been ligatured.

Tumours of the transverse colon are exposed by a transverse incision; oblique lateral incisions are required for tumours of the hepatic and splenic flexures. Muscles should be split rather than divided, while all motor nerves should be preserved. Retracting-forceps will be found of great advantage.

The tumour is separated from adherent omentum and pulled out along with any adherent loops of small intestine. The bowel is crushed and divided, and when the tumour has been brought sufficiently far outside the abdominal cavity, the peritoneum is carefully shut off with gauze packing. The tumour must be very thoroughly freed, for it is absolutely essential to bring it well out of the abdominal cavity, while it is immaterial whether a longer or shorter portion of healthy large intestine is removed along with it. This is an absolutely essential point. Catgut ligatures are used for tying the mesocolon, as there is a risk of their becoming infected during the resection of the bowel. Crushing-forceps may be applied to the mesentery if desired.

After the tumour is thoroughly freed and brought outside the abdominal wound, one has to decide how the continuity of the bowel is to be restored when the tumour has been excised, and how the intestinal contents can be best led away from the site of the resection.

It is only in exceptional cases (when the bowel has been very thoroughly emptied as a result of careful preparation and diet) that direct union of large intestine is to be

[1] *Annals of Surgery*, 1904.

[2] This description does not apply to patients who are in a very bad general condition with severe fæcal impaction (ileus) at the time of operation. In the latter the removal of the contents of the intestine by artificial opening or enteroanastomosis will be sufficient.

[3] We have not the exact figures at our disposal at present, but they will be published separately. Rotter has recorded five radical cures out of eight operations.

attempted, either by end-to-end suture, or by lateral anastomosis with occlusion. On the other hand, if the patient has been well prepared, a direct union may as a rule be made between the lower ileum and the large intestine. Ileo-colostomy is then performed as described in Section 154 (*vide* Fig. 378), only the point at which the ileum is inserted being varied.

If such a unilateral occlusion is out of the question, because it involves the sacrifice of too much bowel, the two limbs of the bowel should be stitched to the parietal peritoneum and fascia of the wound with sutures which include the serous and muscular coats. Two pairs of compression-forceps are then applied to both the afferent and efferent bowel at a sufficient distance beyond the tumour. The distal pair on the efferent limb is removed, the bowel tied with a strong ligature, and divided close to the proximal forceps. The afferent bowel is divided between the two pairs of forceps.

After applying a clamp to the afferent loop and packing a layer of protecting gauze round it, the crushing-forceps are removed, and a glass tube, with a rubber tube attached, is fixed in the gut. This ends the first operation.

After the bowel has been well evacuated and the patient's strength restored, food is withheld for a few days, and the spur between the two limbs is destroyed, for a distance of 7-8 cm., by means of Dupuytren's enterotom or suitable crushing-forceps. This is of course more easily done if both ends of the gut have been left open with a glass tube in each.

Instead of simply destroying the spur, one may anastomose the two limbs, and when the anastomosis is healed the artificial anus may be closed. This method resembles that of M'Graw, only here the bowel is stitched instead of using the elastic ligature; the latter is less trustworthy, as the opening is apt to narrow again.

In cases where the gut is comparatively free from fæces at the time of the first operation, primary anastomosis may be performed as shown in Fig. 380. The artificial anus is closed after eight to ten days.

156. Surgical Interference in Disease of the Vermiform Appendix.[1] The treatment of interval cases of appendicitis has been fully considered in our former edition. The indications for operative interference in appendicitis have widened so enormously in recent years that it is difficult to formulate rules on this subject.

Now that every busy surgeon counts his operations for appendicitis by hundreds, and the statistics of some surgeons run into thousands, the temptation of treating any part of the subject too exhaustively must be avoided. The information we here give is therefore confined to the bare essentials; further details will be found in the excellent and exhaustive treatises by Sprengel[2] and Kelly.

The significance of the operation for appendicitis is very different according to whether we are dealing with the so-called radical operation during the quiescent stage or during the acute stage. The radical operation, as performed by the majority of surgeons, is not an operation for appendicitis, but in a large proportion of cases is merely amputation of an appendix which shows no sign whatever of existing inflammation, but which is removed because at one time it was the seat of inflammatory changes, the results of which can still be recognised. This operation may be classed along with those other cases in which the operation is performed on account of distress in the shape of appendicular colic, the appendix itself showing no sign of disease when examined, or where, exceptionally, some ulceration, retained excrement, a calculus, cicatrices, adhesions, or kinking may be discovered as the cause. In 39 per cent of his radical operations Roux found no marked change; in 61 per cent he found either a perforation, a cicatrix, or some stenosis.

[1] Haberer (Lecture, Vienna, 1905) has traced the historical development of appendicitis. In 1824 Louyer-Villermay first reported two fatal cases of inflammation of the appendix. Shortly after this Melier and Meniere advocated laparotomy in cases of suppuration from this cause. Burne (1839) referred the majority of cases of perityphlitis to perforation of the appendix. Mikulicz (1885) and Kronlein (1886) reported successful treatment of acute peritonitis with resection of the appendix, and in 1888 Gaston advocated appendectomy as a radical measure. The American surgeons (M'Burney and Murphy) were the first to undertake early operation on principle.

[2] Sprengel, *Deutsche Chirurgie*, 1906.

It is evident that such operations must be incomparably more successful than operations performed during inflammatory attacks. In the present state of abdominal surgery an operation on so small an organ as the vermiform appendix is entirely devoid of danger, and may be undertaken without hesitation. The mortality in such cases with a surgeon of the aseptic school is nil.

An exception, however, must be made when extensive adhesions have formed after a severe acute suppurative attack, for in these cases the appendix is often so buried that its separation may result in considerable bruising or even perforation of the intestine, which, if unnoticed, will lead to serious results. This radical operation in cases where there are no, or only very slight, adhesions, has been treasured as the jewel of operative surgery. Without exposing the patient to danger and with a minimum of trouble and anxiety, it gives the surgeon the satisfaction of having for ever relieved the patient, not only from suffering, but also from a danger constantly threatening his life.

Roux has come to the conclusion that the radical operation should be performed on every patient who has had a single attack of appendicitis, while other surgeons prefer to wait till after a severe attack or till several attacks have occurred.

Our own experience has led us to recommend operation if the patient has had one *definite attack of appendicitis, or repeated or continuous attacks, even though the symptoms have been but slight, provided there is sufficient evidence of the existence of changes in the appendix.* Every surgeon must have seen cases in which the patient, after recovering from one or two slight attacks, has subsequently been seized with a fatal attack. It is such calamities as these which have led surgeons to recommend radical treatment.

Where the choice is given, one should certainly take to heart the advice given by Roux and other specialists on the appendix—it cannot be enough emphasised—and always operate in the stage at which all symptoms of inflammation have entirely disappeared, *i.e.* some months after an acute attack.

(*a*) *Technique of radical Operation when Inflammation has subsided.* The method, often described as M'Burney's or Roux's method, of opening the abdomen by splitting the muscles in the direction of their fibres gives the least chance of trouble after the operation for the removal of the vermiform appendix. For, apart from infection, which should not occur, the only injury which can result from the operation is the formation of a ventral hernia. If the abdomen be opened by separating the muscular fibres, and if injury to their nerve-supply be avoided, there is no question of the formation of a hernia. Not only that, a patient operated on by this method can leave his bed and follow his occupation after eight days, just as a patient can on whom our operation for the radical cure of hernia has been performed.[1]

The incision (Fig. 382) is purposely made over the fleshy region of the abdominal muscles, three fingers'-breadth above and parallel to Poupart's ligament. Divide skin, subcutaneous tissue, and the aponeurosis of the external oblique,[2] and with blunt hooks pull apart the edges of the latter as widely as possible. Next incise the fascia covering the internal oblique muscle, and separate and pull apart the muscular fibres, again putting in the blunt hooks. Lastly, the same manœuvre is gone through with the transversalis muscle.

The fascia transversalis, which is now exposed, is divided. The peritoneum merely requires to be incised for about an inch in order to allow of the finger being introduced and the cæcum brought out till the point of entrance of the ileum appears. In the angle between the two, where the anterior longitudinal band ends, the base of the processus vermiformis can be located with certainty, and is the first thing to

[1] The incision, the direction of which changes in the different layers, was recommended by M'Burney in 1894. Baracz and the Americans call it the gridiron incision.

[2] The dispute about large or small incisions has not the importance attributed to it by Hahn and Bier. For radical operation in the quiescent stage our incision is about 7 cm. long; in acute and complicated cases it must be longer. v. Eiselsberg and Haberer justly maintain that it is not right to make the operation in the depths of the wound more difficult for the sake of getting a scar shorter by one or two centimetres. This certainly means more risk to the patient. The surgeon who knows how to stitch and get genuine linear scars attaches no value to abnormally small incisions.

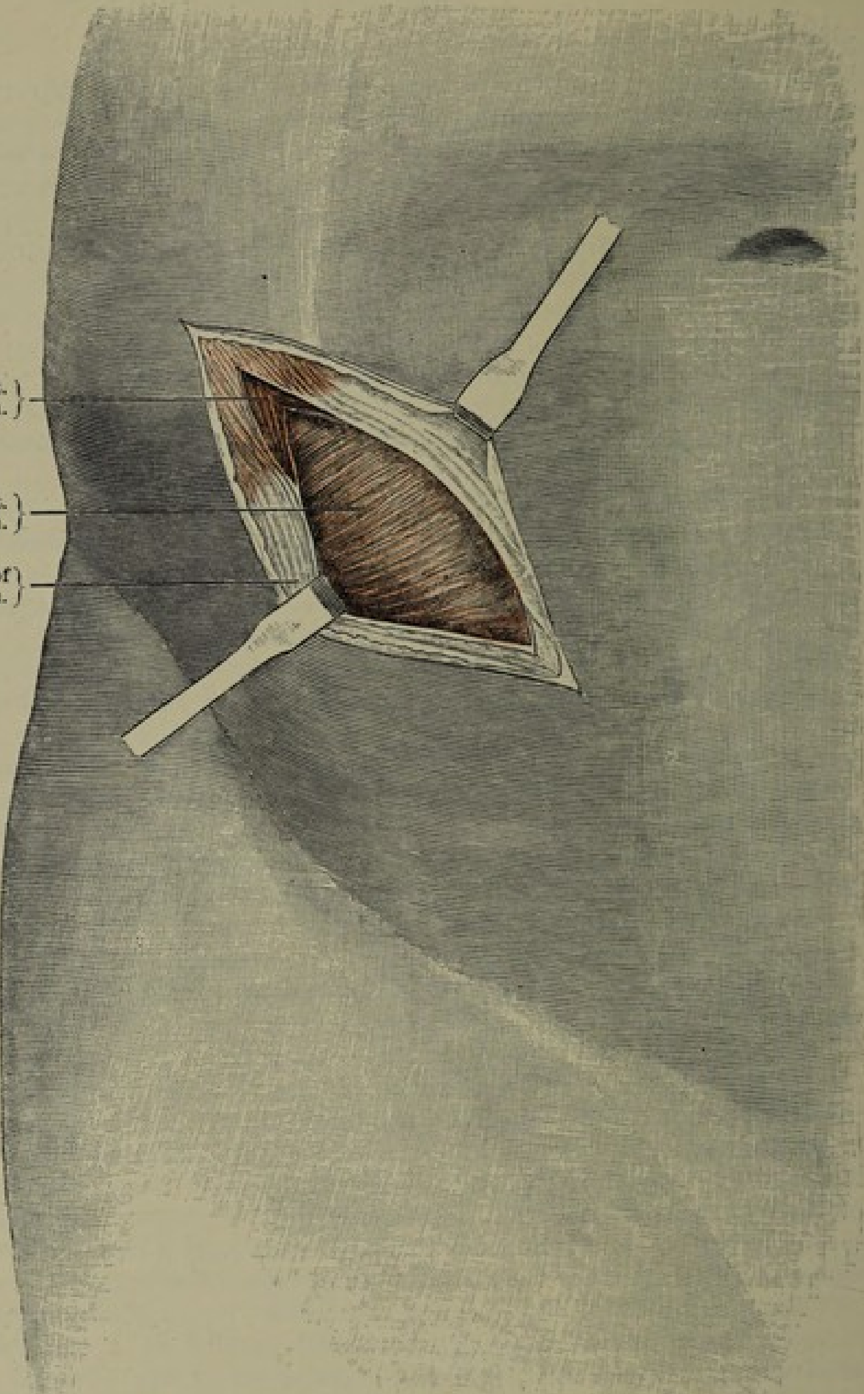
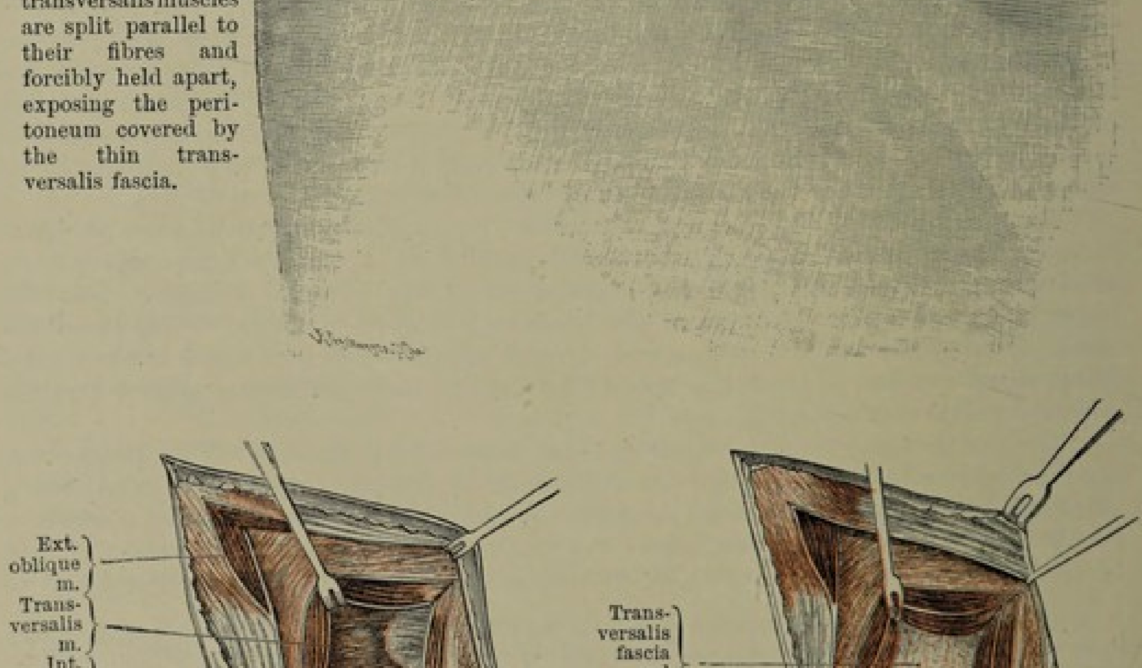


FIG. 382.—Permuscular incision for removal of the appendix, dividing skin, superficial fascia, aponeurosis of ext. oblique as well as muscular fibres (separation). The incision is placed three fingers'-breadth above the outer third of Poupart's ligament. The internal oblique and transversalis muscles are split parallel to their fibres and forcibly held apart, exposing the peritoneum covered by the thin transversalis fascia.



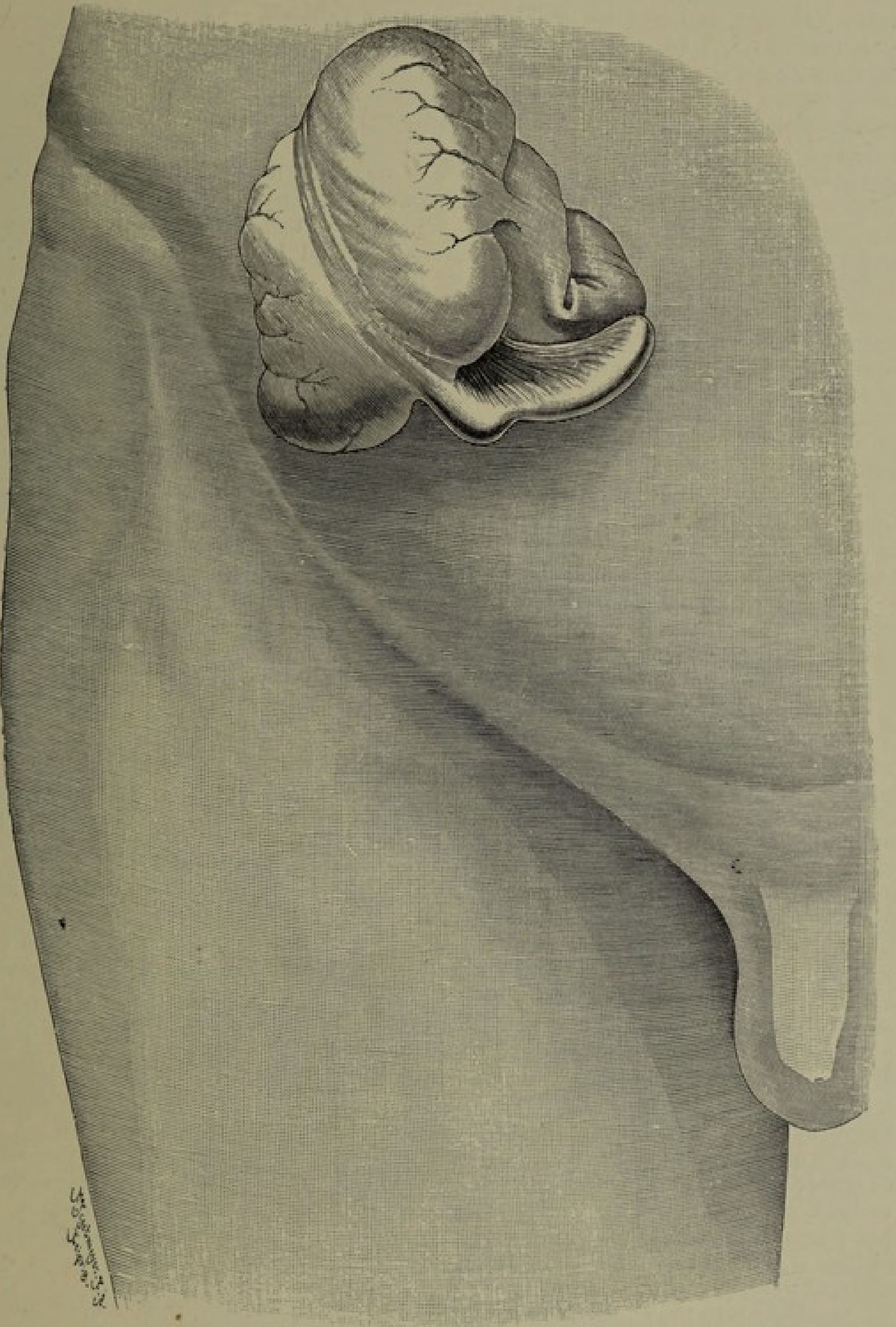


Fig. 383.—Radical operation for appendicitis. The cæcum and lower end of ileum have been drawn out of the wound. The figure shows the anterior longitudinal muscular band of the large intestine ending at the base of the appendix. The meso-appendix is well seen.

look for. The appendix is then freed and brought up to the abdominal wound. A small pair of crushing-forceps is applied at the base and then taken off, the point of their application is ligatured, and the part beyond cut off. The forceps should not be too narrow. A sufficient breadth is thus crushed, so that it is not necessary to cut through an uncrushed portion. The stump is buried by means of a continuous serous suture, and for this purpose it is best to use the end of the ligature which has been applied to the small artery in the mesentery of the appendix. If the tip of the appendix is firmly adherent deep down, it is often an advantage to separate and divide the base first, after which the process is gradually freed towards its tip, dividing the shortened mesentery and the adhesions towards the apex.

The base is crushed, tied with a silk ligature, and then divided with the thermo-cautery. Previous to dividing it, however, it should be grasped with a pair of Kocher's artery-forceps which form a useful handle.

In such simple cases, when the appendix shows no material macroscopic changes, the peritoneum and fascia transversalis are stitched up without a drain (de Quervain uses the tobacco-pouch stitch), and stitches may be introduced to close the split edges of the muscle. A continuous suture is put into the divided external oblique, and the skin incision is closed.

(*b*) *Early Operation in the Acute Stage of Appendicitis.* In the few years that have elapsed since the publication of our last edition, the greatest revolution has taken place regarding the question of operation in the acute stage of appendicitis—the so-called early operation. Formerly there were only a few strenuous advocates of the early operation, *e.g.* Rehn, Sprengel, Bernays, Sonnenberg, Riedel; now, however, experience of its undoubted advantages has led to its general adoption.

Bernays was among the first to convince the general public as well as the practitioner of the benefits of early interference, by publishing the brilliant results he had obtained in seventy-one cases of acute suppurative and gangrenous appendicitis, in which all his patients recovered after early operation.

In the last few years, the equally good results of other surgeons such as Körte, Rotter, Krogius, Kümmel, Riedel, Ochsner, and especially American operators, have borne this out. Körte, in his exhaustive work on perityphlitis, has produced convincing proofs of the advantages of early operation.[1] According to Nordmann,[2] of eighty patients operated on within the first three days for appendicitis, when the inflammation was still limited, none died! while of fifty-four operated on within the same period when there was diffuse peritonitis sixteen died, the majority of the latter having been operated on the third day after onset. At the Congress of the Deutsche Gesellschaft für Chirurgie it was shown that the mortality from the genuine early operation (*i.e.* when the patient is operated on within twenty-four hours of the onset) is nil, and that it increases on the second and third days to reach still higher percentages in the intermediate stage. In contrast with Bernays' figures, in forty-five of Rotter's cases operated on in the first twenty-four hours, there were only four in which pus had formed, while of sixty-five operated on on the second day pus was present in thirty-five. While all his cases of pure appendicitis recovered, he had a mortality of 3 per cent for cases with merely serous exudation in the surrounding parts, and a considerably higher mortality in cases of suppuration, *i.e.* when perityphlitis had occurred.

The statement made by Bernays that "with early operation we are in a position to secure 98 per cent of recoveries even including the worst cases" has been absolutely verified. We can count on almost certain recovery from early operation so long as the phlegmonous inflammation, which, according to Roux, is characteristic of acute appendicitis, is limited to the appendix itself, *i.e.* merely purulent infiltration of the wall, ulcerative changes of the mucous membrane, or more extensive gangrene.

In addition to the appendix being intensely red and swollen, it is almost always covered with lymph, and there is a sero-purulent exudation round it. The period of the true early operation lasts so long as the surrounding serous and subserous tissues have not become involved in the acute suppurative infiltration or necrosis, *i.e.* when

[1] Compare also the great works of Kelly and of Sprengel on Disease of the Appendix.

[2] Langenbeck's *Archiv*, Bd. 78.

acute perityphlitis or paratyphlitis has not been superadded. This localised or circumscribed condition may be over-stepped in six hours, especially if there is a perforation and gangrene at the base of the appendix, but otherwise it may continue till the third day. In short, the most favourable time is passed with the lapse of twenty-four hours, after which the operation can no longer be regarded as "early."

Technique of early Operation in the acute Attack. As a rule a larger incision is required when operating in the acute stage than in the interval. There is therefore no advantage to be gained by splitting the muscles, or by the incision through the sheath of the rectus. We agree with Senn, Barker, and Bernays that it is better to choose the thinnest part of the abdominal wall, where the aponeuroses of the muscles unite to form the rectus sheath. This pararectal incision (*vide* Fig. 384) is placed external to the rectus sheath, and divides the skin, fascia, and the united aponeuroses of the three abdominal muscles. As is often necessary, it may be prolonged upwards or downwards without doing any harm.

The peritoneum is then freely incised, and its edges are grasped with artery-forceps to allow of the escape of any collection of fluid. After separating the omentum, which is often adherent, traction is made on the cæcum, and the appendix sought for with the finger and pulled out of the wound with or without the cæcum. If, after separating the adhesions, the appendix is found to have perforated, and pus or other infective fluid is found to be escaping from the lumen or from a small abscess in the vicinity, the origin of the appendix should be clamped, and the process rapidly removed. Escape from the lumen must be mopped up at once with gauze.

The removal of the appendix may be made more difficult if there is an open perforation at its base, or if the base has become thickened and friable from phlegmonous infiltration. As a rule it should not be crushed: a ligature is simply tied round it, and if necessary a portion of the cæcum may be included to give a better grip. In this case the cæcum should be clamped.

If there is much sero-purulent fluid already present round the appendix and in the cavity of the pelvis, mere swabbing may not be sufficient, and irrigation with saline may be necessary, but in the latter case a free outflow must be provided. A drainage tube is passed down to the stump, in case the ligature on the appendix gives way, and in addition, if there is a copious exudate, large glass tubes are passed down into the pouch of Douglas, upwards along the ascending colon and occasionally in other directions, depending on the position of the appendix. Besides the glass tubes, gauze drainage is very useful. Bernays inserts a gauze strip down to the stump and places gauze in contact with every inflamed loop of intestine. M'Cosh's cigarette drain (wick and rubber wrapping) is still better. The peritoneum and fascia transversalis alone are united round the drain and gauze. The muscles, superficial fascia, and skin are brought together after a day or two by secondary suture, or may be temporarily stitched over a piece of iodoform gauze.

(*c*) *Operation for Appendicitis in the intermediate Stage after Abscess Formation.* A professor of clinical medicine, justly held in high esteem, when discussing the treatment of appendicitis, is regularly in the habit of saying to his students that with all their operations at the present day surgeons do no more good than in the days when they limited themselves to opening perityphlitic abscesses handed over to them by the physician. In the early operation the diagnosis may be as often erroneous as correct, and operations are performed in cases of commencing typhoid, acute gastro-intestinal catarrh, biliary colic, etc. Operations after the inflammation is past could in great part be left undone, and are performed on perfectly healthy vermiform processes.

Now and then mistakes are undoubtedly made from operating early, but this is no reason why one should relinquish the great benefits of early operation in cases of genuine acute appendicitis. Those who have had the experience of seeing a surgeon decline to operate, although the friends of the patient urgently desired operation in the early hours of the disease, and then have seen the patient die of peritonitis in a few days; or who have seen the waiting policy followed till the abscess has become obvious to the eye of the physician, and the operation has become a serious consideration as the result of metastatic processes (the formation of fresh abscesses, thrombo-phlebitis

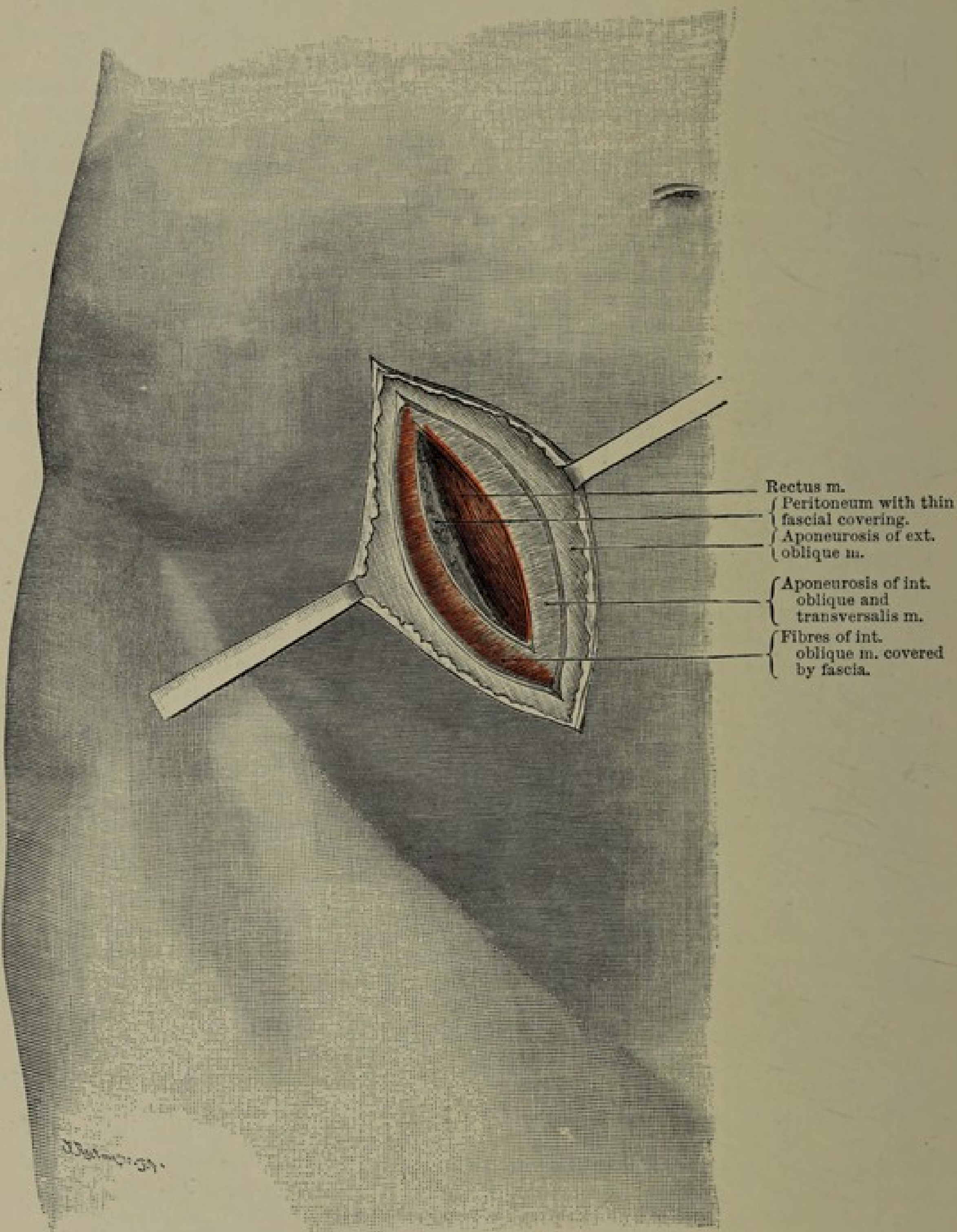


FIG. 384.—Parareceal incision in acute appendicitis associated with peritonitis. Skin, aponeurosis of ext. oblique, int. oblique, and transversalis muscles are divided, the edge of the rectus is exposed, with underneath it the transversalis fascia and peritoneum.

mesenterica (Golya) subhepatic abscess and pylephlebitis, acute phlegmonous parotitis) or as the result of infection of the peritoneum from opening deeply situated abscesses, abscesses in the pelvis or under the liver; or those who have seen two or three attacks of the mildest type followed by a fourth fatal recurrence, will have little inclination to gamble with the life of their patient, and wait for abscess formation with its attendant risks, when they can avoid it.[1]

On the contrary, when we see a patient with an abscess already definitely formed and easily diagnosed, we reflect whether it need be opened at all, or whether it would not be better to wait for spontaneous perforation into the gut.

If the temperature is already falling, the pain disappearing, and the distension diminishing, there is no need to be in a hurry to open the abscess, provided the patient is kept under supervision and properly treated by rest and diet, without opium. The fall of temperature is a certain indication that the inflammation is subsiding. When the abscess is easily accessible to the knife, by all means cut the course of the disease short by opening it.

On the other hand, when the inflammation is still of an acute and progressive character, operation must never be postponed. Here, however, the state of affairs is quite different from that of the genuine early operation. In the latter case, where the inflammation is limited to the appendix and its immediate neighbourhood, one aims at a radical cure by removing the diseased organ, whereas when an abscess has formed the removal of the appendix becomes a secondary consideration; and one has to treat the perityphlitis (paratyphlitis, parahepatitis, or pericolitis, depending on the position of the appendix and the extent of the inflammation). The first object is, then, the evacuation of the pus. Primary removal of the appendix is only indicated when it can be done quite easily, or when it seems necessary for the cure of the abscess.[2]

The method and place of opening depend upon its site. Abscesses form not only at the classic point between the umbilicus and anterior superior spine of the ilium, but also inside the true pelvis, in the left iliac fossa, towards the umbilicus, in the right lumbar region, below the liver or below the diaphragm, according to the site of the appendix. It follows, therefore, that the incision may require to be through the rectum, through the posterior vaginal wall, in the middle line of the abdomen, above the left Poupart's ligament, in the right lumbar region, at the umbilicus, or below the costal margin. When the abscess is in its "normal" position the incision is best made parallel to and just above Poupart's ligament, even in cases where the chief swelling seems to be situated above this point, and where the tenderness and resistance are both more intense at a higher level. If the incision be made farther away from Poupart's ligament it often opens the free abdominal cavity at a point where the exudate appears to be superficial only. The incision is made one finger's-breadth above the ligament, through skin, superficial fascia, and external oblique. The deeper abdominal muscles, often œdematous, are raised upwards with a blunt dissector from the groove of Poupart's ligament, and the dissection is continued upwards and backwards towards the exudate till pus wells up.

In cases in which the inflammation is abating it may be necessary to dissect deeply through the infiltrated tissues. Care must be taken not to bore into the ilio-psoas muscle. When the incision is made in the middle line for large pelvic abscesses it is also advisable to use a blunt dissector after cutting through the skin, superficial fascia, and linea alba in order to avoid injury to the bladder, which is often closely applied to the abscess.

Injury to the bladder will be avoided by seeing that the bladder is emptied, if necessary, by passing a catheter. It may be a very difficult matter to open deep

[1] Ochsner (Tristate Soc., Oct. 1904) had a mortality of 1·9 per cent in 255 cases of acute appendicitis with and without perforation, but without abscess, 3·4 per cent in 117 with abscess, and 30 per cent in those with general peritonitis.

[2] According to Nordmann, Korte's mortality was only 0·5 per cent when the abscesses were simply opened in the intermediate stage, while it was 8 per cent when the radical operation was done at the same time.

abscesses above or below the liver in the lumbar region. A large incision is essential, and the tissues must be dissected in layers, care being taken not to open and drain the abscess through the free peritoneal cavity. A short time ago one of our colleagues had a death within a few hours as the result of this mistake in a case of subhepatic abscess.

In spite of opening the abscess recovery may be very slow, or indeed the patient may finally succumb. This happens when one large and well-defined abscess has been opened, and when other abscesses which do not communicate with it are overlooked.

The foul-smelling contents of the abscess must be thoroughly removed by careful continuous irrigation with physiological saline, but it is not desirable to repeat the irrigation. The wound should be dressed with warm compresses, frequently changed.

To shorten the period of convalescence in such cases, and to render recovery certain, we have proposed in this intermediate stage that after the abscess has been opened the radical operation should be performed exactly as during the acute stage. A fresh incision is made quite separate from the one communicating with the abscess cavity, and as far removed from it as possible—*i.e.* at the border of the rectus muscle. Adhesions are carefully broken down, the appendix isolated and brought up into the wound (together with the cæcum if necessary), and amputated as described above. Catgut sutures are employed. The contiguous portions of the small intestine and cæcum, which may be covered with a layer of lymph, must be examined for a possible secondary perforation.

As in the acute stage the wound must be lightly packed with a strip of xeroform gauze passed down to the stump of the appendix. A glass tube should be inserted alongside the gauze, and the dressing should be completely shut off from the abscess wound by a carefully applied covering of collodion.

By means of this procedure we have seen large abscesses which have been opened externally heal up with comparative rapidity, so that we were able to discharge the patients in a few weeks without the necessity for disturbing their minds with the prospect of a second operation for the radical cure.

(*d*) *Operation for general Peritonitis in Cases of Appendicitis.* The surgeon who waits for the formation of an abscess, or for definite perityphlitis, lays himself open to blame should peritonitis ensue as a result of the delay. It is a fact that every year a great many lives are still lost from delay in operating during the acute stage, because a localised inflammatory process has been allowed to spread to the general peritoneal cavity.

It is a question of the virulency[1] of the bacteria, on the one hand, and the quantity of the infectious material present in the peritoneal cavity, on the other hand, which determines the early occurrence of diffuse peritonitis with all its accompanying dangers. If the perforation be a large one, as in extensive gangrene of the appendix, or if it be situated at the base, where intestinal contents can escape, the risk is much greater. Like Roux, we find that a serous or sero-purulent exudation into the free peritoneal cavity is of constant occurrence. Such exudations, however, doubtless find a natural limit for themselves as a rule, by the formation of fibrinous adhesions between the intestine, omentum, and abdominal wall. Not infrequently at autopsies on cases in which a large perityphlitic abscess has been opened, other multiple abscesses are found between the coils of intestine and masses of adherent omentum, under the diaphragm, and extending over the liver and spleen. A small number of these abscesses arise from secondary perforation from purely perityphlitic suppurative foci; most are the immediate consequence of the infective material which escapes when the appendix perforates. Such secondary perforations from an abscess are more dangerous than the primary abscess formation, because in the former case the infective material has developed in the body and become adapted to it, and is consequently much more virulent. It is desirable, therefore, to open the primary suppurative focus as early as possible in the progressive stage of inflammation. In spite of this, a number of patients nevertheless die after abscesses have been opened

[1] Brunner has shown experimentally that virulence and the quantity of the infective material decide whether the peritonitis becomes diffuse or not. Compare also Tavel and Lanz on peritonitis.

from the development of further abscesses, and if death is to be avoided in these cases the primary source of infection must be attacked, the appendix removed, and with it the periappendicular foci, before they have reached the stage of extensive abscesses.

Early operation is even more urgently indicated in those cases where there is no local pus formation, but where an exudate rapidly involves the whole peritoneal cavity, *e.g.* in streptococcal and *b. coli* infection of adults, and in pneumococcal peritonitis in children. The direct method of treatment of such a diffuse peritonitis extending from the diaphragm into the true pelvis is, as a rule, highly unsatisfactory owing to the shock which results from opening and handling the inflamed peritoneum, and the increase of absorption of septic material. If the abdominal cavity be opened freely and all the suppurative foci evacuated and drained, the existing collapse is augmented to a dangerous degree, and the means of preventing this has not yet been discovered. In his experiments on shock, Crile established the fact that cutting off the arterial supply to the intestine prevented the fall in the blood pressure—the chief symptom of shock. It remains to be ascertained whether some such temporary expedient be permissible in peritonitis. Possibly the application of pressure-forceps to the mesentery during the very short time required for examination and cleansing of the intestines might be adopted. Frequent subcutaneous and intravenous transfusions of salt solution are very effective as a remedy for shock. According to Crile a very large amount often requires to be introduced (as much as double the volume of the blood in the case of animals) before a successful result is obtained. Katzenstein has seen excellent results in these conditions by the use of continued slow but copious saline injections into the rectum. As an accompaniment to this, hypodermic injection of strychnine is excellent. Elevation of the buttocks and lower extremities should also be employed.

In peritonitis it is very useful to empty the stomach and intestine by washing out, and it may be necessary to form one or more fæcal fistulæ. It is a noteworthy fact that those surgeons who have obtained the best results in peritonitis lay great stress upon thoroughly evacuating the intestines by means of purgatives as opposed to the morphin treatment. Bernays' custom is to give calomel hourly in a dose of $\frac{1}{10}$ gr. after twelve hours have elapsed since the operation in the acute stage, and, if necessary, to give seidlitz powder and magnesium citrate (of course in cases in which there is no fear of further trouble from the perforation, *i.e.* when the appendix has been amputated).

Bernays, in opposition to Ochsner, strongly defends the use of aperients.

Besides the measures already mentioned for improving the patient's resistance or getting rid of the toxæmia, we have found the following treatment very serviceable in a large number of cases of general peritonitis following appendicitis.

The abdominal wall is incised on both sides at a point corresponding to that which we have recommended for the removal of the vermiform process. The incisions need not be any larger than is necessary to remove the appendix, and this is undertaken in the first place. The exudate is then thoroughly washed out and the abdomen irrigated with normal salt solution at a temperature of 42° C., using a long curved glass tube with a bulbous end which is passed upwards towards the liver, stomach, and spleen, and downwards into the pouch of Douglas. The irrigation is continued till the fluid comes away clear. Large long drainage tubes are passed from both wounds down to the pouch of Douglas and into both flanks, and warm moist compresses applied which are frequently changed. A saline purge (Carlsbad salts) is given to get the bowels thoroughly emptied, and if this fails to act they must be emptied by making one or more fæcal fistulæ. Very often in peritonitis of this sort, instead of suturing the base of the appendix, one has to utilise it for drainage.

The following is a summary of the principal points in the treatment of appendicitis:—

(1) In acute appendicitis it is the duty of the physician to urge the question of immediate early operation, for by no other treatment can the dangers be so certainly and rapidly averted. Operation should be performed under proper aseptic

precautions, preferably in hospital, within the first twenty-four hours, or if possible the first six to twelve hours.

(2) In the subacute stage surgical interference is called for if the inflammation and fever are increasing, and as a rule consists merely in the thorough evacuation of abscesses. When the latter are shut off and the temperature is falling, operation is not urgent, for as a rule they discharge spontaneously into the bowel. If, however, they are easily reached they should be opened.

(3) With the onset of general peritonitis the abdomen should be opened at once, the appendix if possible amputated, the exudate removed by irrigation and drainage, and the stomach and intestines emptied. If, however, paralysis of the bowel and symptoms of collapse are already present, enterostomy only is to be undertaken.

(4) When the inflammation has subsided, the removal of the appendix offers the most certain and safe means of preventing a further attack.[1] If possible three months should be allowed to elapse before undertaking the removal of the appendix.

(i) Surgery of the Rectum

157. Excision of the Rectum. As this is the most important operation on the rectum we will consider it first. It is most often undertaken for carcinoma of the rectum, but is also used in the treatment of other new growths, and occasionally for syphilis, tuberculosis, stricture, and prolapse. Extirpation of the rectum may either take the form of amputation, *i.e.* the rectum is removed from below upwards for a distance varying to a total excision, or of resection, in which an intermediate portion is excised.

Cases in which the sphincteric apparatus can be saved may be included in the term amputation, as the technique is very similar. One is, however, guided in the selection of the method by the situation and extent of the carcinoma. It must be admitted that there are surgeons who regard amputation as the routine procedure on principle, and only modify the operation to the extent that, when the tumour is situated low down, they bring the bowel down and fix it in the anus; whereas, when the tumour is situated high up they make an iliac, gluteal, or abdominal anus—in short they bring out the bowel in an abnormal position.

It is going too far to reject excision entirely. No one is in doubt as to what is to be done in a case of carcinoma of the pars analis. Here the anal canal and a portion of the rectum two fingers'-breadth above the new growth must be extirpated or amputated. The best method to adopt is that of Lisfranc: incision round the anus and removal of the rectum together with the surrounding fat and glands from the coccyx to the prostate or vagina (occasionally with portions of these organs), and from the inner surface of both sides of the pelvis.

In disease of the rectal ampulla,[2] the anal portion as a rule escapes, the growth being limited to the ampullary portion. In these cases we agree with Rehn that amputation is the normal operation, but we always attempt to preserve the sphincteric apparatus of the pars analis, when the latter is healthy. The rectal ampulla corresponds to that portion of the rectum extending from the pars analis up to the point where the bowel is completely surrounded by peritoneum, and has a mesentery. Tumours in this portion can be distinctly felt from below (at any rate under anæsthesia), and the extent of their mobility or fixation can generally be definitely determined.

Our method of removing the rectum by means of a posterior longitudinal incision with resection of the coccyx is the most satisfactory. It gives excellent access, and always enables one to reach sufficiently far above the growth as is compatible with a proper removal of the diseased tissue including the glands. Besides aiming at preserving the sphincters in these cases, our operation differs from amputation of the

[1] In Korte's cases (Nordmann) there had been only *one* preceding attack in 75 per cent of the cases which ended fatally as the result of recurrent attacks.

[2] Rehn's expression pars pelvina does not distinguish this section sufficiently from the pelvic colon, *i.e.* the intraperitoneal part of the rectum.

anal portion in that the peritoneum is opened, for the latter extends downwards on the anterior wall of the ampullary portion to nearly the upper border of the prostate.

Resection becomes a question of first importance when the carcinoma involves the lower part of the pelvic colon. In these cases, Kraske's operation with partial excision of the sacrum, or its modification with a parasacral incision, introduced by Hochenegg and others, can be employed. Even then, however, excision can only be contemplated when the tumour is either found to be movable or can be easily mobilised by simple division of the peritoneum. Tumours of the pelvic colon can as a rule be felt under chloroform by firm palpation through the abdominal wall, or can be recognised with the proctoscope.

Lastly, there are those cases where the growth extends up on to the pelvic colon and down on to the ampullary portion of the rectum; their mobility is limited and cannot be determined with certainty. They can only be dealt with, with any degree of certainty, by the combined method which Quénu has developed, namely, intraperitoneal as well as coccygeal (or sacral) dissection in one stage, with total amputation of the rectum and the formation of an artificial iliac anus.

Cases are inoperable when the growth is adherent to the wall of the pelvis or to an organ, such as the bladder, which cannot be completely removed; and also when the growth has given rise to metastatic deposits (most frequently in the liver) or to carcinomatous peritonitis. Palliative measures must then be resorted to, *i.e.* artificial anus (*vide* Enterostomy). With these exceptions, however, the indications for excision of the rectum have been greatly extended in recent years, and it is very rare to find a surgeon opposed to operation in general. Moreover, from the evidence furnished by a number of clinics, it is shown that although the operative mortality is by no means small, the prospect of radical cure is as good in the rectum as in other organs more suited for operation.

In the fourth edition we noted and referred to the statistics of Kraske, Hochenegg, (Pilcher) von Eiselsberg (Prutz), Madelung, Garré (Schneider), Küster (Wendel), v. Bergmann (Wolff), Wölfler and Schuchardt. The immediate results vary greatly, according to the position and extent of the growth. In the more simple cases, the mortality, according to some surgeons, is 3 to 4 per cent, but in the advanced cases, when the combined method has to be used, it amounts to nearly 50 per cent according to Kraske. Rotter's mortality in 24 cases was 44 per cent. Hochenegg lost 3 out of 5 patients from the combined operation, otherwise his mortality was only 6.2 per cent. Mayo's[1] mortality in 19 cases, where Quénu's operation was used, was 26.3 per cent. According to Gross, the mortality from the combined method is only 8 per cent in women, and 80 per cent in men.

On the other hand, Martin du Pan[2] records 25.7 per cent of radical cures in 83 of our cases. Rotter (Petermann)[3] reports 28 per cent of radical cures, while Poppert had 17 radical cures out of 60 cases, and of these 8 were amputations and 9 resections. In the latter the comparison is very equal. Hochenegg (Richter[4]) records 33·3 of radical cures out of 63 patients. Mayo states that of the cases who recovered after operation by Quénu's method, half were permanently cured, and places the percentage of radical cures as 36·8 per cent in all his 19 cases.

As we have stated on a former occasion, the prospect of obtaining a permanent cure increases with the severity or the radical nature of the interference, and consequently runs in some measure parallel to the operative mortality. It is not to be wondered at that Quénu's abdomino-perineal method gives the greatest number of radical cures, for it is an operation to which greater danger is attached, and in which no attempt is made to maintain the normal continence, *i.e.* an artificial anus is made. As the mortality is less by the first three methods of operation, and a good proportion of perfect results may be obtained as regards continence, it must be admitted that Kraske, Poppert, and others, are right in holding that the more conservative methods should be employed, when the surgeon, after careful examination of the case, thinks that a radical cure may be thus obtained. Hochenegg got

[1] *St. Paul's Med. Jour.*, April 1906.
[2] *Thèse de Berne*, 1905.
[3] Langenbeck's *Archiv*, Bd. 80.
[4] *Deutsche Zeitschr. f. Chir.* Bd. 81.

complete continence in 9 out of 29 cases that recovered after resection, and Poppert had 10 cases of union by first intention with complete continence in 20 resections.

158. Technique of Amputation of the Rectum. The preparation of the patient, provided acute obstruction is not present, consists in thorough purgation a few days before operation, and irrigation of the bowel with large enemata. Fluid diet is restricted (no milk), and for the last two days 8 grains of bismuth are administered every three hours and 10 drops of opium three times.

For the historical development of the technique of the operation, reference should be made to the admirable papers of Krönlein and Rehn, read before the twenty-ninth Congress of the German Society of Surgeons in Berlin, 1900. Since Lisfranc performed the first extirpation of the rectum three-quarters of a century ago, great progress has been made, and the credit of having improved the technique of the operation is due more especially to Kraske, who, by introducing the method of gaining access from behind, greatly widened the possibilities of dealing radically with the disease. Rehn drew attention to the importance of an exact knowledge of the anatomy of the parts as demonstrated by Waldeyer, Gerota, and Goldmann.

Rehn agrees with Waldeyer as to the necessity, from the surgical point of view, of distinguishing between: (1) the perineal part of the rectum ("pars perinealis recti"), the firm sphincter apparatus which is closely interwoven with the pelvic fasciæ and muscles; (2) the loose and sacular pelvic part ("pars pelvina recti") which, reaching to the level of the third sacral vertebræ, is half intraperitoneal, and is enclosed in the rectal fascia—a thickening of the subserous tissue which is prolonged laterally to be attached to the pelvis; (3) the pelvic part of the colon ("pelvic colon" of Jonnesco), which is entirely enveloped in peritoneum and has a mesentery reaching to the sacral promontory. In this mesentery is the main artery of the rectum, the superior hæmorrhoidal, which divides into two lateral branches descending under the fascia of the pelvic portion of the rectum. Lower down are the hæmorrhoidal plexus of veins, the lymphatic vessels, and the sympathetic nerves. Between the fascia and the sacrum are the middle and lateral sacral arteries, the sacral venous plexus, the sacral lymph glands, and the spinal nerves.

The lymphatics from the skin of the anus go to the lymphatic glands in the groin, those from the rectal mucosa pass to glands which extend as far as the peritoneal reflexion and lie on the lateral aspect of the rectum in relation to the lateral branches of the superior hæmorrhoidal artery, between it and the fascia propria recti: higher up the glands lie in the mesentery of the pelvic part of the colon.

As we mentioned above, amputation is performed in carcinoma of the anal and ampullary portions of the rectum, *i.e.* in all cases in which the tumour can be reached from below with the finger. Adhesions to the prostate, vagina, or uterus are not direct contraindications, but when there are more extensive adhesions to the bony wall of the pelvis or to a large area of the bladder, operation must be abandoned.

(*a*) *Lisfranc's Perineal Method.* This method is suitable for carcinoma of the anal portion, where the muscular sphincteric apparatus cannot possibly be saved.

A circular incision is made round the anus, through healthy skin, which is dissected up and stitched over the anus so that the orifice of the latter is closed. The edges of the wound are forcibly separated with sharp hooks or retractors, and the whole region thoroughly cleansed with lysol, ether, and alcohol.

The rectum is then freed all round with scissors or the knife guided by the left forefinger, keeping well away from any induration and clamping all bleeding vessels. As soon as the attachment of the sphincter and levator ani is divided posteriorly the tumour becomes more movable. The bulb of the urethra is separated in front, after having passed an instrument into the bladder, by dividing the muscle of Roux at the level of the prostate, after which the dissection is carried upwards between the prostate and the prerectal fascia. If the prostate is adherent, part of it should be removed along with the tumour.

In women, the posterior vaginal wall is detached, but if it is adherent a sufficient extent must be removed along with the tumour. Laterally, the bundles of vessels entering the bowel should be under-run with an aneurysm needle, and tied with

catgut before they are divided, after which the unopened rectum can be pulled down. It is essential that a portion two fingers'-breadth above the tumour-induration be brought down, for it is here that the bowel is to be divided and, avoiding any further tension, fixed in the site of the original anal ring.

The bowel is then clamped with two pairs of crushing-forceps placed two fingers'-breadth above any induration and divided between them with the thermo-cautery, the projecting mucous membrane being destroyed. Before the forceps are removed, the *upper* end of the bowel is stitched to the skin round the anus with catgut sutures, and iodoform gauze is packed in on either side of the rectum, while in front the wound is closed with deep aluminium-bronze sutures. The forceps are then removed, a tampon is inserted into the rectum, and 4 to 6 wire fixation sutures are passed through the whole thickness of the intestinal wall.

Instead of the rectum being stitched in the region of the anus, it may be brought out laterally through the skin of the buttock between the lower fibres of the gluteus maximus (Witzel). A competent gluteal anus is thus formed, a method by which von Eiselsberg has had "good results."

(*b*) *Kocher's Coccygeal Method with a Posterior Median Incision.* In 1875, after Verneuil and Denonvilliers had separately excised the coccyx, we introduced the method we now regard as the normal one, viz. resection of the coccyx through a posterior mesial incision [1] (previously employed by Dieffenbach). Martin du Pan has shown that, notwithstanding all that Kraske has said in favour of the sacral operation, the great majority of surgeons employ, under various names, the coccygeal method. The statistics are also especially good.

We have seen no trouble follow removal of the coccyx, and therefore cannot set a high value on Kehr's method which aims at preserving it. As Wölfler has pointed out, the posterior mesial incision has the advantage of sparing the nerves and muscles of the anus.

The operation is indicated in those cases where the anal portion is intact, but where the disease involves more or less of the ampulla and the portion above the pouch of Douglas, which is completely covered by peritoneum, and which occupies the pelvic portion of the abdominal cavity, *i.e.* the pelvic colon. The method is thus suitable for a great variety of cases, since the ampulla is the principal site of cancer.

The anus is first of all closed with a subcutaneous circular suture which is firmly tied, the parts are thoroughly cleansed with ether and alcohol, and the patient is placed in the lithotomy position with the pelvis raised, or in the right lateral position.

The incision begins 1 inch behind the anus, and is carried in the natal groove on to the back of the sacrum (Fig. 385). The dense fascia covering the coccyx is divided and stripped off close to the bone, first from the sides and then, by pulling back the tip with a sharp hook, from its anterior surface, taking care to avoid the terminal branch of the middle sacral artery. The sacro-coccygeal articulation is then divided, or, if the latter cannot be found at once, the base of the bone is cut across with forceps.

The ano-coccygeal fascia is now split in the middle line, avoiding the transverse fibres of the sphincter ani, and the portion of the levator ani which crosses behind the rectum, and which is of importance in keeping the anus closed (Fig. 386).

This fascia gives attachments to the levator ani, ischio-coccygeus and coccygeus muscles, all of which are pushed aside with it, so far as their attachments to the coccyx are not already separated.

When this fascia has been sufficiently divided and separated, the blunt dissection of the rectum is begun with the finger, care being taken not to keep too near the rectum in case of tearing it, and to remove the fat and glands which are occasionally infiltrated with the disease. The finger is also passed into the ischio-rectal fossa behind and swept along the sides of the rectum, separating the latter along with its fatty fascia from the sacrum and from the fascia covering the obturator internus, until the

[1] *Centralbl. f. Chir.*, 1875.

whole circumference of the bowel, with the new growth and its coverings, can be grasped.

The lateral bundles of connective tissue, which are rich in fat, and which hold the rectum in position, are hooked up with the finger, or on an aneurysm needle, and ligatured on the proximal side, while forceps are applied to the distal ends. The

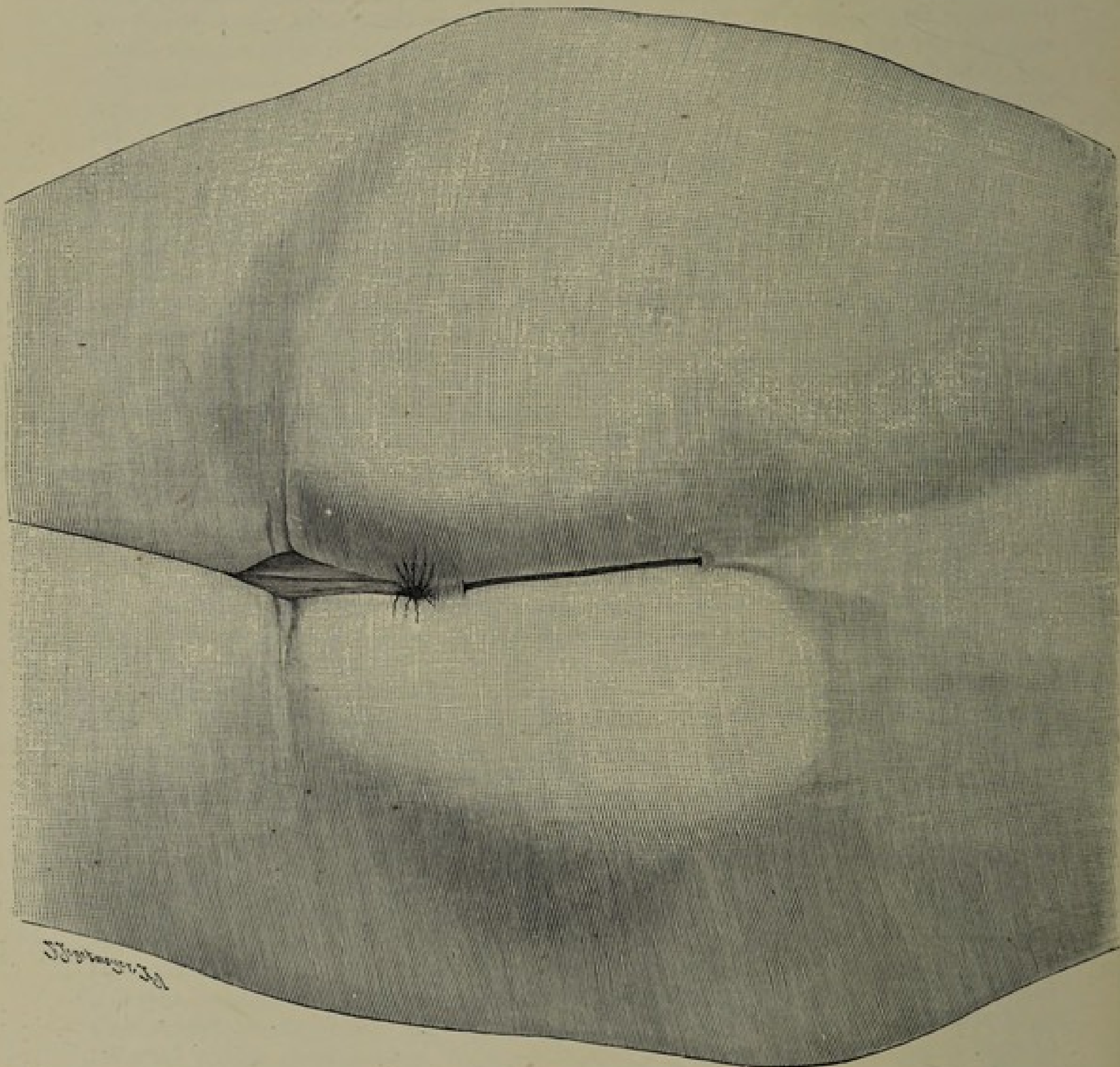


FIG. 385.—Excision of rectum, 1st stage. Patient lying on right side. The anus, after careful disinfection, is securely closed with a subcutaneous circular stitch. The incision is begun above the anus, and carried in the natal groove on to the back of the sacrum.

pouch of Douglas is opened into, as a rule on one side during the lateral dissection, after which the rectum can be easily surrounded with the finger.

It is advisable to expose and open the peritoneum as early as possible. By introducing the finger where the peritoneum has been opened on one side, and passing it round in front of the rectum, the other side can easily be opened, after which it may be freely divided in front of the rectum. Forceps are then applied to the edges of the peritoneum which are subsequently to be sutured. When this has been done the rectum can be pulled down much more easily, and the lateral bundles of vessels from

the superior hæmorrhoidal artery can be put on the stretch, ligatured on the proximal side, and caught with forceps peripherally (*vide* Fig. 387). There is no longer any danger of injuring the rectum. A loop of gauze is passed round the rectum for the purpose of pulling it down.

When the peritoneum has been opened and retracted, and the lateral bundles of vessels divided, the rectum becomes very movable, and the intra-peritoneal portion can be pulled well down, as shown in Fig. 388, where the lower extra-peritoneal portion is seen covered with fat, the upper portion with peritoneum and appendices epiploicae.

If enough has not now been pulled down to allow of two pairs of compression forceps being applied two fingers'-breadth above the tumour, the vessels higher up in

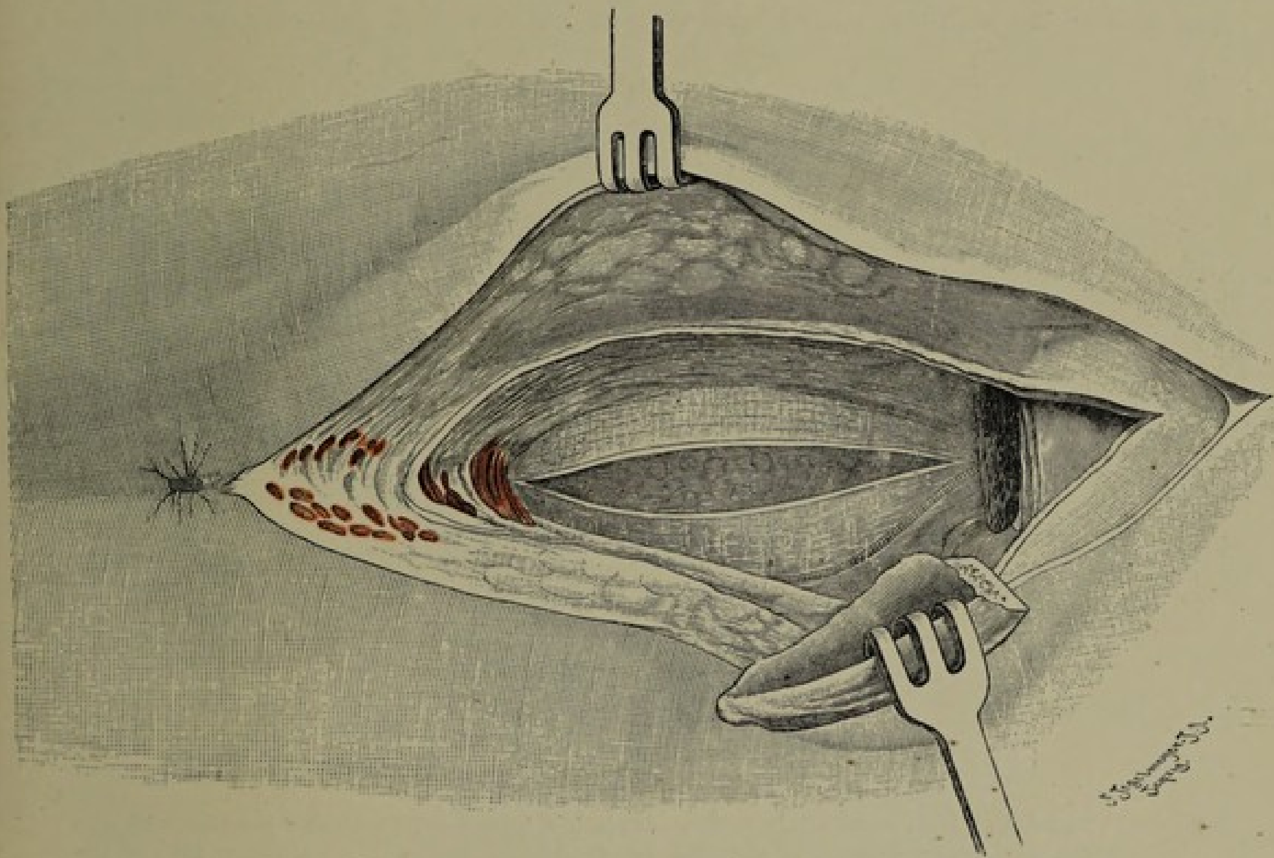


FIG. 386.—Excision of rectum, 2nd stage. The dense superficial fascia has been divided down to the sacrum. The coccyx is detached from the sacrum and turned downwards, exposing the fascia in front of the sacrum, on which a branch of the middle sacral artery is seen. This presacral fascia has been incised as low down as the sphincter ani and the fibres of the levator ani surrounding the rectum. The perirectal fat is seen in the interval between the cut edges of the presacral fascia.

the meso-rectum are hooked down from behind and divided between ligatures. By division of the peritoneum in this way the rectum is readily pulled down (the meso-rectum can easily be divided for a distance of 35-40 mm.).

One has now to determine whether the healthy rectum above is sufficiently free to allow of its being brought down to the anal ring without tension. Two pairs of intestinal crushing-forceps are then applied above the diseased portion, as previously described, *vide* Fig. 389. The upper pair are removed, and a strong silk ligature tied round the groove (the ligature is used subsequently to pull on the bowel to bring it down through the anal ring), after which the rectum is divided with the thermo-cautery between the ligature and the lower pair of forceps, and the mucosa is seared, a protective layer of gauze being packed under it.

The rectum, together with the new growth, is thrown backwards wrapped in gauze,

and completely freed by blunt dissection and scissors as far as the anal portion, all bleeding vessels being secured. This is easily done in women when the vaginal wall is still movable, but in men an instrument must be passed into the bladder before the bowel in front is freed from the prostate.

Contamination of the peritoneum is prevented by plugging with gauze, or sometimes the rent in it may be stitched up immediately after the stump of the rectum has been pulled well down. The object of stitching the upper end of the rectum to the anal portion is to produce the least possible disturbance of function, and at the same time to ensure a proper outlet for the contents of the bowel above. Excision of the mucosa of the anal part (Hochenegg) cannot therefore be recommended as, like the muscle, the mucosa is essential for the preservation of the reflex mechanism. The main thing is to insert the upper end of the gut into the anal ring without the slightest tension, and without the risk of it becoming gangrenous

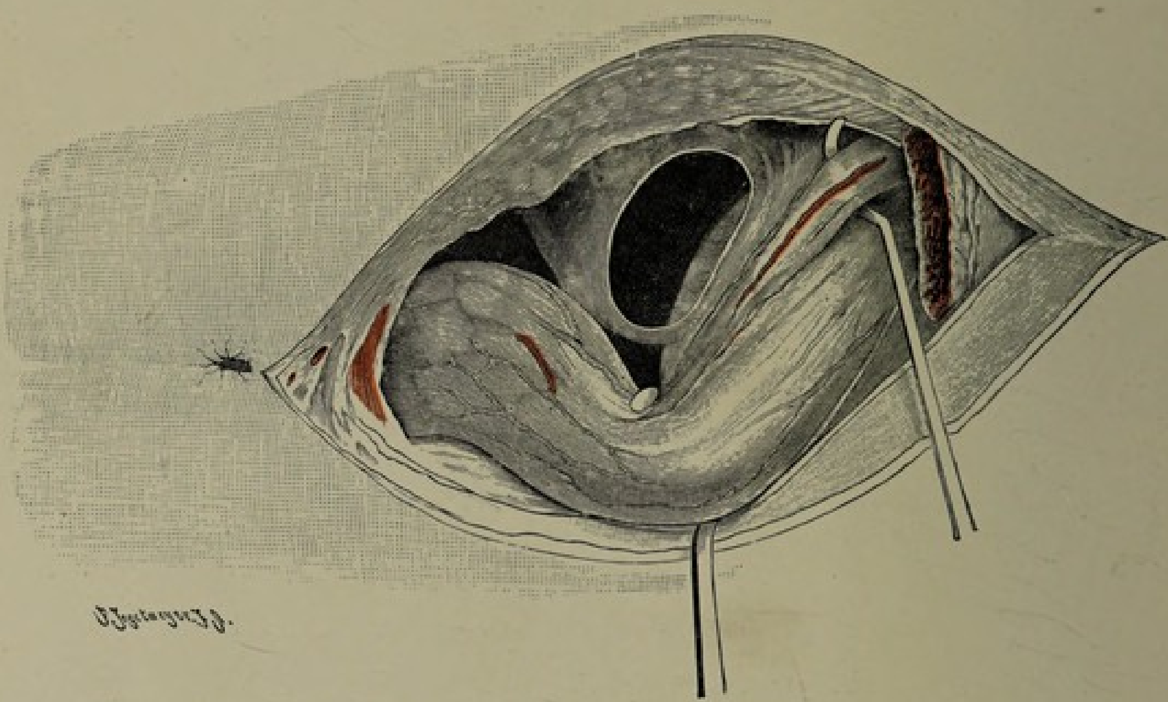


FIG. 387.—Excision of rectum, 3rd stage. The rectum has been freed by blunt dissection with the finger, and drawn downwards and backwards with a retractor. In the upper part of the wound a fatty strand of connective tissue is seen descending on the wall of the rectum, and is raised on an aneurysm needle prior to being ligatured and divided. Anteriorly (*i.e.* above in the fig.) the peritoneum has been opened. Its line of reflexion off the anterior wall of the bowel is well shown.

from being too extensively isolated; and lastly, in stitching it to the anal portion, it is important to pass the sutures through the whole thickness of the wall of the gut so that the junction may be secure.

Crushing-forceps are then applied above the anal portion to prevent escape from the foul ulcer, and the wound is carefully protected with dry gauze. The suture, which was inserted at the beginning of the operation to occlude the anus, is now cut, and the anal portion is dilated with a finger protected with rubber and thoroughly cleansed with lysol. The bowel is then divided below the forceps and the excision completed.

A circular incision is now carried round the anus, and the upper portion of gut is pulled through the anal portion by means of the silk ligature.

Finally the rectum is stitched to the upper edge of the anal portion with interrupted sutures (catgut), which must not be passed too deeply into the upper portion of the gut, nor must they be too numerous for fear of interfering with the circulation. The

bowel has not yet been opened, but now the wound is carefully protected posteriorly with gauze; the ligature on the lower end of the rectum is untied, the lumen packed with gauze, and the edges are stitched through their whole thickness to the edges of the skin incision encircling the anus with aluminium-bronze sutures.

We have also used Murphy's button to unite the anal portion to the rectum.

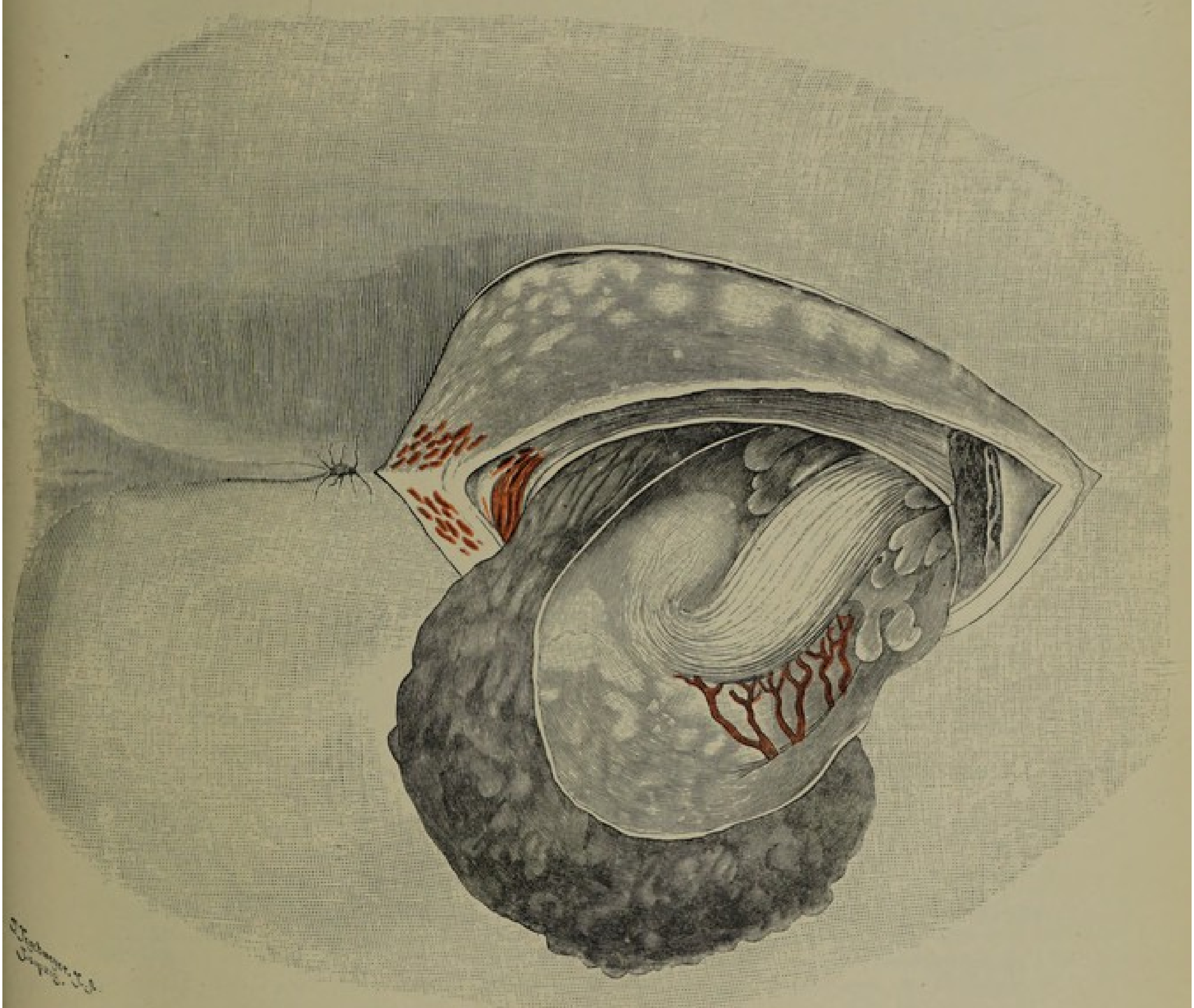


FIG. 388.—Excision of rectum, 4th stage. The rectum has been drawn out in the form of a loop, after detaching the peritoneum and connective tissue bundles which are attached to it laterally, and which contain branches of the superior hæmorrhoidal artery. The anterior and lateral aspects of the upper part of the loop are covered with peritoneum. The anterior longitudinal band is here seen in front, with the vessels behind. On its posterior and lower aspects (here coloured dark) the rectum is covered with fat. The appendices epiploicæ of the pelvic colon are shown in the upper angle of the wound.

The stitching of the anal portion to the end of the rectum is made much easier if the former is split posteriorly, but this interferes with the subsequent function. It is chiefly employed when only the mucous membrane is to be extirpated by Hochenegg's method, for otherwise this is very difficult.

The posterior wound is closed with deep aluminium-bronze wire sutures, leaving

only the lower end open into which iodoform gauze is lightly packed behind the rectum. If the wound has not been contaminated at all, a glass drain is sufficient.

Septic Excision of the Rectum. (*c*) *Septic Excision* (*or Resection*) *of the Rectum by a Longitudinal Incision through its Posterior Wall.* Long before Quénu and Baudet we drew attention to the desirability of excising the rectum as a closed tube (see earlier editions of this work), as it is only in this way that the operation can be really aseptic. (Compare the precautions mentioned in the above description of the coccygeal operation.)

Occasionally, however, one has to depart from this rule. This is so, first of all,

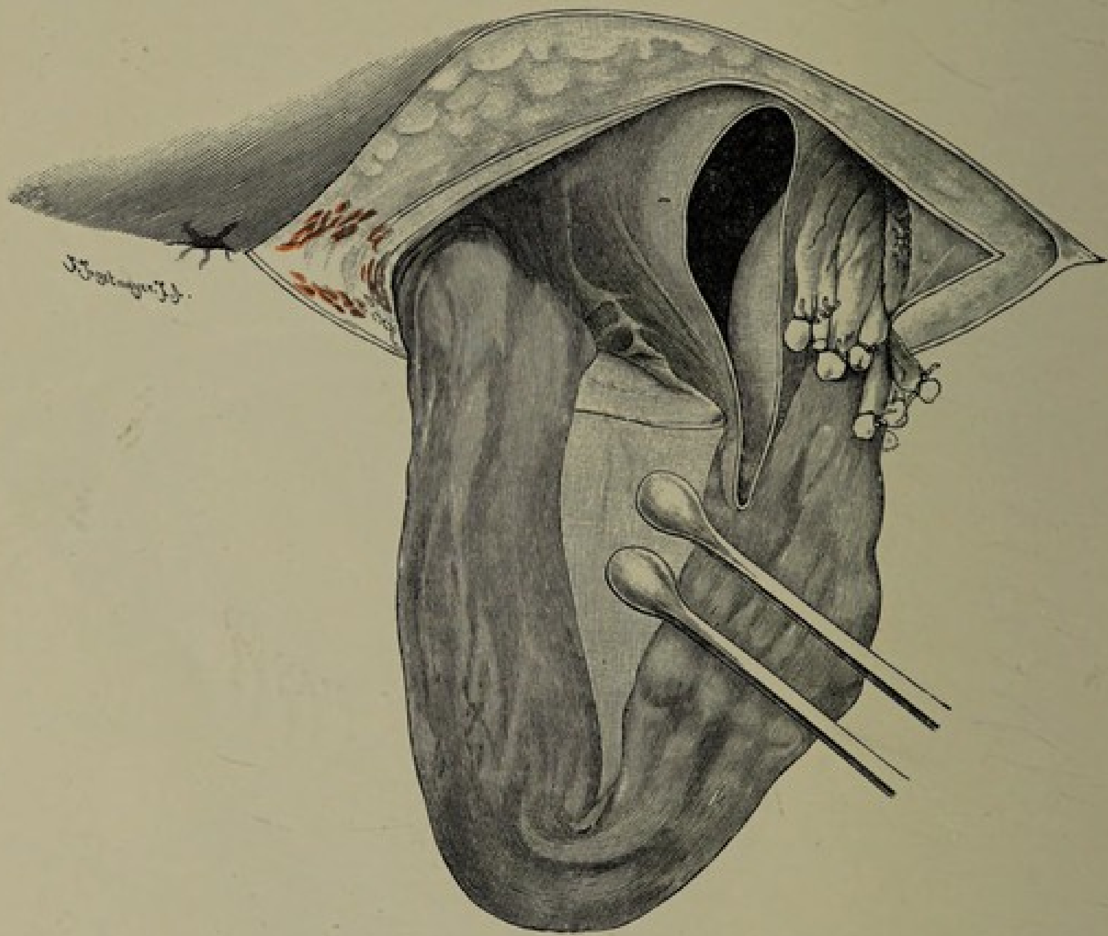


FIG. 389.—Excision of rectum, 5th stage. High amputation by the coccygeal method. The peritoneum is opened and drawn upwards, the lateral and posterior strands containing the vessels are ligatured, and the crushing-forceps are applied above.

if the rectum is torn at any point owing to the infiltration (in extensive ulceration) or to difficulty in separating the perirectal tissues. As a result the wound becomes contaminated with intestinal contents. It is then decidedly better to at once split the rectum through its posterior wall up to the tumour, as is done in the method originally introduced by Dieffenbach.

By catching the edges of the bowel with suitable forceps, *e.g.* Kocher's artery forceps, serious hæmorrhage is controlled, and at the same time good access is got to the ulcer, the rectum can be thoroughly cleansed, and a tampon inserted above the tumour. A finger protected with rubber is then passed above the new growth, which can be easily pulled down and evaginated through the gaping wound.

We have had good results with the following procedure :—The outer layer of the artificially-produced intussusceptum is divided transversely 3 cm. from the distal edge of the tumour. The incision, which traverses the wall of the bowel from its

mucous to its peritoneal aspect, is commenced anteriorly and continued round its circumference, the bleeding vessels being caught with forceps as they are divided.

By isolating, ligaturing, and dividing the vessels entering the bowel on its posterior and lateral aspects, the tumour can be more and more pulled down, until it is possible to divide the bowel 1½ to 2 inches above any induration. The division of the bowel on the proximal side of the tumour is also begun anteriorly, the incision this time, however, passing through the gut from its serous to its mucous surface. The proximal and distal cut edges are united step by step with catgut sutures, which traverse the whole thickness of the bowel. Escape of fæces is prevented by the tampon.

It is unnecessary to repeat that the upper portion of gut must be pulled well down, so that there will be no tension when it is stitched to the lower end.

Now comes the main difference from the aseptic procedure:—The edges of the gut are united with interrupted sutures to the skin along the whole length of the posterior longitudinal incision; this arrests the bleeding and at the same time guards against the evil results of infection better than in any other way. The removal of the presacral glands and fat leaves a space which must be packed with iodoform gauze.

Although prolapse of the rectum subsequently occurs, and renders a second plastic operation necessary, the immediate results of this operation are very good, and it gives rise to the least inconvenience to the patient during the after-treatment.

(*d*) *Excision of the Rectum with Vaginal Section.* The method of excising the rectum in women through a vaginal incision must also be considered here as it is not a strictly aseptic operation. Rehn and Liermann, Murphy, and Schuchardt have introduced the vaginal method for high excision of the rectum in women, and look upon it as the normal procedure. It is undoubtedly the case that division of the posterior wall of the vagina from the vaginal part of the cervix to the frenulum offers very convenient access, and we, too, consider that it is advantageous for all cases of rectal carcinoma which can be felt *per vaginam*, *i.e.* when the tumour is adherent to the vagina or uterus.

From the vaginal incision the dissection is carried laterally down to the anterior rectal wall, and, by means of an incision on either side of the anus, it is carried deeply into the ischio-rectal fossa, by which means free access is obtained. Liermann attaches special importance to this backward extension of the incision, and Schuchardt points out the importance of making full use of it in his method of extirpation of a carcinoma of the uterus. The circuit of the rectum is made by Liermann rather more than an inch from the anus, and separation of the rectum is proceeded with from this point. The further procedure is described below.

Eiselsberg also considers the vaginal method very useful, and he points out that he is often able to remove at the same time part of the vagina or uterus. This is the advantage peculiar to this operation. Where there is a suspicion that a rectal carcinoma has involved vagina or uterus, the vaginal operation should certainly be selected as it allows of free removal of all the disease. Gynecologists (Krönig and Friedrich), in cases of primary carcinoma of the vagina, go so far as to demand an *a priori* excision of the rectum, because of the frequency of recurrence in its neighbourhood. If the vagina and the region of the cervix are involved, it is necessary to remove the lymphatic glands which lie at the bifurcation of the common iliac artery, as they receive the lymphatics from these parts. The chief feature of the operation is that Schuchardt's paravaginal incision is used when the rectum and uterus have to be excised at the same time. The vaginal incision naturally depends on the extent of the adhesions. Excision of the rectum may make other incisions necessary in addition to the paravaginal incision, or a combination with laparotomy may be required (*vide infra*).

159. The Sacral Method of Amputating the Rectum. Kraske must be regarded as the pioneer of modern operative measures for the removal of the rectum, on account of his communication on the sacral method delivered at the Berlin Surgical Congress in 1885. By proving that part of the sacrum can be removed, as a rule without ill effect, and that thereby the highest portion of the rectum can be made accessible for operation from behind, he has made a lasting advance.

The value of his work is not detracted from even now when it has been recognised that in the majority of cases resection of the sacrum is unnecessary. One has only to look through the publications issued by German clinics for the last six years, to see that the sacral method is being more and more abandoned in favour of the coccygeal method. N. Senn describes the sacral operation as not only unnecessary but "absolutely harmful." He employs resection of the coccyx as a general rule, but often does without even this preliminary.

We have not found it necessary to perform the sacral operation for many years, and therefore shall not describe it in detail (for a full description, see Kraske's publication). Neither will we consider its modifications, *e.g.* Hochenegg's parasacral incision, or the osteoplastic transverse division of the sacrum, as the chief objection to all sacral operations is, not merely that they are not necessary for the customary excision of a tumour of the rectum accessible from below, but that in difficult cases of a highly situated carcinoma, which is not very movable, an operation has been introduced (the so-called combined method) which is steadily gaining ground, and is, indeed, regarded as the normal operation by a number of surgeons.

160. The Combined Method[1] of Amputation of the Rectum. (*Abdomino-perineal, Abdomino-coccygeal, and Abdomino-sacral Method.*) For a historical survey of this operation we refer the reader to the works of Ito and Kunika,[2] Gouillod and Faysse,[3] and to the discussion on the subject introduced by Kraske at the German Surgical Congress in 1906.

According to Kraske, the method was proposed by Volkmann and first performed by König. Quénu utilises the combined method to its fullest advantage. His method consists in laparotomy, division of the pelvic colon well above the tumour and of the diseased glands in the mesentery, fixation of the upper end into the abdominal wall as an artificial anus, and removal of the lower rectal portion down to the anus, even should it be 12, 16, or 24 inches long. The rectum is removed as a closed tube, or as Quénu says, "comme un cyste," along with its mesentery, perirectal fat, and glands.

It is obvious that in this way not only can the diseased bowel, and the tissues directly implicated by the growth, together with suspicious lymphatics, be removed, but the groups of glands in the meso-rectum above and to the inner side can be cleared out more thoroughly than by any other method. As Hartmann states, the clearing-out process is only limited by the pelvic wall and adjacent organs. Further, there is less risk of tearing the gut[4] during its separation, *i.e.* the operation will be thoroughly aseptic. Lastly, the main vessels of supply can be ligatured within the abdomen. According to Giordano and Quénu, both internal iliac arteries may be tied.

It is to be conceded *a priori* to Quénu and the supporters of his method that a greater number of radical cures are obtained by the combined operation than by less drastic procedures, although as yet there are not a sufficient number of cases to afford suitable comparison. At the same time the radical cures have been obtained at the cost of the certainty of the immediate result. Gouillod and Faysse, who strongly advocate Quénu's method, estimate the mortality as 6·2 per cent in women, and 66·6 per cent in men, from a series of 31 cases of which 16 were women and 15 men: Ito and Kunika place the mortality as 9 per cent in 22 women, and 64·3 per cent in 28 men. These statistics, therefore, show that the total results are materially worse than after the coccygeal or perineal method. Rotter's mortality out of 25 cases was 44 per cent. In addition, in very extensive excisions, the bladder is liable to be injured. Those injuries occurring in cases of resection are of a transitory nature (Brüning). W. J. Mayo,[5] using a modification of Quénu's method in 19 cases, has had a mortality of 26·3 per cent, and 50 per cent of radical cures among the survivors, which is equivalent to 36·8 per cent of radical cures on all cases operated on. Jaffé in cases of

[1] We follow Rotter in using this very simple designation.

[2] *Deutsche Zeitschr. f. Chir.* Bd. 75.

[3] *Revue de chir.* July 1905.

[4] Hartmann considers that the greater operative mortality in men is due to the fact that it is much more difficult to separate the bowel anteriorly without causing tearing, as the bladder, prostate, and urethra early become adherent.

[5] *St. Paul Med. Journ.* April 1906.

simple resection has found implantation metastases in the lower end of the rectum in 10 per cent of his 30 cases.

To sum up: The typical perineal and coccygeal excisions described above must be regarded in the meantime as the best for malignant disease of the rectum where the tumour is easily palpable from below, and where its mobility can be determined. When, however, the tumour is situated higher up, and information cannot be gathered as to its extent and mobility, the combined method can furnish results obtainable by no other methods.

Technique of the Combined Method with Amputation of the Rectum. We need not describe the details of the technique, for the method consists in amputation, with the formation of an artificial anus at the upper part of the pelvic colon, as already described, with the addition of removal from above of the lower portion of the pelvic colon.

A loop of the upper part of the pelvic colon is brought out through an incision similar to that recommended for colostomy and is clamped with two pairs of crushing-forceps. The lower pair are taken off, the bowel is ligatured and cut across close to the upper pair, the mucous membrane and the redundant tissues of the stump are excised, and the latter is invaginated first with a sero-muscular suture and then with a serous layer as described in resection of the intestine (*e.g.* ileo-cæcal resection). The bowel is then freed by passing an aneurysm-needle underneath it and ligaturing and dividing as much of the mesentery as is necessary to permit of the closed end being replaced inside the abdominal cavity. The forceps are left on the upper end.

The incision is now prolonged two fingers' breadth above Poupart's ligament as far as the middle line, ligaturing the superficial and deep epigastric arteries (the latter lying on the fascia transversalis), and dividing the insertion of the rectus (or if necessary of both recti) into the symphysis pubis. In this way ample room is got without inflicting much injury, and a hernia is subsequently prevented by careful suture of the abdominal wall in layers.

Rotter, Brüning, Gouilloud, and Faysse state that better access is given by an incision in the middle line. The latter is necessary if one intends to follow Quénu and ligature both internal iliac arteries, but personally, we agree with Rotter that ligature of both internal iliacs is not necessary, as the bleeding can be adequately controlled by using a sufficient number of artery forceps. We consider, however, that as a rule, the median incision gives better access, and for this purpose a large retractor is very useful for widely separating the edges of the wound.

The mesentery of the pelvic colon is now divided from the inguinal incision and the bowel mobilised (there may be firm adhesions along the upper and inner surface), after which the vessels (sigmoid and superior hæmorrhoidal [1]) are isolated with the finger or an aneurysm-needle, tied in bundles, and the lower part of the bowel freed, forceps being applied to the distal ends of the vessels.

The bowel is freed in this way along the mesentery of the lower part of the pelvic colon, taking care to remove along with the growth any glands in the neighbourhood. Mayo ligatures the middle sacral artery and cleans out the fat and glands down to the periosteum covering the hollow of the sacrum. Rotter points out that this can be done by blunt dissection as far as the levator ani. The peritoneum forming the floor of the pouch of Douglas is then divided and the rectum freed all round, while the bladder and prostate (or vagina) are dissected off it in front. Rotter has even removed a portion of the bladder without harm. Laterally the vessels may be torn through with blunt dissection (Rotter). The tear in the peritoneum is repaired by suture so as to form a new pouch of Douglas, and the peritoneum is stitched over the raw surface underneath the flexure. As a rule, however, a gauze tampon should be placed in the depths of the pelvic wound in order to keep the peritoneal cavity shut off while the separation is being continued from below.

This finishes the part of the operation performed from above, and the abdominal wound is closed in layers. The upper portion of the bowel is still retained in the

[1] Mayo speaks of ligature of the left inferior mesenteric artery above the promontory. Is it not the superior hæmorrhoidal, after the left colic is given off, which is meant?

grasp of the forceps in the upper angle of the wound, and a part of the wound, for a distance corresponding to the diameter of the gut, is left open (if a mesial incision is employed, one need not trouble at present about the small incision for the iliac anus), after which the peritoneum alone is stitched to the serous coat of the bowel all round, about two inches beyond the forceps.

Up to this point the patient has been in the Trendelenburg position, but now, for the second stage of the operation, he is put in the lithotomy position, the perineal operation being used for a carcinoma situated low down, and the coccygeal for one higher up. An incision is made round the margin of the anal orifice, which is then closed with a firm ligature. The cavity is plugged so that it may heal slowly by granulation. The bowel, stitched in the abdominal wall, is opened, according to the rules given under enterostomy, and a glass tube fixed into it, from which the contents are led off by a large rubber tube. One or two days should elapse before it is opened ; Mayo waits twenty-four hours.

161. Resection of the lower part of the Pelvic Colon. Resection of the lower part of the pelvic colon, as distinguished from amputation, is called for when there is a prospect of performing the operation aseptically, as otherwise the stitches will not hold. It has, therefore, in the first place to be considered for the removal of the lower part of the pelvic colon where the divided bowel is completely covered by peritoneum and can be freely isolated, the ends closed, and a lateral anastomosis made with two or three layers of sutures. Schloffer strongly advocates resection from above, but we only consider it a safe procedure when the above conditions can be fulfilled.

The same rules must be followed here as in resections of other parts of the large intestine. First of all, the contents of the intestine above must be emptied "in toto" by means of an artificial anus.[1] The question of ileo-proctostomy is only to be considered in exceptional cases, when it is possible to bring a loop of ileum in contact with the rectum below the site of suture.

The technique of this method is similar to that of the combined method. An incision is made over the outer third of Poupart's ligament, the upper part of the pelvic colon is pulled out, and an artificial anus made by cutting it across and inserting a glass tube in each end.

The incision is then extended towards the middle line, or what is even better, a separate mesial[2] incision is made, and the tumour thoroughly examined. If it is found that the tumour along with the mesentery of the pelvic colon can be freed sufficiently to allow of the removal of glands and infiltrated tissues, and that sufficient healthy bowel can be got below, after removing the tumour, to join with the bowel above, then resection should be preferred to amputation, for the former operation has the advantage that there is no disturbance of defæcation.

Rehn has shown on anatomical grounds that in separating the vessels in order to free the bowel preparatory to resection, the mesentery should not be divided close to the bowel, as the terminal anastomosis takes place close to the bowel. Further, as in amputation, it is most important to have the ends of the gut so free that there will be no tension when they are sutured together, for, according to Rehn, tension interferes with the circulation even more than the division of vessels. Tension on the superior hæmorrhoidal artery may cause kinking at the point where the inferior mesenteric is given off.

A large tube should always be passed down to the pouch of Douglas, and it is advantageous to thoroughly wash out the lower end of the gut by passing a large glass tube through the anus before closing the abdominal wound.

Resection of the Rectum. The method of resecting a circumscribed carcinoma in the rectum, *i.e.* in the ampullary portion of the rectum, has been described in the appendix to the coccygeal method under septic excision of the rectum. In our experience, it is as safe an operation as amputation in regard to immediate results.

[1] In one of Goldmann's cases, enterotomy had to be performed subsequently, on account of symptoms of ileus after resection.

[2] Brüning as well as Gouillod and Faysse are in favour of the mesial incision.

The danger of fæcal soiling of the wound followed by infection and cellulitis is avoided by uniting the gut only along its anterior aspect and providing for the escape of the intestinal contents posteriorly by stitching the mucous membrane to the skin.

It is a different question whether, after freeing the rectum from behind and isolating a tumour situated below the peritoneal reflexion, or higher up where the bowel is only covered on its anterior surface by peritoneum, one ought to undertake a resection with circular suture. Suture in the circumstances often succeeds and gives very satisfactory results. We have got perfect union in these cases with a Murphy's button as well as with suture. Nevertheless, every surgeon of experience will admit that one cannot count with certainty on healing taking place by first intention, and one must always be ready on the slightest sign of the suture giving way with escape of fæces to interfere, otherwise one will be guilty of gambling with the life of the patient.

An artificial iliac anus must either be made beforehand, and the fæces entirely prevented from entering the rectum, or a large strong tube must be passed into the rectum above the site of suture and the fæces led off as long as there is a large raw surface. In addition, there is the risk of a fæcal fistula forming. This, however, closes whenever a free escape downwards is established. We advise suture with silk of all but a portion ½ cm. wide, and a longitudinal incision upwards and downwards at this point to admit the tube, since in this way the site of suture is made wider.

At the very least, and this is the usual practice, a wide track to the surface must be kept open by packing right down to the seat of suture. When a large Murphy's button is used, we endeavour to prevent accumulation of fæces above it by passing as large a tube as possible *per* anum through the lumen of the Murphy's button and irrigating frequently.

It must be emphasised, however, that (with the exception perhaps of a small circumscribed tumour situated at the lower limit of the pelvic colon) it is better as a rule for the operator to perform amputation of the rectum down to the anal portion, preserving the sphincter and levator ani, and making the anastomosis here without tension. The functional results by this way are equally good, and the dangers from defective suturing are avoided.

Further, by this low supra-anal anastomosis, the treatment of all types of fistulæ (division) and strictures (dilatation and plastic operation) is greatly facilitated.

The Combined Method for Resection of the Rectum. This method can be used as a substitute for the radical operation of Gaudier and Quénu. It differs from the latter, however, in that, while the pelvic colon is separated through a mesial incision in an exactly similar manner, it is not cut across and utilised as a permanent iliac anus, but is pulled down and united to a healthy portion of the rectum lower down.

From evidence derived from Schloffer's statistics and Ito and Kunika's publication, Brüning (*loc. cit.*) has made a comparison between the dangers of the combined method for amputation and resection. In 38 cases where the former was used, he finds a mortality of 45 per cent, and in 25 cases of the latter 52 per cent. There is, therefore, not a great difference between the two methods as regards mortality. In women amputation gives rather better results.

Brüning holds that the invagination method introduced by Trendelenburg, Kümmel, and others, and recommended by Maunsell, in which the tumour is mobilised from the abdomen and evaginated through the anus, so that the resection is entirely extra-anal, with subsequent reposition, should be rejected on account of the results. Its mortality in 9 cases is 66 per cent. The invagination is often very difficult and involves very extensive separation, stretching, and tearing of the tissues.

We will here only deal with the combined method in regard to cases where the tumour is first mobilised intra-peritoneally, then exposed by our coccygeal method from below and resected, with union of healthy intestine above to healthy intestine below.

It is unnecessary to refer again to the statements we made in connection with resection of the extra-peritoneal portion of the rectum, and to further emphasise

that healthy gut be pulled down and joined to the upper part of the anal portion since this merely depends on preservation of the latter; and, according to Rehn's observation, the flexure can more easily be mobilised in so free a manner that it can be united to the anal portion without any tension and therefore without interference with the circulation. We therefore consider sigmoideo-anal anastomosis the best method, particularly if there is a question of employing the combined method on account of the high situation and extent of the tumour.

Kümmel[1] has shown that the nutrition of the transverse colon is even less affected by division of its mesentery than is the pelvic colon, since a marginal artery running in a wide arch gives off the vasa recta to the gut: de Quervain[2] has employed Kümmel's method with success. The accompanying figure (Fig. 390), taken from Gegenbauer's *Anatomy*, will illustrate the justification of extensive division of the transverse mesocolon and the mesentery of the descending colon between the middle and left colic arteries, and even farther down, if it is desired to sacrifice the whole of the intestine below.

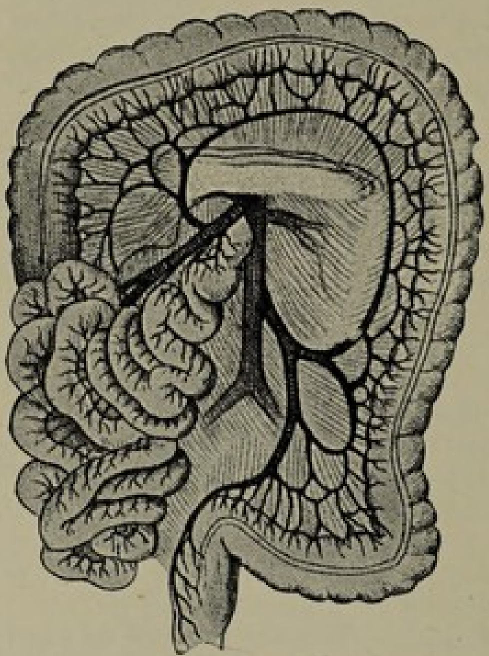


FIG. 390.

Rotter draws attention to the advantage of the combined resection method over the radical operation with the formation of an iliac anus. Even in cases when resection proved either impossible (14 out of 25 cases) or the lower part of the intestine became necrotic and a sacral anus had to be made, Rotter was able at a subsequent operation to establish complete continence in the majority of the cases by means of circular suture and a plastic operation.

162. Excision of Hæmorrhoids. When hæmorrhoids cause trouble they should be at once removed. If an operation is to be performed it is essential that anæsthesia should be complete to allow of the anus being fully stretched so that the upper bunches of hæmorrhoids can be thoroughly brought down into view. The method of removing the masses by cutting them off (Langenbeck and Smith used the Paquelin cautery), after applying a wing-shaped clamp, is open to the risk of serious secondary hæmorrhage, although Baracz recently speaks in favour of it. We have, however, never seen injurious effects follow ligature and removal of the distal part of a hæmorrhoid, provided that the stump left to necrose is not too large. To avoid this the following methods should be adopted :—

(*a*) *Method by Ligature.* The anus is stretched after the patient is well anæsthetised. The prominent bluish masses are now seized with powerfully-closing ring forceps, which should be similar to pressure-forceps, with the ring of an ovoid shape, the narrower part being at the free end. After the base of the mass has been crushed with these forceps, a catgut ligature is passed through the pedicle and carried first round one side, and then, as the forceps are removed, it is tied round the whole of the crushed base, and the superfluous tissue is cut off. By this means all tissue containing fluid beyond the ligature is removed and the liability to gangrene from sepsis originating in it is prevented. Each mass is treated in a similar manner. A bismuth suppository is introduced thrice daily, and the bowels are prevented from acting by rigid attention to diet and by opium.

(*b*) *Injection Method.* Instead of the operator ligaturing and removing the piles after seizing them with fine curved forceps, a strong solution of carbolic acid (20 to 50 per cent in alcohol) or of gelatine (2 per cent) may be injected.

[1] *Berliner Chirurgenkongress*, 1900. [2] *Revue médicale*, 21st annual volume.

(c) *Excision by Whitehead's Method.* The method described by Whitehead of extirpating hæmorrhoids, together with the mucous membrane of the anal canal, is attractive on account of the neatness of the operation, which may be done under cocaine anæsthesia. We perform it as follows:—As soon as the patient, by straining, has forced out the bluish-red folds of the mucous membrane containing the varicose veins, an incision is made at one side of the anal margin at the junction of the skin and mucous membrane, and the latter is grasped with forceps and pulled down. Projecting from the outer surface of the mucous membrane are the varicose masses, which, as a rule, can easily be separated from the sphincter.

The mucous membrane, which has been freed and pulled down, is now divided transversely above the level of the piles, and the healthy mucous membrane above is at once stitched with interrupted catgut sutures to the anal margin, and this is repeated until the whole diseased mucosa of one side is excised and the healthy mucous membrane above it is united to the anal margin. The same procedure is carried out on the other side. In this method of performing the operation, hæmorrhage is reduced to a minimum. If care be taken to introduce the stitches so as to include the whole of the floor of the wound, no after-hæmorrhage takes place into the tissues. Bismuth is applied to the sutured surface and, as recommended above, a bismuth suppository is introduced thrice daily and the bowels are kept confined.

This operation removes the piles very completely, and the healing is very satisfactory. It is, however, not always easy to strip the mucosa and the varicose veins quite cleanly from the sphincter, and when the varicosities are very large and reach high up, a dense circular scar cannot be avoided. Even in simple operations of this kind, the scar is always indurated because it is not formed asceptically. In spite of every precaution, slight infection and inflammation, with cutting of the stitches, as a rule occurs. In these cases the result is anal stenosis, which for a long time causes the same discomfort to the patient as accompanies a fissure, especially if one or other of the stitch-ulcers remains open. The condition is aggravated if the patient dreads and strives to prevent a motion of the bowels.

In consequence of the occurrence of such complications, we have found it necessary to modify considerably Whitehead's method, and we now only employ it in its typical form in exceptional cases. M'Burney[1] disapproves of Whitehead's operation on account of the danger of a stricture forming, and only excises single hæmorrhoids, never more than 2 or 3. The anus must be capable of dilatation to a considerable degree if the bowel is to be emptied without inconvenience. This is impossible if the anal margin is the site of a circular scar, no matter how fine. On this account the ligature method is, as a rule, to be preferred.

On the other hand, it is quite permissible to separate and ligature isolated piles by small incisions in the anal margin. Tags of skin, which are frequently met with, may be excised, and the mucous membrane is stitched to the skin.

163. Operation for Prolapse of the Anus and Rectum. The majority of cases of prolapse of the anus in children can be remedied in a short time by curing the diarrhœa or constipation, and employing cold douches to tone up the levator ani and sphincters and by replacing the prolapse immediately after its descent.

In adults, on the other hand, after a time the lax tissues become œdematous, the mucous membrane comes down after every stool, and protrudes in a fold, as in the case of hæmorrhoids.

The simplest method of dealing with these cases is often to seize the fold in ring-forceps (applied in the long axis as for hæmorrhoids) and then transfix, ligature, and cut it off. Langenbeck's method is much less reliable on account of the risk of subsequent bleeding.

In the more severe cases of rectal prolapse, steps must be taken to restore the muscular resistance of the pelvic floor. For, according to Waldeyer, the prolapse originates like a hernia either because of the congenitally-low position of the pouch of Douglas, or because the latter sinks down as a result of pressure on and stretching of the muscles forming the floor of the pelvis. In other words, the anus becomes a

[1] *New York and Philad. Med. Journ.*, 1905.

hernial orifice, through which the mucous membrane or the whole wall of the rectum is protruded by the force of the intra-abdominal pressure.

The extent to which the whole perineal and anal region bulges under strong pressure is easily seen in children: in adults with weak muscles the conditions are similar. In the early stages, therefore, the question is one of limiting the stretching of the pelvic floor.

Thiersch has described a simple operation in which the calibre of the anal ring is reduced (like the orifice of a hernia) by passing a thick silver-wire suture threaded on a curved needle subcutaneously round the anus, the wire being left in position.

Verneuil first attempted to reduce the circumference of the rectum by cutting a triangular flap, the base of which is at the anus and the apex at the coccyx, and stitching the muscular coat transversely. The benefit of the operation, however, lay in the fact that the stitches were passed transversely through the skin at a high level; in other words, a rectopexy was performed at the same time. This method had been extended by Gérard Marchant, who passed the stitches through the sacro-sciatic ligament, while Cuneo in addition performed a temporary resection of the coccyx. Duval and Lenormant completed the suture of the levator ani and employed Marchant's plication suture of the rectal wall.

Hoffmann [1] attains the same object by making a)—(-shaped incision behind the anus, and exposing the sphincter and posterior fibres of the levator ani, after which he stretches the wound out antero-posteriorly with sharp hooks, and sutures it transversely in layers. Helferich [2] employs a crescentic incision behind the anus, and detaches the sphincter ani on both sides so that they can be slid over one another and thus shortened, in which position they are sutured.

It is easier to employ a posterior mesial incision as recommended by Gérard Marchant, in opposition to Verneuil, and through it to expose the sphincters and posterior fibres of the levator ani and the coccygeus. These muscles can then be shortened by means of a suture, and in a similar way the sphincter in front of the anus, as well as the recto-urethralis muscle (Roux) can also be shortened, so that stretching is impossible.

This operation inflicts less injury than Kehrer and König's method of excising a wedge-shaped portion of the anus and rectum, and it has the further advantage that no sensitive scar is formed in the region of the rectum itself, as the mucous membrane is left intact.

Strengthening the pelvic floor, even if combined with rectopexy, is not enough in a severe case of prolapse of the rectum. When it is not merely the mucous membrane, as in prolapsus ani, or only the lowest part of the rectal wall that is prolapsed, but when the rectum is evaginated from above and escapes through the anus, the displacement must be prevented by anchoring the bowel high up, or by excising the movable portion.

Rectopexy is one of the suspension operations, but in reality its value consists in shortening the muscles and making a strong posterior support for the rectum. It is always worth while to fix the sutures to the coccyx at the same time.

Colopexy is another matter. Proposed by Jeannel, simplified by Verneuil, and independently carried out by Bogdanik and Tuttle, it has up to the present time given good results when properly performed. Lenormant [3] was able to collect 101 cases in which it had been employed (108 operations) without a fatality. One case died of hæmorrhage from a duodenal ulcer which was present at the time. He is fully justified in stating that the numerous objections to it that have been raised, viz. the danger of ventral hernia, volvulus, and internal strangulation, are largely of a theoretical nature, and are in part attributable to imperfect technique.

On the other hand, Lenormant has come to the conclusion that recurrence took place in nearly half the cases which were observed for one year. It is therefore important to select each case after a careful examination, while, according to Ott and

[1] *Centralbl. f. Chir.*, 1905, No. 35. [2] Biefinger, Inaug. Dissert., Kiel, 1903.
[3] *Revue de chir.*, Paris, Feb. 1907.

Hoffmann,[1] it is probably better to combine the operation with reconstitution of the perineum.

We agree with Lenormant in recommending an additional plastic operation on the perineum in front of the rectum, using a transverse incision and stitching the levator ani longitudinally with deep stitches; and a similar operation performed behind (Hoffmann) but with a simple transverse incision and longitudinal suture of the muscles.

Technique of Colopexy. An incision, 4 to 6 inches long, is made above the outer two-thirds of Poupart's ligament, dividing skin, superficial fascia, and the aponeurosis of the external oblique. The superficial epigastric artery is ligatured. The fibres of the internal oblique and transversalis muscles are split, and the transversalis fascia is divided and the peritoneum opened.

The pelvic colon, which is occasionally found to be abnormally long and free, is pulled forward and its lower part drawn upwards, while an assistant controls the amount of traction *per* rectum. When satisfied that the rectum can be pulled upwards and put on the stretch, one proceeds to suture.

We do not see any advantage in excising a portion of the pelvic peritoneum; we prefer to proceed at once to stitch the serous coat of the bowel to the peritoneal covering of the anterior abdominal wall below the incision for a length of 4 inches. The bowel is pulled firmly up and carefully applied to the iliac fossa while this is being done, and over the first row of stitches a second row may be inserted, so as to include the fascia at a point where there are no vessels or nerves.

The risks of the operation are greatly increased if the bowel has to be opened for disease of its mucous membrane (as in Jeannel's first method), or if resection of the long pelvic loop is undertaken to avoid the possibility of volvulus or kinking. Unless there are absolutely definite and urgent indications, it is well to avoid anastomosis, resection, or the formation of an artificial anus.

Resection of the prolapsed gut without colopexy is a different matter. The method which has been chiefly developed by Delorme and Rehn has given good permanent results in suitable cases, but is not free from the dangers of infection and stenosis. Total circular resection, as practised chiefly by Mikulicz, is suitable for cases in which, as the result of congestion and inflammation, there are considerable changes in the prolapsed portion of bowel, such as thickening, ulceration, and narrowing of the lumen.

If excision of the diseased prolapse is decided on, it is very essential to see that the divided edges of the bowel above and below are healthy preparatory to undertaking anastomosis. After replacement of the intestinal coils which occupy the prolapsed pouch of Douglas, two strong stays are passed through the whole thickness of the edges of the gut at the apex of the prolapsed bowel which is forcibly pulled down and clamped transversely. The bowel is then cut across by dividing first the mucous membrane, then the muscularis, and finally the serous coat (as far as the latter comes into the prolapse).

The larger vessels on the posterior aspect of the bowel are tied, and after a thorough cleansing with lysol the edges of the wound are sutured, silk being used for the serous and muscular coats and catgut for the mucous membrane.

The sutures are first introduced in front where the pouch of Douglas extends lowest, a continuous suture being employed in such a way as to bring two broad surfaces in contact. Over this a continuous hæmostatic suture is inserted which includes all the coats with the exception of the mucous membrane, the latter being united separately with a continuous catgut stitch.

When it is impossible to clamp the bowel securely above, we begin the excision in front, cutting through the mucous, muscular, and serous coats of the outer tube and the serous coat of the inner. The bleeding points are then secured and the serous coats are at once united, the stitches being left long. This we continue step by step, stitching the edges immediately after division so that separation of the divided gut cannot take place. The long ends of the stitches are only cut short when the continuous suture through all the layers has been begun.

[1] Cf. also Weiss (v. Eiselsberg) Langenbeck's *Archiv*, Bd. 73.

Excision without clamps is more uncertain as regards asepsis, and it is important that the bowel should not be allowed to slip back for an instant, otherwise complications from bleeding and infection of the peritoneum may be set up. Resection is the most dangerous of the operations for prolapse. According to Lenormant, the mortality in 110 cases was 10·9 per cent.

Not uncommonly stenosis results some while after circular resection, and the necessary treatment by dilatation is a source of trouble to the patient. It is, therefore, a question in these cases where the bowel is much altered, whether it is not better to confine oneself to a regular coccygeal amputation of the rectum ; the latter operation, when carried out in the manner we have already described, with preservation of the sphincteric muscular apparatus, has decided advantages over resection in the region of the rectal ampulla.

(k) Surgery of the Kidneys

164. General Remarks. Before undertaking any operation on the kidney, one must be absolutely sure that the other kidney is functionally efficient. This is a rule which must never be transgressed. It is essential to know in certain cases, *e.g.* in a difficult nephrotomy, partial nephrectomy, or when one finds a condition different from what was expected, whether one is justified in undertaking entire removal of the kidney. Unless we have this previous knowledge we are in an embarrassing position.

Preliminary segregation of the urine should also be performed and a comparison be made between the secretion of the right and left kidneys. If there is any uncertainty, the ureter, at least on the diseased side, should be catheterised and the urine of that side compared with the mixed urine passed.

Kümmel of Hamburg has recently [1] published the results of his large experience in this direction. If the urine obtained by ureteral catheterisation is of normal specific gravity, with a freezing point of 1 to 2, as a rule the kidneys may be regarded as efficient, even should an abnormal constituent such as albumen be present. Rovsing regards the freezing point of the blood as unimportant, but if it is much reduced, *i.e.* from 0·56 to 0·62 or more, it is probable that the renal functions are at fault.

Much more reliable information is gained from an examination of the urine than from palpation of the kidney (in regard to size or tenderness on pressure, etc.), as very often when one kidney is at fault, or seriously diseased, the enlarged and palpable kidney is the healthy one.

If the second kidney is functionally healthy, it is quite safe to pass from nephrotomy to nephrectomy, or to undertake an operation which may seriously impair its function temporarily or for a considerable time. Although the amount of urine secreted is regularly diminished by a half or more after unilateral nephrectomy, it always rises in a few days and within a fortnight may regain the normal.

We entirely agree with Garré and Ehrhardt [2] that acute nephritis, with blood, albumen and casts may be produced after unilateral nephrectomy, but we attribute this to the avoidable toxic effects of prolonged chloroform anæsthesia, and especially to the use of antiseptics such as perchloride of mercury and carbolic acid in the preparation and treatment of the wound.

165. Incision to expose the Kidney and Ureter. It is a mistake to place side by side all the possible incisions which are recommended for exposing the kidney, as is done in the latest text-books on renal surgery. The surgeon must always adapt himself to the individual case, and, when necessary, make exceptions to the rule. This does not, however, prevent us from regarding one incision as a rational one on anatomical and physiological grounds—an incision which should be adhered to as the normal by all who have not had large enough experience to employ modifications of it.

Rational incisions are those which expose the diseased organ with the least

[1] *Gynecology, Surgery, etc.*, Chicago, 1907. [2] *Nierenchirurgie*, Berlin, 1907.

damage, avoiding especially injury to large muscles and their nerve-supply, and to blood-vessels, and which can be simply and firmly united by suture.

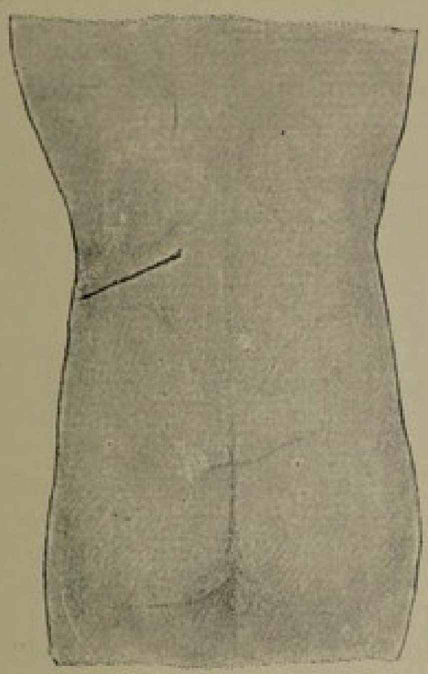


FIG. 391*a*.—Oblique incision for lumbar nephrotomy.

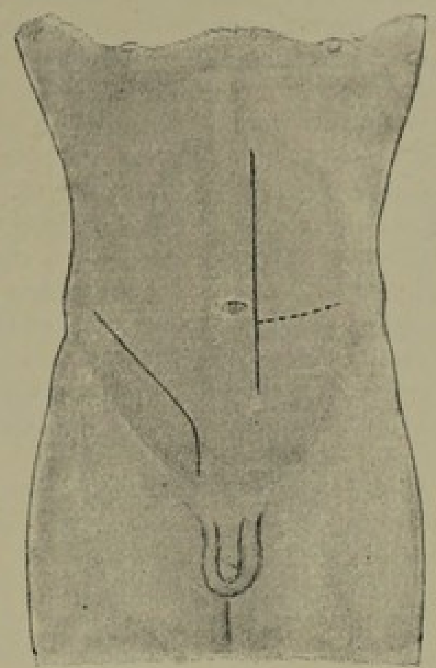


FIG. 391*b*.—Mesial incision for transperitoneal nephrectomy (left). The incision on the right side is for ureterotomy (obliquely three fingers'-breadth above Poupart's ligament, terminating as a pararectal incision).

The oblique incision is the one which satisfies the above conditions when exposing the kidney from the loin, the mesial incision, when the abdominal route is chosen. Unless there is any reason to the contrary, the lumbar route is always selected, as it gives the most direct access to the kidney, and with the oblique incision there is no unnecessary injury to muscles and nerves. We therefore reject Simon's vertical incision for nephropexy. Our incision does not correspond to the oblique lumbar incision described by Garré and Bergmann, but closely resembles that recommended by Czerny-Braun.

The oblique incision (see Fig. 392) has the inestimable advantage that it can be readily extended forwards (cf. Trendelenburg's oblique incision) without doing serious damage, if more room is required, *e.g.* in following down the ureter, or if the tumour is a large one. On the other hand, we agree with Garré, and as early as 1877 gave it as our opinion, that very large renal tumours are best exposed with least injury by the intraperitoneal route. We also pointed out that when the mesial incision is used the posterior layer of the peritoneum must always be divided to the outer side of the colon.

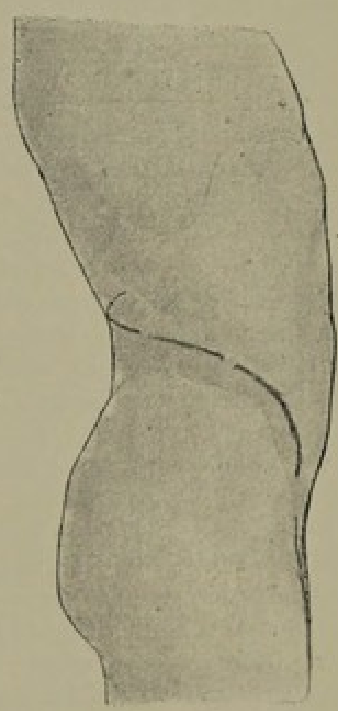


FIG. 391*c*.—Prolongation of oblique incision for combined nephrotomy and ureterotomy.

Nephrotomy by the intraperitoneal route is best performed through Sänger's mesial incision, and not as in Hartmann and Langenbeck's operations through an incision at the outer border of the rectus (pararectal),

as in the latter the nerves to the rectus are divided and the resistance of the abdominal wall is impaired. If the mesial incision alone does not give enough room, it is much better to divide the rectus transversely at the level of the umbilicus, *i.e.* at a tendinous intersection by means of an incision at right angles. This procedure is also recommended by Hartmann. The addition of the transverse incision gives excellent room and the muscle can be securely sutured without any harm resulting.

While we do not regard the oblique incision as the normal one in the case of a large tumour, which requires a long incision, we consider the prolongation that Israel employs for exposing the ureter after removal of the kidney as the proper procedure. The oblique incision, when prolonged into the inguinal region, follows the direction of the fibres of the external oblique and is parallel to the nerves supplying it. As shown in Fig. 391*c*, we curve the incision downwards to the edge of the rectus and carry it through the united aponeurosis of the three great abdominal muscles, and sometimes the rectus sheath, down to the fascia transversalis. It is analogous to that employed in ligature of the common iliac artery, and gives just as good access low down, while it allows the upper edge of the wound to be retracted much more. (For details, see Exposure of the Ureter.)

166. Exposure of the Kidney with Division of the Capsule. Decortication. Nephropexy. The kidney can be exposed and the capsule incised quickly and without much bleeding by means of the short oblique incision already mentioned. Rapid exposure is also very urgently called for in rupture of the kidney, which not uncommonly follows an injury in the loin, and which may be accompanied by serious hæmorrhage. The bleeding may be arrested by exposing the kidney and ligaturing or suturing the tear in its substance; in many cases, however, removal of the organ has to be undertaken.

Acute inflammation of the kidney is to be regarded as another urgent indication for operation. We owe to Reginald Harrison the discovery of the fact, that in certain forms of acute nephritis not only can the nephralgic pain, hæmaturia, and albuminuria be rapidly arrested, but also the reflex functional disturbances of the other kidney (*i.e.* according to Israel, the ischæmia reflexly produced by irritation of the sensitive nerves in the pedicle).

According to Korteweg, anything which obstructs the kidney, even urinary retention, causes a venous congestion and a sort of strangulation, resulting in anuria which can be removed by an incision to relieve tension. When one considers how very often the medical treatment of an acute nephritis (following scarlet fever or other infections) leaves the kidney in a chronic inflammatory state, which results in contraction and often death, one is led to the conclusion that during the acute stage early and thorough relief of the renal circulation by incision should be resorted to.

We agree with Lennander that a wider sphere must be assigned to the surgical treatment of acute nephritis than is usually accepted. Lennander recommends incising the capsule and freeing the kidney by open treatment in cases of oliguria or anuria as well as when there is severe pain and tenderness on pressure in cases of nephritis. The same treatment should be followed when there is danger of the condition passing into a chronic stage with constant pain.

The object of exposing the kidney and dividing the capsule in chronic nephritis is not to relieve tension but to enable a collateral anastomosis to be formed with the vessels in the surrounding tissues. A few surgeons, Edebohls in particular, are as enthusiastic over the results of this operation as the greater number are indifferent.

Asakura, Stursberg, Zaajer, and Ceccherelli have shown by experiments that the new vascular anastomosis, between the decapsulated kidney and the surrounding tissues, produced by the operation, is quite extensive enough to directly influence the blood-flow through the kidney. Johnson, it is true, could not corroborate this.

Babes[1] attempted to provide a good blood-supply to the decorticated organ by opening the abdominal cavity, and either placing the kidney inside the peritoneum or by pulling out the omentum and wrapping it round the kidney.

Exposure and division of the kidney capsule are especially indicated in nephropexy

[1] *Centralbl. f. Chir.*, April 1904.

for floating kidney, and give very good results where morbid symptoms (pain, colic with or without intermittent hydronephrosis and congestion, gastric disturbances,

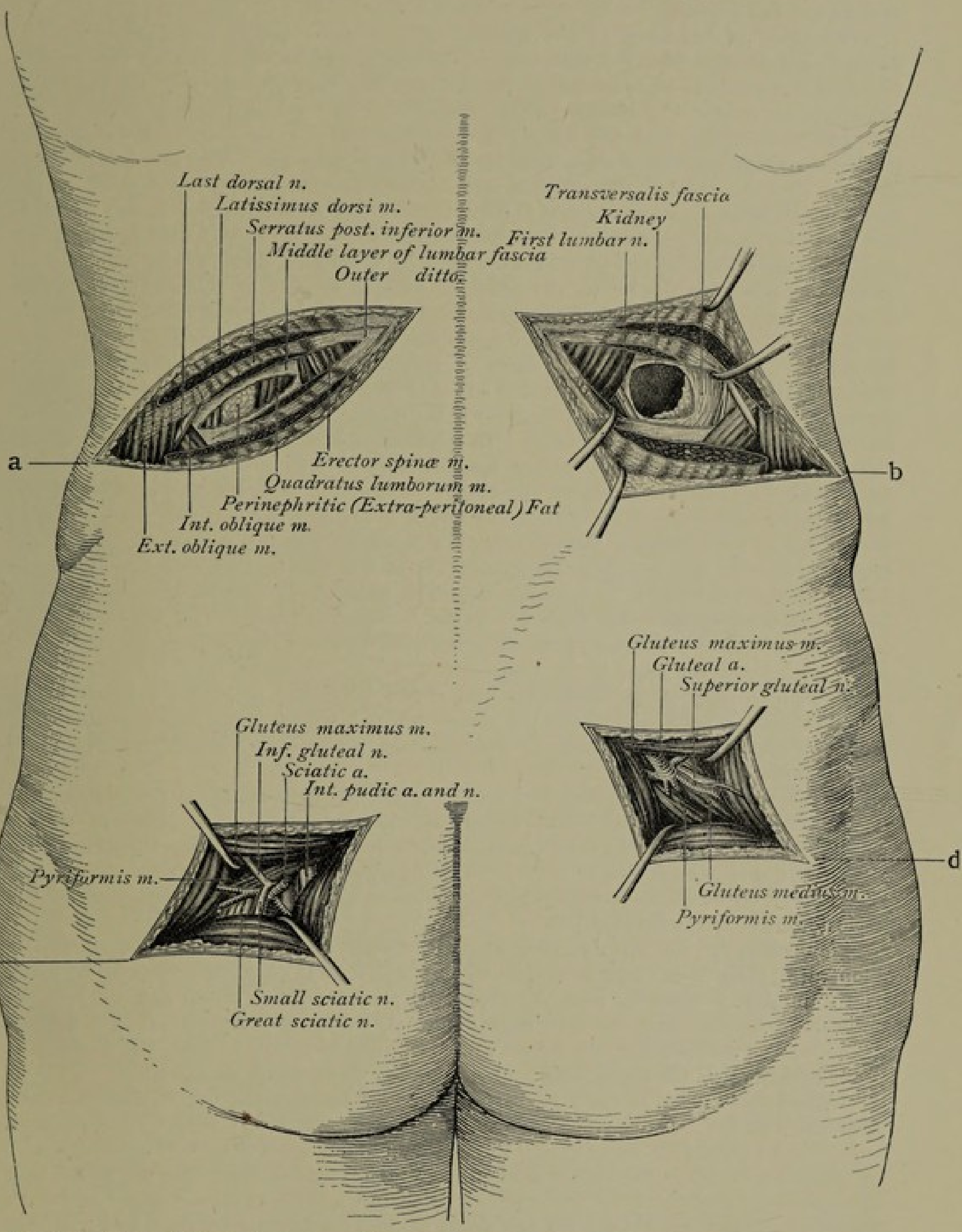


FIG. 392.—(*a*) and (*b*) Nephrotomy. (*c*) Ligature of the sciatic and internal pudic arteries, and exposure of the great sciatic, small sciatic, and internal pudic nerves. (*d*) Ligature of the gluteal artery and exposure of the superior gluteal nerve.

vomiting, etc.) can be recognised as definitely dependent on the floating kidney, particularly when mere "neurasthenia" or hysteria can be excluded. After fixation

of the kidney the symptoms remain entirely absent. In most cases the kidney can be reliably fixed if a proper technique is employed, even when it occupies a position lower than the normal.

Technique of Exposure of the Kidney.—The incision begins posteriorly over the prominence of the erector spinæ muscle, in the angle between it and the twelfth rib, and extends forwards as far as the mid-axillary line. It divides the skin and subcutaneous tissue, the strong lumbar fascia, and the muscles arising from it, viz. the latissimus dorsi and the subjacent serratus posticus inferior. The outermost digitation of the latissimus dorsi appears as a broad flat mass. The serratus posticus forms a thin muscular layer where it overlies the sacro-lumbalis, but beyond it the fibres pass obliquely upwards and outwards, forming a still thinner layer, which is not always well enough developed to be distinctly recognised. The edge of the sacro-lumbalis may either be nicked or drawn forcibly inwards. When a larger incision is made, the posterior border of the external oblique muscle of the abdomen, which descends from the last rib at the anterior angle of the wound, is divided transversely for a short distance, as also are the subjacent fibres of the internal oblique, which ascend obliquely upwards and forwards. Beneath the erector spinæ, and occupying the interval between it and the nicked edges of the oblique abdominal muscles, is the strong, glistening, transversely-striated lumbar fascia, which gives origin to fibres of the transversalis abdominis muscle. In *nephroraphy* it is only necessary to divide the latissimus dorsi and the lumbar fascia between the outer border of the erector spinæ and the posterior edges of the oblique abdominal muscles, the muscles themselves being left uninjured. After this fascia is divided, the edge of the quadratus lumborum is seen passing almost vertically upwards parallel to the margin of the erector spinæ, beyond which it projects. The last dorsal nerve appears at the lower border of the twelfth rib, and passes obliquely downwards and forwards, sometimes beneath and sometimes over the edge of the internal oblique. The ilio-hypogastric nerve (from the first lumbar) extends downwards and outwards from (in the prone position) beneath the edge of the quadratus.

The outer edge of the quadratus may either be nicked or drawn inwards. The abundant loose post-renal fat, and the vessels which lie beneath the transversalis fascia, are then exposed. The kidney is now reached by carefully separating this fatty capsule with the finger.

If the kidney does not occupy a normal situation, it is not always easy to expose it sufficiently freely for accurate inspection and palpation by an incision merely through the soft parts. In such cases one must not hesitate to divide subperiosteally the twelfth or the eleventh, or even a rib still higher. The upper edge of the wound is retracted upwards, an incision made down on to the rib, and after reflection of the periosteum the rib is divided.

Nephropexy. For fixation of a floating kidney,[1] we adhere to the method finally adopted by Hahn (who first proposed nephropexy in 1881), and employed by N. Senn. The kidney is pushed up into the wound by pressure made by an assistant on the anterior abdominal wall, its true capsule nicked, and carefully detached with a blunt dissector. After catching the edges with our toothed artery forceps, the incision is prolonged towards the lower pole, which is pulled upwards by its capsule.

Considerable force is required in stripping off the capsule, but it must be done with care, as the capsule is easily torn, and it is desirable to separate it for as great an extent as possible. In stripping the capsule off the concave surface care must also be taken not to rotate the kidney into an unsuitable position, otherwise the ureter may be kinked or transfixed by the needle. Basham[2] asserts that one cause of failure consists in fixing the kidney too low down or in an abnormal position, and a second in associated lesions (pyelitis, stone, kinking of the ureter) which are not corrected.

After the capsule has been separated, it is stitched along with the fatty capsule

[1] The operation of nephrectomy formerly practised, and recommended by Martini for floating kidney, is no longer to be regarded as a normal procedure. It may occasionally be necessary later on if disturbance of the urinary secretion or urinary fistula remain after a conservative operation, or if the trouble continues in cases complicated by nephritis.

[2] *American Journal of Surgery*, May 1906.

to the lumbo-costal and lumbo-dorsal fascia with 8 to 10 silk sutures threaded on a curved needle, so that a portion of kidney substance lies quite free in the bottom of the tunnel formed by the capsule. The surgeon then satisfies himself that the kidney lies firmly in this position and is no longer pushed down on respiration. In passing the sutures, the last dorsal and first lumbar nerves, which are seen in the upper and lower extremities of the wound, must be borne in mind, as if they are included in the sutures, radiating pain, which may persist for some time, is the result.

The capsule is now still further separated round the lower pole, and xeroform gauze is packed round the latter and brought out through the wound. The gauze fills up the wound and is in contact with all the exposed area of the denuded kidney surface. It is well to partly close the wound with a couple of deep sutures and leave in the gauze. The latter is only removed after fourteen days, for the object is to procure a granulating surface right down to the kidney, which will give rise to extensive cicatrisation between a large part of the surface of the kidney and the connective tissue and fascia of the loin.

Catgut should not be used, as the sutures must hold the kidney firmly in position for a considerable time. We consider it unnecessary and even dangerous to pass the suture round the last rib, for the pleura may readily be injured, and no better hold is got than by stitching the kidney to the strong fascia between the rib and the crest of the ilium. We consider any attempt to pass the sutures through the substance of the kidney to be absolutely useless, as they cut out either at once or at least subsequently on the slightest pull, and do not fix the kidney so well as simple suture through the capsule. Gardner [1] points out that a renal fistula may arise from injury of the central calyx, which generally comes near the surface of the kidney.

Exonephropexy, *i.e.* placing the kidney in the soft parts of the loin, is associated with the danger of kinking of the vessels or ureter. We have tried it and have abandoned the operation. Beck, Baldwin, and Kukula push the capsule or the kidney itself through a slit in the quadratus lumborum; Kukula, however, lost one patient out of three from vomiting and anuria.

167. Nephrotomy. Nephrolithotomy.[2] Pyelotomy. When the kidney has been exposed in the manner described in the previous section, one may have to incise its pelvis or split the kidney itself *in situ* to evacuate collections of fluid or remove stones. Garré rightly asserts that in nephrotomy the capsule should not, as a rule, be removed, *i.e.* the kidney should not be decapsulated, to avoid giving rise to more severe bleeding. The converse is the rule in nephrectomy. Among the fluids to be dealt with are blood, urine, contents of cysts or pus; anuria from obstruction by a stone or from acute congestion of an inflammatory nature is one urgent indication for immediate nephrotomy. Some surgeons have incised the kidney itself in cases of congestive hyperæmia, while others are satisfied with decapsulation.

(*a*) *Nephrotomy and Nephrolithotomy.* Tuffier's so-called "sektionsschnitt" is the incision most generally adopted when there is a choice in the site of the nephrotomy opening. Zondeck, however, has made some admirably-injected preparations to demonstrate the correct situation for incision of the kidney. He has shown that the anterior and posterior vascular territories of the organ are fairly-distinctly demarcated from one another, and that by making the incision about 1 cm. behind the convex border and cutting towards the pelvis no large vessels will be encountered. We have already alluded to a case which we saw in the practice of one of our colleagues where fatal hæmorrhage occurred after an absolutely healthy kidney had been incised.

Before the kidney is incised, it must be brought out of the wound. Clamps can then be applied to the vessels in the hilum and the hæmorrhage controlled. The incision should only be 3 to 4 cm. long to begin with, *i.e.* just large enough to admit the finger for examining the pelvis and calices. Once the finger is in the pelvis, it is much easier to extend the incision upwards and downwards with a probe-pointed knife without doing damage. If it is merely to drain an abscess, there is no need for the longer incision necessary for the removal of large impacted stones.

[1] *Annales des mal. génito-urinaires*, 1905, No. 8.
[2] Garré states that Czerny first performed nephrolithotomy, and Morris pyelolithotomy.

In a case of nephrolithotomy it is essential to examine the kidney both from the outside and inside so as to be sure that no concretions are left behind. A sound should also be passed down the ureter, or coloured fluid injected through it into the bladder to ascertain that it is patent.

If there is copious hæmorrhage from the division of a large vessel, a suture should be passed round the latter and tied. A deep suture is a very certain means of arresting hæmorrhage, having, however, the disadvantage that it may interfere with the circulation to such an extent that necrobiosis and necrosis may take place, as may happen after ligature of any large vessel. Not very long ago we had occasion to note the separation of large necrotic portions of the kidney in the course of a case (an arterio-sclerotic kidney which ran a normal aseptic course) after using numerous catgut sutures. Albarran maintains that by employing loose tampons instead of sutures the kidney regains its functional activity much more readily.

Sutures should only be employed when one is sure that the outflow by the ureter is quite free and that there is no sepsis present. A mild degree of infection must always be taken for granted in cases of nephrotomy, for both Tavel and ourselves have shown that even with a healthy kidney one can never be sure that bacteria excreted with the urine will not infect the wound. Whenever sutures are employed, a drainage tube must be passed down to the kidney, while helmitol and urotropin are subsequently administered.

If hæmorrhage occurs after an infected kidney or pelvis has been opened, the kidney must be packed, and if the incision is a large one, sutures must be inserted as well, and a drainage tube passed into the pelvis. In the case of multiple abscesses plugging alone is permissible.

(*b*) *Pyelotomy*. Pyelotomy is indicated when stones have to be removed from the pelvis of the kidney, especially when a small stone is impacted in the ureter. It is also indicated when the pelvis is dilated and a portion of it is to be resected, or a plastic operation performed on the upper end of the ureter (*vide infra*, Transpelvic Ureterostomy).

When the renal pelvis is dilated, pyelotomy is a much more simple and bloodless operation than nephrotomy. There is, however, more chance of a persistent urinary fistula resulting, and at the same time it gives poor access to stones situated in the calices. If the pelvis is properly exposed from behind and opened at an easily-accessible point, a fistula can be prevented by inserting two layers of fine silk sutures. If pus is present in the pelvis, the latter must be drained, and should a fistula result, it can be subsequently closed.

Appendix. Nephrostomy and Pyelostomy. A permanent urinary fistula has occasionally to be made either in the kidney itself or in its pelvis, in the treatment of certain conditions necessitating operation on the ureter and bladder, especially in total excision of the bladder for malignant new growths.

168. Nephrectomy. We owe this operation as well as the development of renal surgery to the researches of Simon. It is clearly indicated in the case of a unilateral renal tumour, and in rupture of the kidney, with hæmorrhage which cannot otherwise be controlled. It is, however, more frequently undertaken in suppurative conditions of the kidney, especially tuberculosis. In suppurative cases it must be proved by segregation of the urine that the function of the renal parencyma is already seriously impaired, and also (possibly by means of the kryoscope (Koryani)) that the other kidney is able to respond to the increased demands made upon it.

In tuberculosis of the kidney the conditions are similar in so far that the functional efficiency of the other kidney must be determined. When, however, there is no doubt about the diagnosis, the indications for nephrectomy are still more definite, and the operation is performed even when the function of a tuberculous kidney is still comparatively good. Excellent results are obtained by early operation in the case of renal tuberculosis, and we consider early excision by far the best treatment.

Even when the disease is bilateral, excision is still indicated, provided that the function of the other kidney is not yet really diminished by the disease. Here, of course, there must be special reasons for excising the more diseased kidney in the

shape of bleeding, pain, or suppuration and its sequelæ. Experience has shown that the condition of the other kidney improves and its functional activity increases correspondingly as soon as the evil effects on the rest of the body are removed.

The lumbar operation is the correct one in traumatic, suppurative, and tubercular cases, as well as in a persistent renal fistula, while the transperitoneal route is to be preferred for tumours.

(*a*) *Lumbar Nephrectomy.* The same incision is employed as that described for nephrotomy, the operator prolonging it, if necessary, forwards towards Poupart's ligament (cf. Bergmann's lumbar incision). Bergmann's incision is often the best for a diseased floating kidney. In any case, the incision should always be made long enough in the first place.

Before attempting to remove the kidney, decapsulation should always be performed if the capsule is not adherent, as otherwise considerable difficulties may be encountered. In attempting extracapsular nephrectomy when the capsule has become adherent to the surrounding parts as the result of inflammation or new growth infiltration, neighbouring structures, *e.g.* colon, peritoneum, and particularly the great vessels (vena cava) are very liable to be injured.

It not infrequently happens, however, that the capsule is involved in the disease and is considerably thickened (up to 1 cm. or more in tuberculous pyonephrosis). However, the correct way to excise the kidney is first of all to shell it out of its capsule, when this is possible, after which an excision of the capsule (in most cases only partial) can be undertaken if not too dangerous.

It is not always possible, when there are multiple abscesses, to avoid opening into some of them in stripping off the capsule, but this is a much less serious accident than the bleeding and injury which is associated with pericapsular excision. There is no doubt, also, that the capsule may be sometimes directly invaded by the new growth. The case must then be regarded as too far advanced for a radical cure to be obtained, in so far as the capsule cannot be subsequently removed without serious risk.

The treatment of the pedicle in the case of a large tumour, or when there is much inflammatory thickening of the capsule and perirenal tissue is by no means easy. After the kidney has been detached from its capsule (in the case of a tumour numerous vessels have to be ligatured), it is sometimes as well to incise the capsule round the hilum so that a securer type of pedicle may be obtained.

If a long enough pedicle can be got, the artery and vein should be isolated separately with an aneurysm needle, tied and cut across. Strong catgut should be used in infective cases, silk in an aseptic case. One is often glad enough to be able to tie a single ligature tightly round the whole pedicle and afterwards, if the individual vessels can be seen in the stump, they may, for greater security, be tied separately.

The ureter, which lies posteriorly, should be separated from the vessels whenever possible. In suppurative and tuberculous conditions great care must be taken that its contents do not infect the surrounding parts. The ureter should be ligatured low down and a pair of artery-forceps applied on its renal side, after which it is cut across between the two with the thermo-cautery. A ureter, the muscular wall of which is still intact, is securely closed in this way.

When, however, the wall of the ureter is diseased and thickened, as occurs in tuberculous cases, it is quite a different matter. Here the most rational procedure would appear to be to excise the ureter *in toto* right down to the bladder. We are satisfied, however, that it is only reasonable to do this when the terminal part of the ureter is healthy, for infection arising from the deeply placed stump is far worse than if the upper end of the ureter is accessible in the region of the wound. We have seen miliary tuberculosis with a fatal issue result from the development of a small tuberculous abscess after the low removal of the ureter.

In these cases it would be better to follow Kümmel's advice and resect a portion of the bladder wall, provided that one has learnt by means of the cystoscope the extent and degree of affection of the bladder. As a general rule, the ureter is merely ligatured above (Israel, Rovsing, and others) and iodoform injected into the stump, which is sutured in the wound. According to Rovsing, the disease of the bladder

should be treated with carbolic injections (1 to 20 carbolic acid injected twice daily and allowed to remain in the bladder for five minutes).

When nephrectomy is undertaken for a tumour of the kidney, the only difference is, that very copious hæmorrhage often occurs in separating the fatty capsule, and that it is seldom possible to strip off the "capsule proper." We much prefer the access afforded by the transperitoneal operation in dealing with large tumours, *e.g.* a renal sarcoma in children, although with the extended oblique incision it is often possible to get access to the region of the colon extraperitoneally and then proceed immediately to the separation of the latter.

(*b*) *Transperitoneal Nephrectomy.* We were the first (1876) to adopt the transperitoneal operation on the strength of a deliberate diagnosis. The case was a large renal sarcoma. We recommend an incision in the middle line to which, if necessary, may be added a transverse incision, as shown in Fig. 391*b*.

The tumour is at once exposed, covered by the peritoneum of the posterior abdominal wall, in front of which is the ascending or descending colon. If it is impossible to keep the intestines packed away in the other side of the abdomen, they must be wrapped in warm sterile towels. The veins on the surface of the tumour are usually enormously distended. We found in our first case that it is best to incise the peritoneum parallel to, and to the outer side of the colon, and displace the latter inwards. The rest of the peritoneum is retracted outwards, and all the vessels, especially veins, are isolated with an aneurysm needle.

Carefully arresting the hæmorrhage step by step, we reach the space between the fatty capsule and the tumour posteriorly. Here the separation proceeds more easily till the pedicle is reached and can be tied.

One must afterwards be careful to see whether the blood-supply to the colon has been damaged, for if so resection may be necessary. The large raw surface is then covered over by drawing together the edges of the peritoneum with sutures. Drainage in front is unnecessary, but a tube is inserted through a small incision in the loin, at the outer border of the quadratus lumborum.

Hyper-nephromata are among the most favourable tumours for radical treatment, only, however, so long as they can be separated from their surroundings by blunt dissection. We shall record our experiences elsewhere. Wenzel, from an experience based on twenty-three operations for "epinephroma," recognises the decided superiority of the transperitoneal method.

The transperitoneal method has the advantage that one can easily examine the condition of the other kidney. Before the introduction of segregation, ureteral catheterisation, and cryoscopy, we used to determine this (as regards its vessels) by palpation in cases of lumbar nephrectomy, passing the hand through an incision in the peritoneum external to the colon.

169. Excision of the Suprarenal Body. The suprarenal body has recently been excised in the treatment of Addison's disease. Hadra and Oestreich performed laparotomy for a supposed malignant retroperitoneal growth, the incision extending between the xyphoid cartilage and the umbilicus. After division of the small omentum, a pulsating tumour the size of a hen's egg was separated from the aorta. It proved to be a tuberculous suprarenal capsule. The wound was stuffed and the patient recovered. The Addisonian symptoms (marked weakness, emaciation, and severe gastric pain) disappeared. There had been complete absence of bronzing of the skin.

(l) Surgery of the Ureter

170. General Remarks. A great advance has been made since the last edition in the treatment of injuries and other conditions of the ureter requiring incision, or resection with either end-to-end anastomosis or implantation into the bladder, and occasionally into the bowel and abdominal wall

Anastomosis and implantation of the ureter have been, as a rule, performed on account of accidental injury during operations, especially on the female reproductive

organs, and in consequence have generally been carried out intra-peritoneally. Krönig has performed uretero-cystostomy no less than 25 times, 23 being intra-peritoneal, with only one death.

Total excision of the ureter is chiefly called for in tubercular disease, when it has become extensively involved from the kidney.

Incision and resection of the ureter are most often undertaken for the relief of obstruction, more especially when a calculus, in its passage from the kidney, has become impacted in the ureter, but also in stenotic and valvular conditions secondary to injuries and inflammation, particularly in connection with obstruction (uronephrosis) and floating kidney.

Lastly, tumours, especially of the bladder, call for resection of the ureter. When undertaken for the treatment of a ureteral fistula, the latter is, as a rule, the result of an operative lesion.

With regard to technique, it is well to distinguish between the lumbo-renal portion of the ureter, *i.e.* the portion continuous with the pelvis of the kidney, the abdomino-iliac, and the pelvi-vesical portions. Finally, a clear distinction must be drawn between the intra-peritoneal and extra-peritoneal operations in these three regions.

171. Intra-peritoneal Anastomosis of the Ureter with Ureter and Bladder. As mentioned above, it is chiefly as a result of injury during laparotomy that restoration of the ureter by anastomosis is called for. We anticipate the discussion of this, since it also demonstrates the method of establishing normal conditions in cases of intentional exposure and opening of the ureter.

(*a*) *Uretero-anastomosis.* Experience has shown that in the case of a divided ureter union by simple end-to-end suture (Schopf), by lateral anastomosis with occlusion of the ends (Monari), and even by the better end-to-side method, is not reliable. A partial wound can be repaired with a double row of fine silk sutures which do not include the mucous membrane, after the fashion of Lembert's sutures, but in the case of a total division the invagination method is required.

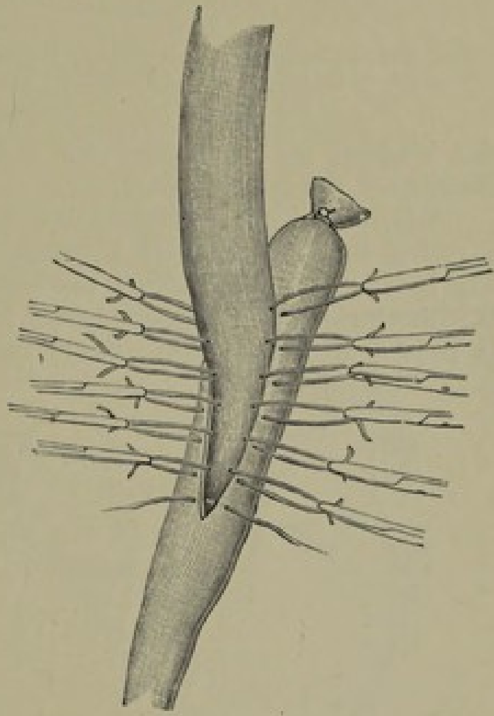


FIG. 393.—Ureteral anastomosis, invagination method.

The invagination method which was introduced by Weller van Hook, and improved by Emmet Bache, is strongly recommended by Döderlein and Krönig. As in an end-to-side intestinal anastomosis, the vesical portion of the ureter is closed with a circular occluding suture and a longitudinal slit is made lower down into which the renal end of the ureter (best divided obliquely according to Depage and Mayer) is inserted, care being taken that it projects some millimetres beyond the lowest angle of the wound. The edges of the slit are then stitched with fine sutures all round to the wall of the portion implanted in it.

In the intra-peritoneal operation, if peritoneum can be united to peritoneum, there is no need for drainage, provided that there has been no escape of infective contents from the ureter.

(*b*) *Uretero-cystostomy.* The idea of reimplanting the ureter in the bladder after dividing its lower end only occurred as a possible alternative after the method of implanting it into the gut had been evolved. Yet it is by far the more natural and less dangerous method, because in this case the fear of an ascending infection, always present and of great importance in implantation into the gut, need not be entertained. Boari has published an excellent paper on the subject of uretero-cysto-

neostomy. The operation is indicated, according to Boari, in cases of injury to the lower end of the ureter, and more especially in fistula formation, as in uretero-vaginal and uretero-uterine fistulæ. Poggi originated the idea in 1887, and Paoli and Busacchi performed the first experiments on animals. Novaro (1893), Bazy, Hegar, and Schede have performed the operation on the human subject.

Novaro inserted the end of the ureter directly into an opening in the apex of

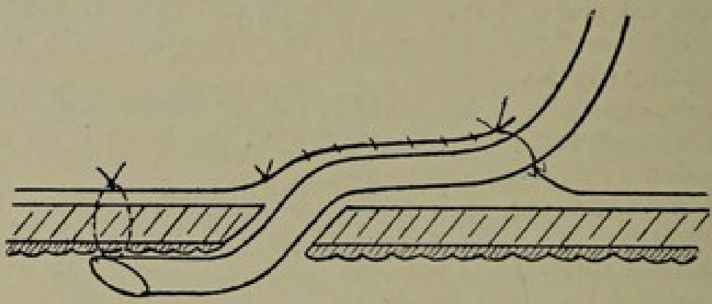


Fig. 394.—Uretero-cysto-neostomy, Depage's method. The figure shows the manner in which the ureter is inserted into the bladder. The peritoneum has been stitched over part of the ureter.

the bladder, and converted the suture subsequently into an extra-peritoneal one. Boari used the same method.

A laparotomy is performed and the ureter is sought for. The parietal peritoneum covering it is divided. If a fistula is present, the ureter is cut through above it. The bladder, a part of which has been rendered prominent by introducing a catheter, is incised close to its apex, to prevent backward flow of urine. A ureteral sound is passed into the ureter (Bazy) from below through the incision in the bladder.

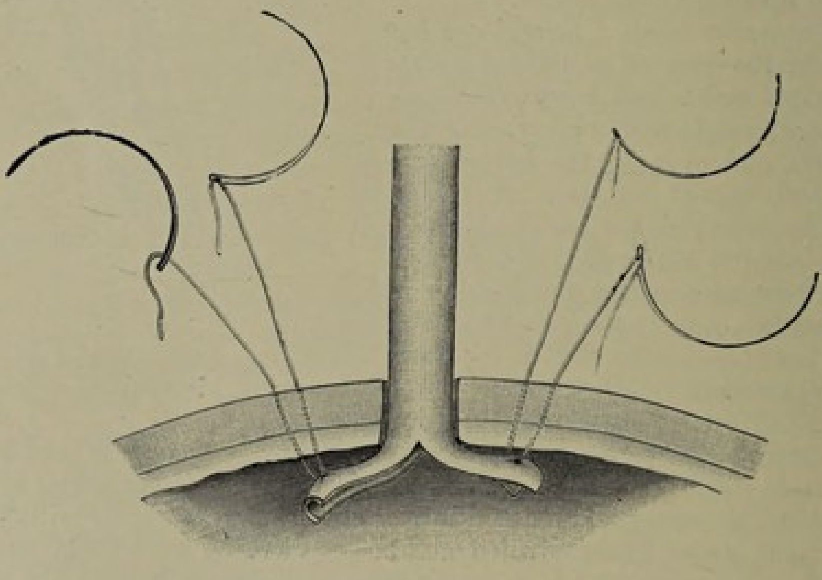


Fig. 395.—Uretero-cystostomy, Sampson-Krönig method.

Fine catgut sutures are now put in so as to unite the mucous membrane of the ureter—the opening of which may be split laterally if necessary—to the mucous membrane of the bladder. The remaining layers are next sutured. Care must be taken not to narrow the ureter by these stitches.

Bazy employs side-to-side anastomosis. He makes a lateral slit in the ureter, and stitches the edges to a corresponding opening in the bladder. End-to-side union between the ureter and bladder has, however, proved much better. Margarucci[1] points out that if the periureteral tissues in which the ureteral arteries (branches of

[1] *Policlinico*, Rome, 1904.

the renal arteries) lie, are preserved, the ureter can be safely isolated for 8 to 10 cm. (3 to 4 inches). Garré emphasises the extent to which it can be stretched.

Fritsch was the first to call attention to the necessity of pulling the ureter well down so as to project into the bladder. Witzel then instituted the method of implanting it obliquely into the bladder wall, after his manner of making an oblique fistula in the stomach and intestine. Depage simplified the latter operation in the manner illustrated in Fig. 394, and has had very good results.

Depage and Mayer,[1] who have reported on 64 cases of uretero-cystostomy (up to 1904) with a mortality of 11·7 per cent (the purely operative mortality being 5·9 per cent), recommend that, after division of the peritoneum, the ureters be cut obliquely. A small hole is then made in the bladder, and the ureter pulled through it by means of a fine silk thread, the ends of which are passed through the bladder wall, about 15 mm. distant from the opening, and tied. The opening in the bladder may be partly closed, if necessary, while the detached peritoneum is replaced and stitched over the ureter as it enters the bladder for a distance of 3 cm.

Fig. 396.

Fig. 397.

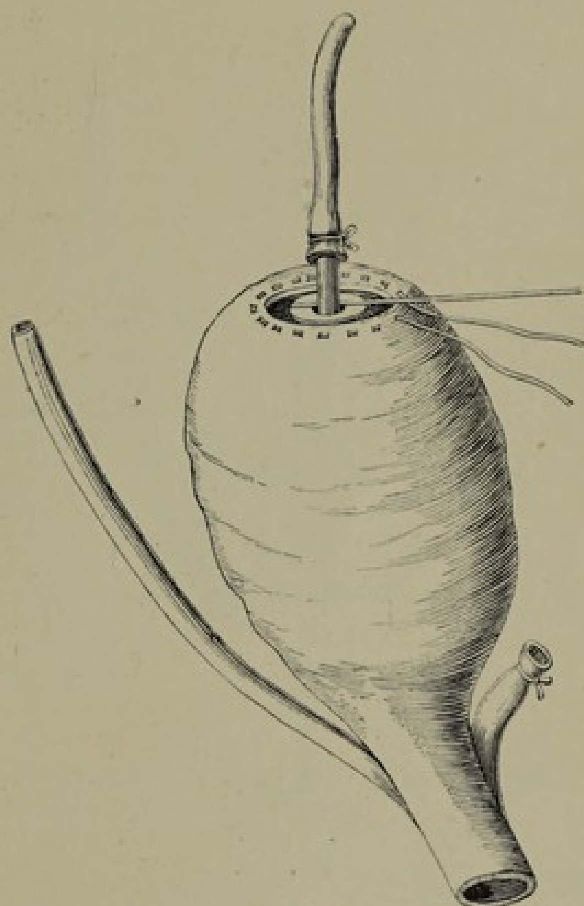


Fig. 398.

The difference between Krause and Sampson's methods, and their modifications by Döderlein and Krönig, is similar to that between those of Witzel and Depage. Both split the ureter for some distance (*vide* Fig. 395), pull the two flaps through the hole in the bladder by means of a double suture, and fix the ureter near the opening with stitches. But while Krause merely fixes the flaps to the mucosa, Sampson, Döderlein, and Krönig pass the stitches through the whole thickness of the bladder wall.

Krönig has only had one death out of 23 cases of intra-peritoneal implantation using Döderlein and Krönig's modification of Sampson's method. Double implantation has even been carried out successfully. Rissmann made two openings in the bladder and pulled the split ureter in through the one and out through the other (distant 3 cm.) and fixed it in the latter.

Novaro has further pointed out that it is desirable, in intra-peritoneal implantation, to unite the peritoneum over the isolated strand of ureter running through the abdomen : Witzel also adopts the same method.

To effect this, Novaro strips the peritoneum back from the front of the bladder over the site of suture and stitches it there.[2]

Boari has introduced a button (Fig. 396, 397) analogous to that of Murphy, of which the narrow end is tied into the ureter and the broad end into the bladder. The walls of the two openings are pressed apart by the pressure of a spring. The button greatly simplifies the operation. When the broad part of the button has

[1] Langenbeck's *Archiv*, Bd. 74.

[2] Cf. Lichtenauer, *Monatsschr. f. Geburtshilfe*, Bd. 22, and Stoeckel, *ibid.* Bd. 51.

been introduced into the opening in the bladder, the latter is fixed round it with a purse-string suture, as in the case of Murphy's button (Fig. 398, borrowed from Boari's work). Boari did not lose a single animal in which this method was employed, and no fistulæ resulted. Boari, following Novaro, recommends that the peritoneum of the bladder should be raised up as far as the site of implantation, and that a gauze drain should be put in, a glass tube, however, probably being better for this purpose.

Unlike implantation into the intestine, the operation gives rise to no functional disturbance, neither to infection nor to stenosis.

In cases of defect of the ureter, which, in spite of traction on the ureter and freeing of the bladder (according to Kelly by division of its pubic ligaments), do not permit of union, Boari recommends a uretero-plastic operation, which may best be illustrated by two diagrams borrowed from his work on the subject (Figs. 399, 400). It consists in the formation of a long flap with its base above: this is converted by suturing into a tube, and the ureter is invaginated into its upper end.

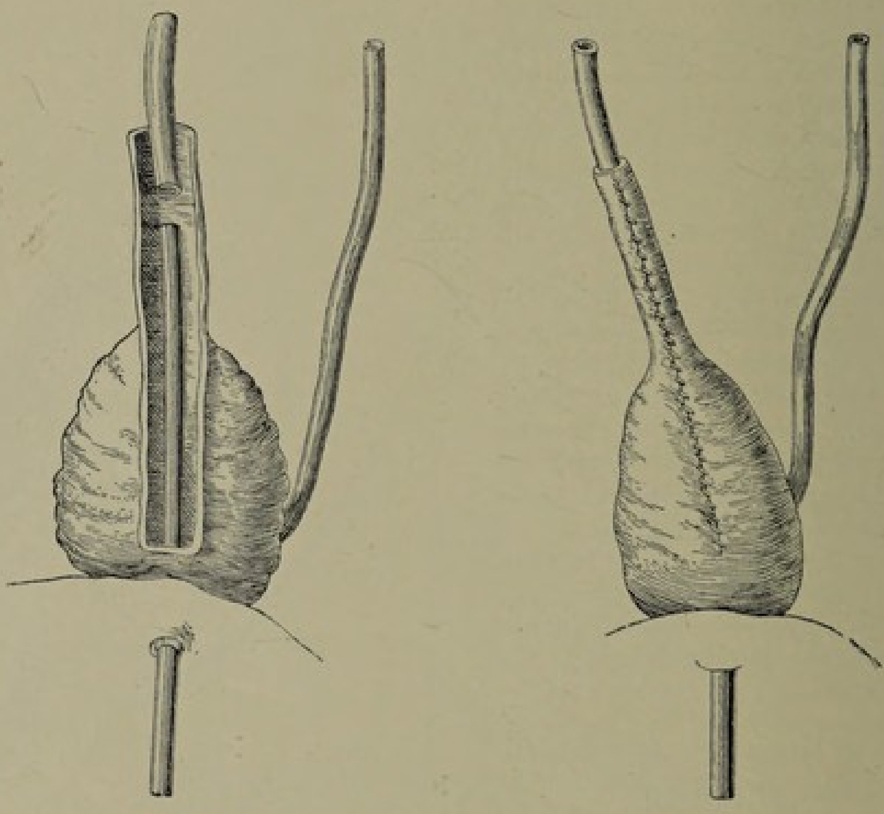


Fig. 399. Fig. 400.

(c) *Uretero-Trigono-Sigmoideostomy* (*Maydl*). According to Garré, Bardenheuer and Novaro devised the operation from experimental observations. The first to perform it, besides Maydl, were Eiselsberg and Herczel.

The above name was introduced by Reuben Peterson, who has published an excellent work on uretero-enterostomosis. He has performed a large number of experiments with the special object of getting a clear idea of the effects of the operation on the kidneys. He finds the conditions identical in man and animals. The result of his studies of the literature on the subject, and of his experiments, is very definite. All endeavours to prevent infection ascending to the kidneys when the ureters are implanted in the intestine are unavailing, and consequently general infection or severe lesions of the kidneys cannot be prevented. In thirty-three cases in human beings the mortality was 33 per cent. Secondary stenosis cannot be prevented and results in hydro- and pyo-ureteritis, or hydro- and pyo-nephrosis.

The operation is therefore unjustifiable. How far Franck's operation of cysto-

proctostomosis has a future before it is still undecided. Halstead has performed it with success. On the other hand, the operation called by Peterson uretero-trigono-enterostomy, namely, implantation of the ureters with the part of the bladder wall immediately surrounding their terminations, has quite justified itself. The mortality is small, the danger of severe infection passing upwards is insignificant, although no valve or muscular sphincter can be formed. The rectum tolerates the urine quite well, and its sphincter action is sufficient to prevent incontinence.

The idea of keeping the openings of the ureters intact originated with Tuffier, but Maydl first performed the operation in its present form in a case of extroversion of the bladder. The mortality in thirty-six cases has only been five.

The operation, as described by Maydl and modified by Peterson, is as follows :—

No purgative must be given, nor must the rectum be washed out beforehand, but after the patient is under the anæsthetic the rectum and colon are thoroughly washed out. For cases of extroversion of the bladder (according to Tuffier) an

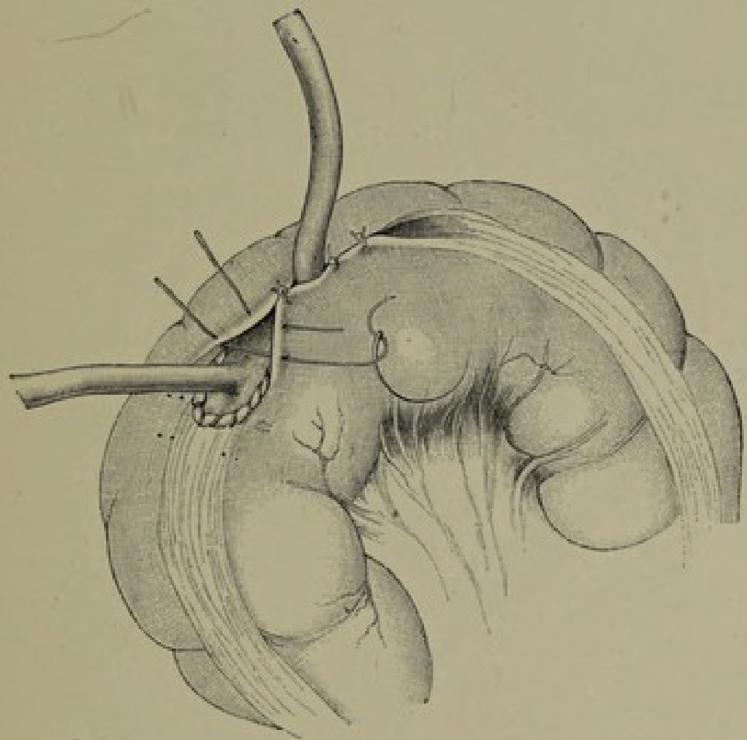


Fig. 401.—Implantation of the trigone and ureters into the pelvic colon. The trigone has been united all round to the opening in the bowel, and invaginated.

incision is made round the bladder, which is freed extra-peritoneally. Peterson divides the bladder as far as the fundus with scissors. A rectangular piece, at least $1\frac{3}{4}$ in. square, is next cut out round the orifices of the ureter. It would probably be more convenient for suturing if the piece was more elliptical in shape. The abdominal cavity is opened and the sigmoid flexure (in dogs the descending colon) is pulled out, and an incision is made in its long axis (the loop of bowel should be emptied, and a clamp applied) corresponding in length to the portion of bladder excised. The latter is now placed along one margin, serous coat to serous coat, and a suture put through the whole thickness, as shown in Fig. 401 (borrowed from Peterson's work). The suture is continued all round (Peterson only cuts down as far as the mucous coat, and does not excise this till two-thirds of the suture has been inserted). The parts are now thoroughly cleansed and the serous suture is introduced.

Peterson has discovered that, in dogs, the trigone of the bladder is supplied by the vesical arteries, and these must therefore be carefully preserved, as they have very little anastomosis with the arteries to the ureters. Boari's button cannot, of

course, be used. The reason why ascending infection does not occur is, that at the end of the ureters there is neither wound nor suture which could propagate infection (of coli bacilli, etc.) upwards, nor does the mouth of the ureter gape. No known method has succeeded in establishing a valvular or muscular closure, and operative endeavours to this end are rather injurious than useful.

It is a great improvement to isolate a portion of the intestine as a reservoir for the urine. If the pelvic colon can be pulled out sufficiently, it should be emptied and clamped as low down as possible (*vide* Fig. 402) and the afferent

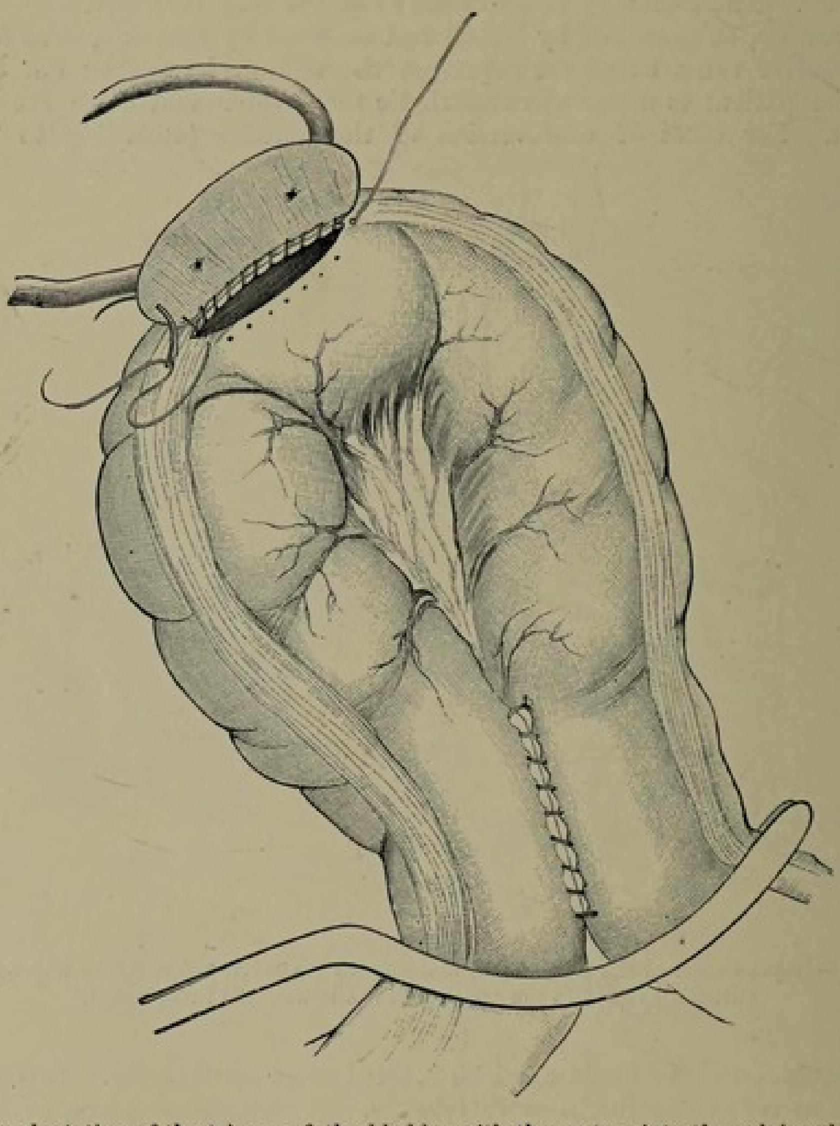


FIG. 402.—Implantation of the trigone of the bladder with the ureters into the pelvic colon, associated with entero-anastomosis. Stage 1: The figure shows the mucous membrane of the trigone with the orifices of the ureters united on one side with the bowel.

anastomosed directly to the efferent limb, after which the trigone is inserted into the summit of the loop (Fig. 402). End-to-side anastomosis is more certain, but is more difficult to perform than lateral anastomosis. In the former the afferent bowel is divided, its distal portion closed with an occlusion suture, and its proximal end inserted into the base of the efferent limb.

172. Extra-peritoneal Operations on the Ureter. (*a*) *Surgery of the Lumbo-renal portion.* To expose the ureter at its commencement, the oblique incision described for nephrotomy is used. It is employed in the form of pyelolithotomy already described to remove stones impacted in the upper part of the ureter, and as

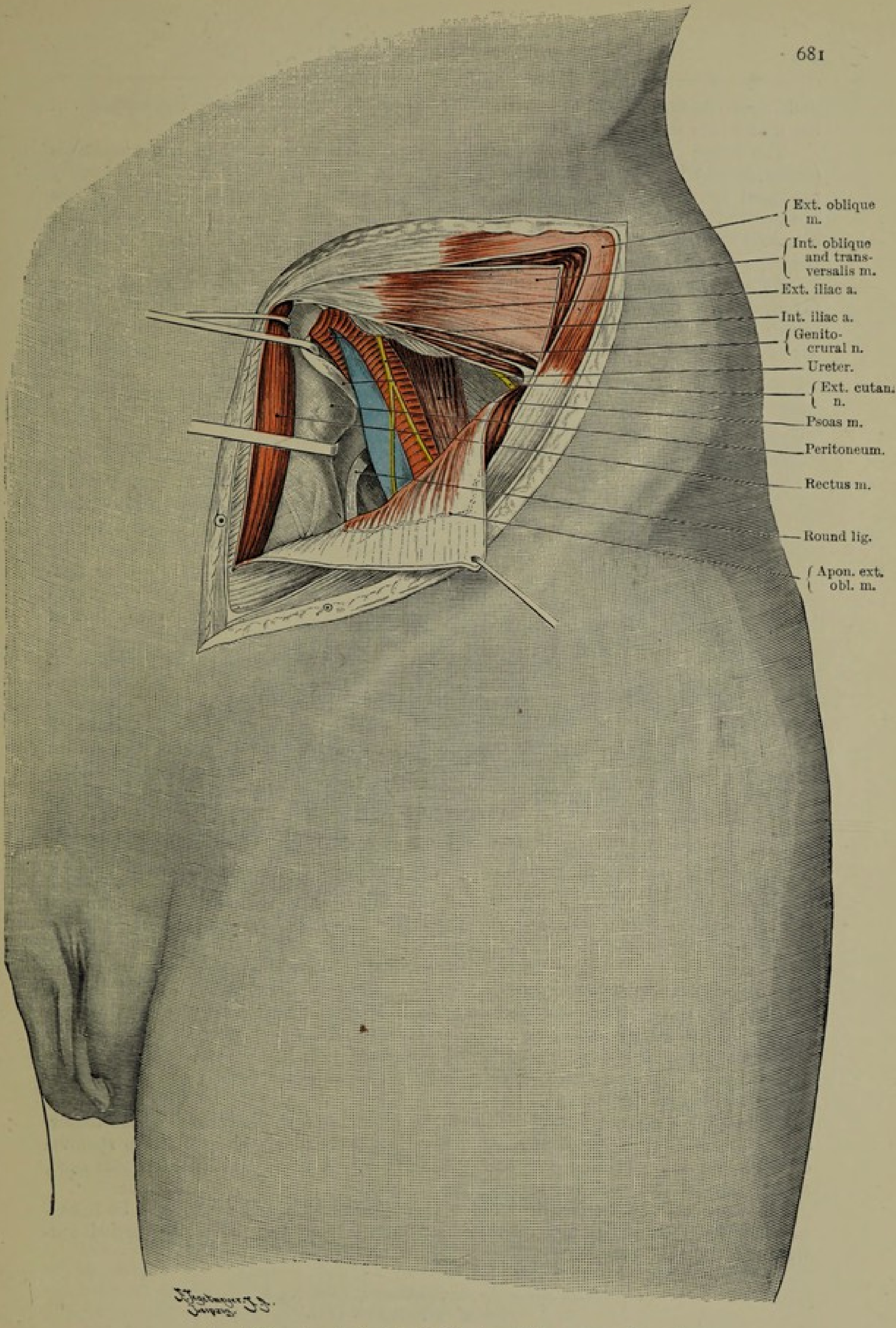


FIG. 403.—Angular incision for ligature of the common iliac artery. (Only a small part of the trunk of the artery is here represented.)

pyelo-ureterostomy, when there is a valvular constriction, or when the opening of the ureter into the pelvis is oblique.

The latter conditions may be either congenital or the result of hydronephrosis (uronephrosis). Donati has shown that when hydronephrosis is experimentally produced by tying the ureter, the renal parenchyma is rapidly destroyed and does not recover. When, therefore, the functional power of the kidney is found to be poor, one does not hesitate to excise the kidney, provided, of course, that the estimation of the capacity of the other one is satisfactory.

As an alternative an anastomosis may be made with a portion of the ureter favourable for the outflow of urine, followed possibly by excision of the sac, pyeloplication, or pyelostomy. A lateral anastomosis is made at the lowest point of the sac of the hydronephrosis (Küster), or the principle of Finney's gastroduodenostomy may be applied and the spur between the ureter and the sac divided in its whole extent down to the bottom of the sac, the edges being united by sutures (Trendelenburg).

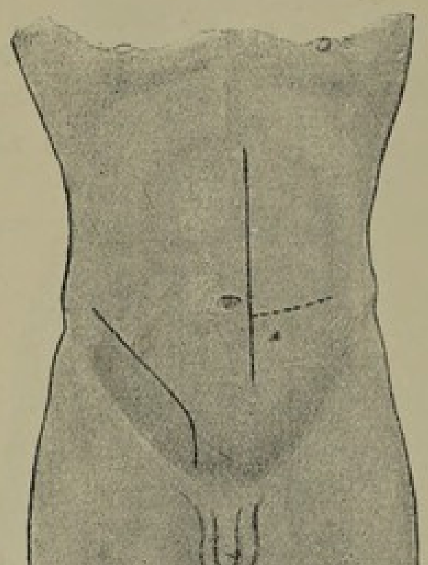


Fig. 404.—Mesial incision for transperitoneal nephrectomy (left). The incision on the right side is for ureterotomy (obliquely three fingers'-breadth above Poupart's ligament, terminating as a pararectal incision).

(*b*) *Operation on the Abdomino-pelvic portion of the Ureter.* The portion of the ureter, which crosses the bifurcation of the common iliac artery at the brim of the pelvis in its course to the bladder, can be exposed in its whole extent by an incision analogous to that described for ligature of the common iliac artery (*vide* Fig. 403 for the dissection and Fig. 404 for the line of incision).

The incision is made three fingers'-breadth above Poupart's ligament, obliquely downwards to the outer border of the rectus. The aponeurosis of the external oblique and the united fasciæ are divided at the border of the rectus. The muscles are split and the flap retracted downwards. The transversalis fascia and peritoneum can now be raised from the internal iliac fascia over the edge of the psoas towards the middle line.

The ureter is lifted off the great vessels along with the peritoneum. It is easily recognised and isolated; and can be followed downwards along the wall of the pelvis, and upwards on the posterior abdominal wall.

Fowler[1] has reported two cases in which calculi in the ureter were removed through the iliac incision. Morris collected 46 cases in 1899 and later on reported 16 more.

(*c*) *Operations at the Intra-mural and Intra-vesical end of the Ureter.* When a stone is impacted in the termination of the ureter, it is best removed by suprapubic cystotomy. A tumour, stricture, or a prolapse of the ureter in this situation should be dealt with in a similar way.

Young[2] has made a careful study of the anatomy of the lower end of the ureter, and has published a series of very interesting operations, chiefly for the removal of calculi impacted in the lower end of the ureter. A suprapubic incision was used, and the stones were removed through the bladder.

In these cases a transverse incision through the skin and fascia is to be recommended, for then the mesial incision between the recti can be easily carried outwards through the muscle.

[1] *Annals of Surgery*, Baltimore, 1903, No. 5.
[2] *Annals of Surgery*, Dec. 1904.

(m) To Expose the Bodies of the Lumbar Vertebræ

173. Lumbo-Vertebrotomy. We insert here the description of the operation for exposing the bodies of the lumbar vertebræ, as the region under consideration is the same as that for nephrotomy.

From the size of the lumbar vertebræ it is most common to find that circumscribed tuberculous foci here tend to give rise to abscesses, or to pain and disturbances of function without abscess, so that a speedy and thorough removal of the focus has, therefore, to be considered. The bodies of the lumbar vertebræ are exposed from the back in the following manner :—

A longitudinal incision is made towards the outer border of the prominence formed by the erector spinæ, and the lumbar aponeurosis is divided till the muscle fibres appear. In the upper part of the incision, fibres of the latissimus dorsi and serratus posticus inferior, which have their origin from the aponeurosis, are divided.

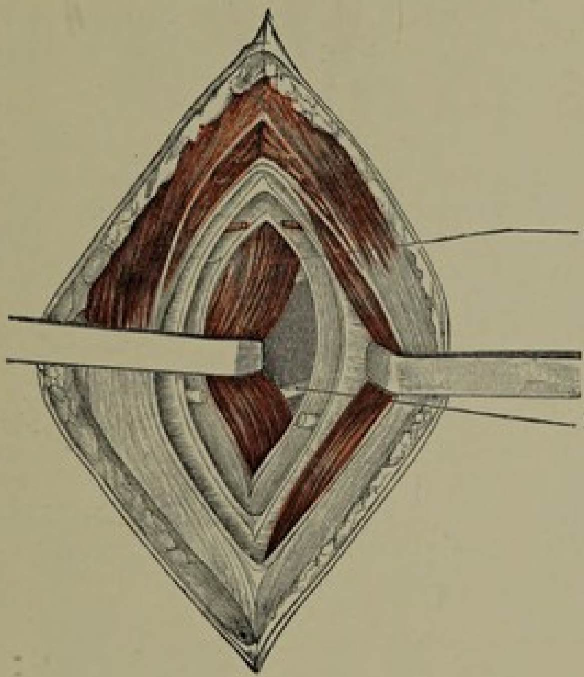


Fig. 405.

The erector spinæ is retracted towards the middle line. The deep layer of the lumbar aponeurosis is then divided and the quadratus lumborum exposed. The slips of this muscle are separated from the transverse processes of the vertebræ. In doing this the lumbar arteries and nerves, which run obliquely downwards beneath the quadratus, must be remembered. The origin of the psoas is then detached from the transverse processes, and the muscle raised from the lateral aspect of the vertebræ along with the fibres which take their origin therefrom.

(n) Surgery of the Bladder

174. High (Supapubic) Cystotomy. Opening the bladder above the symphysis is, as a rule, quite simple, but, in order to avoid the risk of opening into the peritoneum, or of bleeding from the bladder wall, and infiltration with urine from a defective outlet, certain rules must be followed out.

Introduced by Franco in 1556 it was formerly only exceptionally performed on account of the great danger of infection, it is now, although regarded as the normal

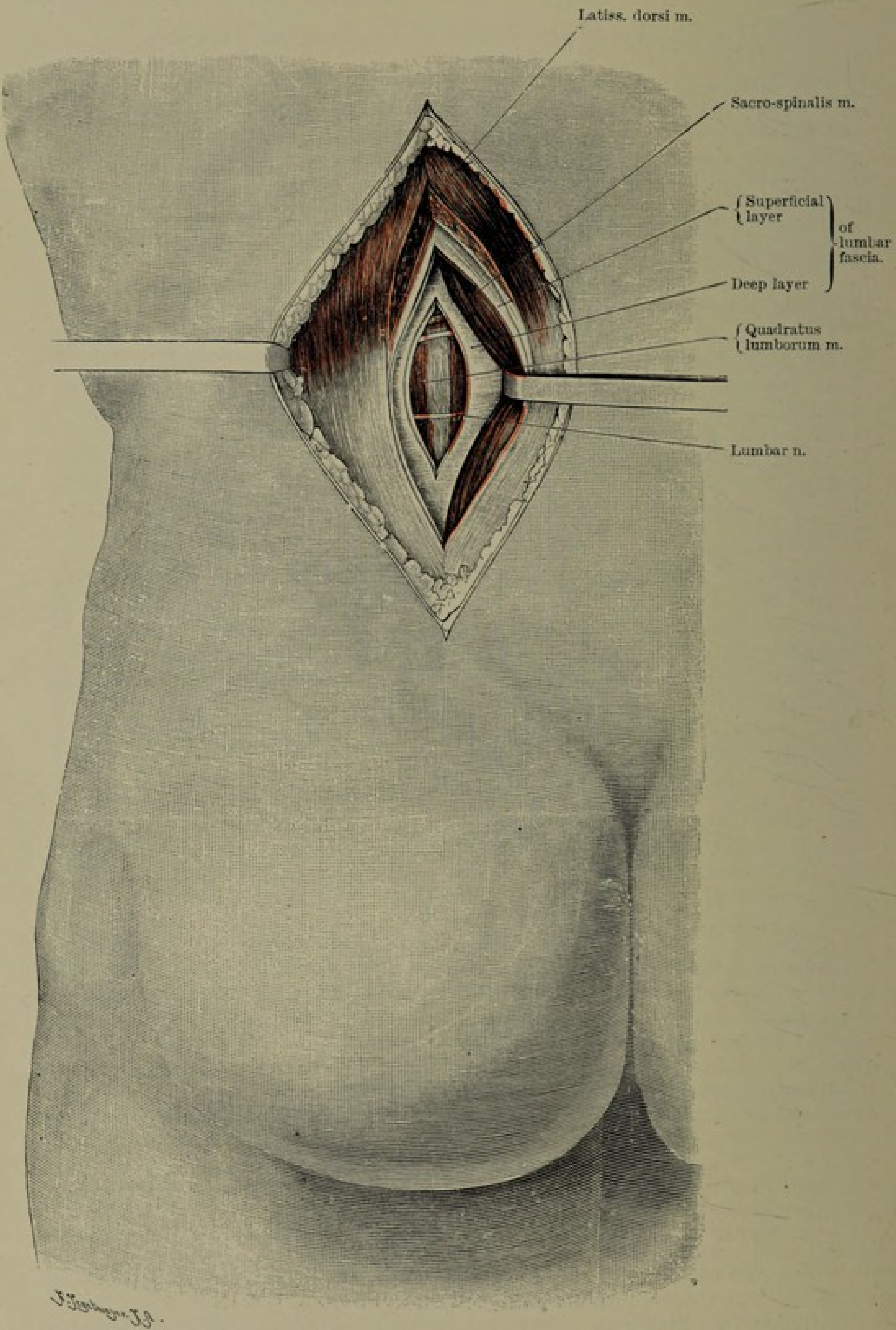

Latiss. dorsi m.
Sacro-spinalis m.
Superficial layer
Deep layer
of lumbar fascia.
Quadratus lumborum m.
Lumbar n.

Fig. 406.

method for removing foreign bodies and calculi, and for the treatment of ulcers, the extirpation of growths, and for repairing a tear in the bladder. We have learned how to avoid the dangers of infection with stagnation of urine and their results, which were formerly the main disadvantages of the method. As Fracassini[1] has shown, provided there is no infective process present, wounds of the bladder heal rapidly and well.

The operation may be quite well performed under local anæsthesia, if there are any objections to the employment of a general anæsthetic. Bier's lumbar anæsthesia is occasionally indicated and is often of value, especially if there are affections of the kidney or stomach associated with the bladder lesion. The bladder mucosa is particularly sensitive, and injury to it produces an intense desire to micturate, with pain referred to the penis.

The suprapubic incision in the case of a vesical calculus gives absolute certainty of complete removal, and offers the great advantage of primary union. On the other hand, for all cases in which the bladder must be left open and drained, the perineal opening is more satisfactory. The opening above the symphysis occasionally leaves a fistula, and, according to Auneau, the continual and often incomplete outflow from the bladder causes the patient constant annoyance.

The normal incision for sectio alta, also employed by Bardenheuer, is made, curved transversely from one inguinal ring to the other in the fold above the symphysis, through the skin and superficial fascia. A few symmetrical vertical veins in the skin must be ligatured. The fascia covering the recti is then divided and dissected upwards off the muscles, after which a vertical incision is made in the middle line and the attachments of the recti to the symphysis are in part divided, together with the pyramidalis muscles. Very convenient is the introduction of a strong ecarteur. The finger is now introduced behind the symphysis so as to draw upwards the thin fascia transversalis, the extra-peritoneal fat, and the reflexion of the peritoneum, which can either be seen or felt as a transverse fold or projection. By means of this manipulation, combined with elevation of the pelvis, forcible distension of the bladder, or of the rectum, as recommended by Peterson, is quite superfluous ; a process which is attended with a danger of rupture or injury. After thoroughly irrigating it with warm boric lotion, about 6 ounces of the lotion, or an equivalent of air, are injected into the bladder.

The smooth bluish-white bladder wall, covered with a thin layer of fatty tissue containing veins, is now exposed and is easily recognised by the longitudinal direction of its muscular fibres. A loop of silk is passed through the entire thickness of the muscular coat at the lowest part of the bladder which can be conveniently reached, a second loop being similarly passed through the muscular coat below the line of reflexion of the peritoneum. The introduction of these two fixation sutures greatly simplifies the subsequent suturing of the empty bladder. Dandolo inserts the fixation sutures laterally, but they then give no help in the subsequent introduction of the linear sutures.

The muscular coat of the bladder is divided vertically between the two fixation loops until the mucous membrane is seen to bulge forward in the form of a bluish vesicle. The bleeding having been arrested, the bladder is opened by plunging the knife through the bulging mucous membrane. The finger is introduced into the opening before all the fluid or air is allowed to escape. The edges of the mucous membrane must be immediately caught up with hooks or with a thread, after which the opening may be enlarged to suit the necessity of the case, for example, to admit of the removal of a calculus or a new growth, or of the mere inspection and digital exploration of the bladder. The mucous membrane, on account of its greater extensibility, does not require to be so freely divided as the muscular coat. The bladder is closed by a double row of silk sutures, of which the first row includes the mucous membrane only. The superficial one, also continuous, includes both the muscular coat and the superjacent cellular tissue.

Before inserting the second layer of sutures the wound is thoroughly irrigated,

[1] *Policlinico*, 1905.

the hands are purified and gloves are put on. A glass drain is placed between the bladder and the symphysis and left in position for eight days. After the fascia is united, the skin wound is closed.

Suture of the bladder is strongly recommended both by Rydygier and Hofmann. If the urine is healthy and there is no inflammation and ulceration, and no bruised or necrotic tissue has been left, the wound heals best and quickest. We regard silk as the only proper suture material; catgut does not resist the tension long enough as the bladder fills and empties. We agree with Rydygier that a continuous suture is much more reliable. According to Fracassini the mucous membrane heals rapidly underneath a sero-muscular suture.

As regards after-treatment, it is best to tie in a catheter (Nélaton) and syphon the contents of the bladder into a vessel containing carbolic lotion, all aseptic precautions being employed. Sometimes the systematic passage of a catheter is preferable, if spontaneous micturition is impossible, especially if the continued pressure of the catheter causes pain and catarrhal irritation.

In all cases where the bladder has been bruised or torn in removing a tumour, and where necrotic tissue is left, or still more in the presence of infective conditions such as cystitis and ulcer, no sutures must be inserted. The wound in the bladder as well as the external wound must be left open and treated throughout by the open method. In the latter case a longitudinal incision is preferable to a transverse one through the soft parts, as it brings the superficial and deep edges of the wound parallel.

The patient enjoys greater comfort if the wound is simply left open without any packing or drainage, and the escaping urine is caught in dressings, which are frequently changed. Patients on whom we had to operate more than once greatly appreciated this open method of treatment.

The wound is only to be packed when there is fear of bleeding, and it must be drained with a large drainage tube down to the bottom of the bladder (and cavity of the wound) if the urine tends to be retained in a pocket of the bladder.

175. High (Suprapubic) Cystostomy. Reginald Harrison and Poncet place great value on the formation of a vesical fistula above the pubis in certain affections of the bladder. It is especially indicated in all cases in which micturition is painful and difficult and where the passage of a catheter, whether temporary or continuous, occasions great discomfort. Intolerable pain is experienced under the ordinary treatment in cases of severe catarrh of the bladder with consecutive urethritis, whether it be primary, or as usual a secondary inflammation associated with tuberculous and other ulcers or with new growths of the bladder and affections of the prostate.

With regard to affections of the prostate and new growths, surgery has become frankly radical and ventures to aim at removal of the primary disease. In the presence of signs of severe inflammation it may be very desirable to perform cystostomy as a preliminary to a radical operation. Temporary cystostomy may also be required in the treatment of rupture of the urethra and its sequelæ, although perineal incision or possibly repeated puncture of the bladder are sufficient.

The technique of cystostomy is similar to that of cystotomy up to the point when the bladder is opened, but, as a rule, a mesial incision should be used and extended down to the symphysis. The pyramidalis muscles should be nicked on each side above the symphysis.

The preparation of the patient is of importance. It consists in the internal administration of urinary antiseptics, *e.g.* urotropin, helmitol, and vesipyrin (30 gr. per diem) recommended by Hofmann, in washing out the bladder, and even the preliminary injection of a strong solution of silver nitrate (1 per cent).

The after-treatment is also very important. Poncet and Delorme hold that by suturing the edges of the bladder to the skin, infiltration of the surrounding tissues with urine is most effectively prevented. This, however, only affords partial protection, for the wound round about is already infected, and the stitches are likely to hinder discharge escaping from the paravesical tissue.

It is better either to insert a large drainage tube down to the bottom of the bladder, and pack the external wound all round it with antiseptic (xeroform or vioform) gauze till the risk of sepsis is past, or else stitch a tube into the bladder in a "watertight" manner and syphon off the contents, either leaving the wound round the tube open, or packing it with gauze if there is a tendency to the formation of pockets.

176. Cystectomy, Total and Partial. (*a*) *Resectio Vesicæ.* Partial resection of the bladder is undertaken in the majority of cases for tumours. No general description of the technique is required as the operation varies so much according to the position of the tumour. As long as sufficient healthy bladder can be preserved in continuity with the trigone and urethra to form a new bladder, the method of procedure can be deduced from what has been already described (*vide* Surgery of the Ureters).

One or even both ureters may be excised at the same time, and, as Krönig's experience has shown,[1] if a sufficient extent of the bladder is preserved, both ureters may, by following definite rules, be successfully implanted into a newly-formed bladder cavity. If the amount of bladder left is not large enough to allow of the ureter being implanted into it, or if the latter operation is too difficult, provided one ureter is not interfered with, the other may be implanted into it by an end-to-side anastomosis: the invagination method described above, for uniting the renal and vesical ends, cannot, of course, be used.

One point in particular which deserves further attention in the case of an extensive resection of the bladder is the selection of a method which will give sufficient room to allow of the bladder being securely stitched and at the same time enable one to implant the ureters in the reduced bladder cavity.

In order to get better access to the bladder, the suprapubic incision has been prolonged downwards with resection of the symphysis. Niehans has attempted unilateral resection of the symphysis, while Helferich excised subperiosteally a triangular portion (the base upwards). Brahmann turns up a similar wedge leaving it in connection with the recti and pyramidalis, and afterwards fixes it again in position as an osteoplastic flap. Heussner has proposed to chisel through the pubis on both sides.

Manz[2] has lately recommended an osteoplastic resection of the symphysis pubis, which gives very good access with moderate damage. He takes advantage of the simplicity and security afforded by the use of Gigli's wire saw in dividing the pubis. Through an incision extending from one pubic spine to the other, he carefully separates the root of the penis from the pubis, and divides subperiosteally the descending ramus of the pubis with the wire saw as far as the mid-point of the obturator foramen. The horizontal pubic ramus is then dealt with in the same way. Care must be taken in making the skin incision to avoid the spermatic cord, and in separating the periosteum and dividing the bone the dorsal vessels of the penis and the obturator vessels and nerves must not be injured.

The flap is turned up along with the recti and pyramidalis muscles, and, after the operation is completed, is replaced and fixed accurately in position.

One has to decide in each individual case whether resection of the symphysis is unavoidably necessary for excision of a tumour of the bladder. As a rule it is possible to get satisfactory access to the bladder as far as the prostate by a suitable abdominal incision with section of the pyramidales and the use of a strong retractor; the operation can in any case then be carried out extraperitoneally by packing off the peritoneum or even by turning it back and temporarily closing it with sutures.

Berg has devised a radical operation for malignant growths of the bladder analogous to Wertheim's operation for carcinoma uteri. Laparotomy is performed and the peritoneum divided behind the bladder so as to allow of the lymphatic vessels and glands lying along the internal iliac artery being removed. The wound is then drained from the perineum or vagina and the peritoneum is closed above.

[1] Matthias (*Beitr. z. klin. Chir.* Bd. 42) has described two cases of carcinoma of the bladder successfully treated by Mikulicz in this way by cystoneostomy of one ureter.

[2] *Centralbl. f. Chir.*, 1904, No. 15.

(*b*) *Total Excision of the Bladder.* F. S. Watson[1] has published the results of the operative treatment of bladder tumours in 653 cases,[2] including those reported by Albarran. Of these, 410 were malignant. The mortality in 91 malignant cases in which partial resection was performed was 18·6 per cent; in 222 cases, in which the tumour was removed by suprapubic operation without resection, the mortality was 28 per cent; while in 25 cases in which total extirpation of the bladder was performed for cancer, it was 56 per cent. Of the cases of carcinoma operated on, 10 per cent remained free from recurrence after three years, which corresponds precisely with the percentage in the case of papillomata. The worst results as regards mortality and recurrence occurred in sarcoma and myxoma.

Technique of Suprapubic Total Excision (*according to Watson's description*). Laparotomy by a mesial incision. The peritoneum covering the bladder is split in the sagittal plane from front to back in its whole extent (adherent portions must be removed with the bladder), and separated by blunt dissection as far as the entrance of the ureters. The latter are then ligatured and divided. If the prostate and seminal vesicles are involved, they must always be removed.

The urethra is then transfixed from behind forwards with a curved needle at the junction of its prostatic and membranous portions, and the ligature tied on both sides. It is again transfixed and ligatured a little higher up, after which it is divided between the ligatures, and the bladder and prostate are removed. The hæmorrhage is arrested, the peritoneum stitched, the laparotomy wound is completely closed, and perineal drainage employed.

Combined Method. Watson recommends a combined method (analogous to the combined method previously described of excision of the rectum) especially for those cases in which the prostate and seminal vesicles are to be removed at the same time. In it the prostate and seminal vesicles are first separated through a wound in the perineum, and then laparotomy is performed as described above.

The most important point in connection with total excision of the bladder is the method of dealing with the ureters. In regard to this, Watson takes up a very definite position. He does not attempt any form of ureteral implantation, as it is to this cause that the mortality is attributable. He performs lumbar nephrostomy instead some time (four to six weeks) before. In this way the second operation is shortened, and the danger of retention of urine, ascending infection of the kidneys and infiltration of urine into the peritoneum is avoided.

Watson gives a table showing the results of implantation of the ureters in 114 such cases. The death-rate due to the ureteral implantation was 44·6 per cent, whereas in 979 cases in which nephrostomy was performed, the mortality was only 15 per cent; these include 626 cases collected by Schmieden. Nephrostomy should not be performed on both sides simultaneously, but an interval should elapse between the two operations.

The simplest form of nephrostomy consists in pyelostomy, either by stitching the edges of the opening in the renal pelvis to the skin, or by inserting a drainage tube into it, and stitching it in position. The ureter is ligatured and cut across close to the pelvis of the kidney. Even when the nephrostomy is performed through an incision in the kidney substance, and a drainage tube is inserted to keep the wound in the latter open, it is very well borne and functions for years without any trouble.

Another method is that proposed by Goldenberg.[3] Goldenberg, as a result of operations on dogs, recommends implanting the ureters into a loop of the lower ileum, which is then closed, and sutured to the abdominal wall where it is opened.

[1] *Annals of Surgery*, Dec. 1905.

[2] *Vide* also Rafin, Assoc. française d'urologie, Oct. 1905.

[3] A loop of ileum might first of all be isolated, as in Roux's œsophago-jejuno-gastrostomy, by resecting a portion lower down, preserving its blood-supply, and implanting it under the skin of the anterior abdominal wall down as far as the scrotum or under the skin of the penis, or by keeping both ends open by stitching them to the skin, the oral end above, and the anal end below. At the main operation the ureters would be brought into this open receptacle, which has been thoroughly cleansed, and which by peristalsis carries the urine downwards, where it could be caught at the scrotum or penis in a receptacle.

Arnold Schwytzer[1] has performed one complete extirpation of the bladder by the combined method, and inserted the ureters into the rectum. He comes to the conclusion, however, that it is best to follow M'Cosh's plan and simply conduct the ureters into the subperitoneal space left by the removal of the bladder, and collect the escaping urine in a receptacle. It is not improbable that in men the false bladder would empty into the urethra, as occurs after excision of the prostate.[2]

177. Perineal Cystotomy. The perineal route used to be the favourite one for opening the bladder, especially for the removal of stones. Before measures for keeping the wound aseptic were known, chief attention was given to mechanical considerations, viz. the drainage of urine from the open bladder, and the discharge from the wound; as primary union was out of the question, there was no advantage in being able to see clearly either to suture the bladder or to close the wound in layers.

In the old days perineal lithotomy was a very simple operation. The lateral operation in the hands of expert surgeons lasted only a few minutes and was performed in three steps: (1) Opening of the membranous urethra by cutting down on to a grooved staff; (2) Division of the prostatic urethra and base of the bladder together with the prostate in a backward and outward direction with a probe-pointed knife; (3) Passage of lithotomy forceps into the bladder and extraction of the stone. A drainage tube surrounded by a tampon was inserted into the bladder and the intervening space packed with gauze so as to check any bleeding.

Cunningham's collection of cases in 1887 shows how good the results were even in the days when aseptic methods were but little developed; of 7201 cases of perineal lithotomy only 11 per cent died (42 per cent in 147 suprapubic). White also records a mortality of 3 per cent from the perineal and 12 per cent from the suprapubic operation in children. This is now entirely changed and the perineal operation is rarely employed. It is only used in cases where there are severe disturbances in the bladder, and where everything depends on obtaining rapid and safe drainage and also where stones are lying in diverticula at the back of the bladder.

(o) Surgery of the Prostate and Urethra

178. General Remarks. Although the prostate properly belongs to the reproductive system, it is so intimately connected with the bladder and urethra that it is better to consider its surgery here. Further, it gives rise to urinary disturbances much more than to disturbances of the reproductive functions.

Now that it has been proved that prostatectomy affords a radical and safe cure in patients suffering from enlargement of the gland, the surgery of the prostate has in recent years received a great impulse. Such an abundant literature has accordingly sprung up that the attempt to cover even the most important works on the subject would overstep the limits of a text-book. We will, therefore, only consider the conclusions arrived at by numerous discussions and describe the operative technique which at the present time is most to be recommended.

In addition to hypertrophy, surgical interference has to be considered in other affections of the prostate, *e.g.* in malignant disease, especially in its commonest form, carcinoma, or in tuberculosis and prostatic abscess. Tuberculous disease of the prostate is usually combined with a similar affection of the seminal vesicles.

179. Prostatectomy.[3] This operation is called for when the enlargement of the

[1] *St. Paul's Med. Journal*, 1905.

[2] Instead of a false bladder bounded merely by the surfaces of the wound, the isolation and transposition of a loop of ileum into the position of the bladder might here be considered. After shutting off the peritoneum above, the loop might be simply left open above and below and the ureters placed in the upper oral end, the peristalsis being left to carry the urine into the open membranous portion.

[3] According to Watson, Leroy d'Etiolles performed the first prostatotomy in 1832, and Billroth and Dittel performed the first total prostatectomy. American surgeons were the first to employ it generally. The perineal method is associated with the names of Gouley, Goodfellow, Murphy, Nicoll, White, Carpenter, and M'Lean, the transvesical with the names of M'Gill and Delafield, Watson, Fowler, Guiteras, Fuller, and Young. In England, Reginald Harrison and before all Freyer have brought the transvesical method into great prominence. In Germany, Czerny and Mikulicz employed perineal

gland gives rise to retention of urine, a symptom which is generally the first to attract the patient's attention. Of course the paradoxic type of frequent micturition is often present. It is not justifiable to operate merely because the prostate is hypertrophied without there being any disturbance of urination. But, on the other hand, the indications for operation are clear in all cases where the patient has otherwise before him the inconveniences and ultimate fate of a catheter life.

There are, of course, cases in which it is advisable not to operate, as, for example, when complications exist which would involve risk to life in the event of operation being undertaken. Certain complications, as, for example, local inflammatory conditions with fever, will yield to operative interference. In these cases, however, it is often better simply to drain the bladder (cystostomy) first of all, and delay the radical operation for some time.

Associated disease in other organs must of course be regarded as a contraindication. The general condition of every patient must therefore be taken into account and considered according to the rules given in the introduction. According to Legueu, particular attention must be paid to the condition of the kidneys, for Watson has shown that one-third of the cases in which kidney complications are present succumb to operation. If associated with bladder trouble, they are not always easy to recognise.

The most remarkable fact which the extensive employment of prostatectomy has revealed is, that one can remove the prostatic portion of the urethra in whole or part together with the prostate, without producing any real impairment of the function of the bladder. This is largely contrary to our notions regarding the sphincter-action of the bladder, and seems to show that continence of urine depends much more, or even essentially, on the preservation of the musculature of the membranous urethra, rather than on the so-called neck of the bladder.[1]

Legueu gives an extremely instructive description of the results 1½ months after prostatectomy by Freyer's method.[2] The cavity left by the removal of the prostate forms a simple smooth dependent pocket of the bladder and opens with smooth edges into the shortened urethra.[3]

The development of the technique of prostatectomy as illustrated by the numerous discussions in the surgical societies of all countries forms an interesting study terminating in the present view that the intravesical operation, called after Freyer, is to be preferred to the perineal.[4] Experience has taught the strongest adherents of the latter operation to appreciate the advantages of the high operation. Experience has also shown that, as a rule, prostatectomy takes the form of enucleation not of extirpation with the knife, the latter being only necessary in dealing with malignant growths.

Since this point has been realised, the technique of the intravesical operation has been greatly improved, and the mortality which was formerly much higher than after the perineal operation has been reduced to proper proportions. What necessarily brought the majority of surgeons to adopt the transvesical method is the great simplicity of the operation, and still more the certainty of the result as regards normal evacuation of urine, with preservation of the reproductive function, since the vasa deferentia and seminal vesicles remain intact.

(*a*) *Transvesical Enucleation of the Prostate.* This operation, first practised by

prostatectomy most commonly. Kümmel and Rydygier have given an account of their own operations of intracapsular resection. French surgeons, Proust, Hartmann, Tuffier, Legueu, and, most of all, Albarran, have accurately described the technique of the perineal method.

[1] This supports Finger's view that the function of the compressor urethræ is to retain the urine, though Leedham Green has shown that it is not true that the prostatic portion is filled with urine when the bladder is full (*Brit. Med. Journ.*, Aug. 1906).

[2] Freyer has contributed two and Verhoogen one post-mortem report.

[3] Fig. 407 shows the truth of Schwytzer's and M'Cosh's statement, that in the case of a total excision of the bladder, the ureters open simply into the cavity left, and the urine is discharged per urethram ; cf. chapter on Total Excision of the Bladder.

[4] The French surgeons, Albarran, Hartmann, Tuffier, Proust, Legueu, and others who were formerly ardent supporters of the perineal method, have now resorted to the intravesical method, especially Hartmann, Proust, and above all, Legueu.

McGill, but called after Freyer, its most zealous exponent, is performed as follows[1] :—

The bladder is opened according to the rules laid down for suprapubic cystotomy (*vide supra*). It is first thoroughly washed out and partly filled with warm boracic lotion. The patient is placed in the Trendelenburg position, the bladder exposed through a mesial incision and steadied, while a longitudinal incision is made into it. The edges of the bladder wound are grasped and the interior swabbed out.

With the finger-nail, blunt dissector, or the knife, the mucous membrane is

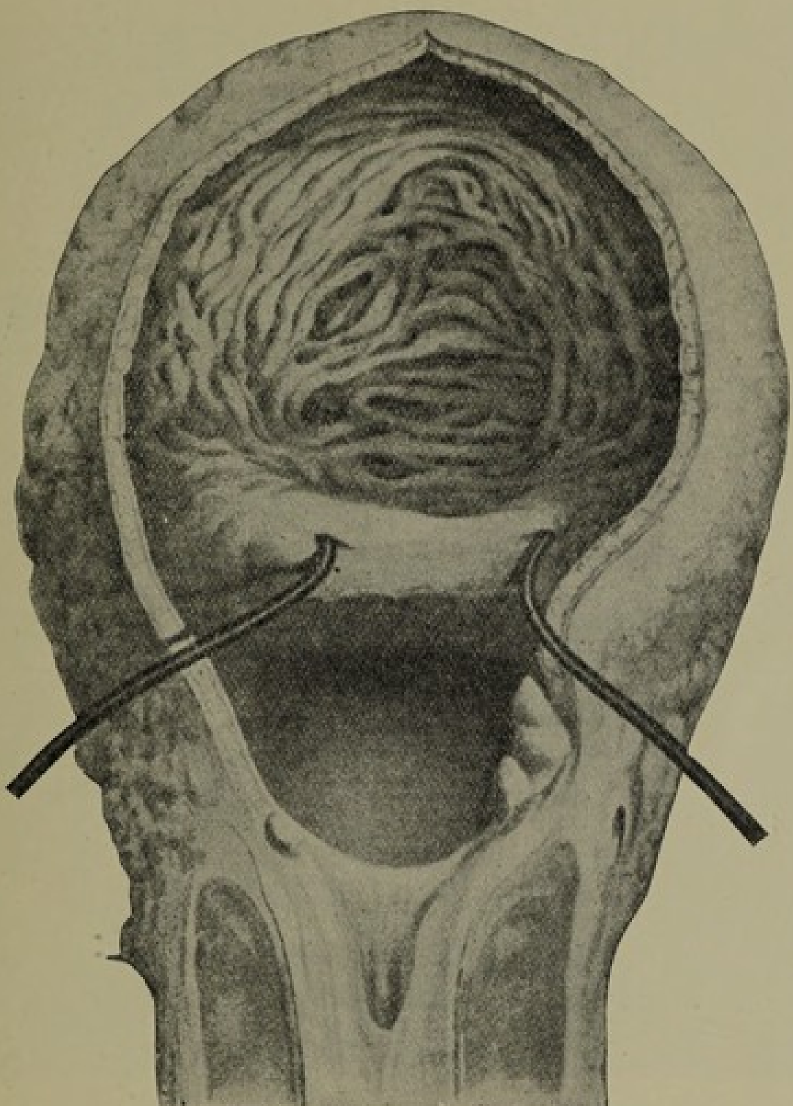


Fig. 407.

torn or cut through immediately behind the internal orifice of the urethra, while at the same time the prostate is forcibly pushed upwards by the fingers of an assistant or of the operator's left hand in the rectum. Guiteras grasps it from above with bullet-forceps. The finger is now insinuated under the mucous membrane on the posterior aspect of the prostate between the capsule and the sheath, and the latter is separated from the whole of the posterior surface as far as the ejaculatory ducts and vas deferens. By gradually burrowing under the prostate the hypertrophied mass can either be detached from the urethra or if it is too firmly adherent

[1] The description follows that of Legueu, with whose kind permission we reproduce the figures from his report read at the 15th International Congress at Lisbon in 1906.

it can be removed along with the portion of the urethra containing the colliculus seminalis, by division of the membranous urethra.[1]

The after-treatment of the wound is as important as the preparation. Freyer passes a large tube ($\frac{3}{4}$ of an inch in diameter) down to the base of the bladder, through which irrigation with a weak antiseptic is carried out, the dressings being frequently changed. The tube is taken out after four or five days, and irrigation is then practised through the urethra. In the case of a septic bladder, careful preliminary treatment is of more importance than the formation of a perineal drain, as Fuller and Israel recommend. Direct drainage of the prostatic space is restricted

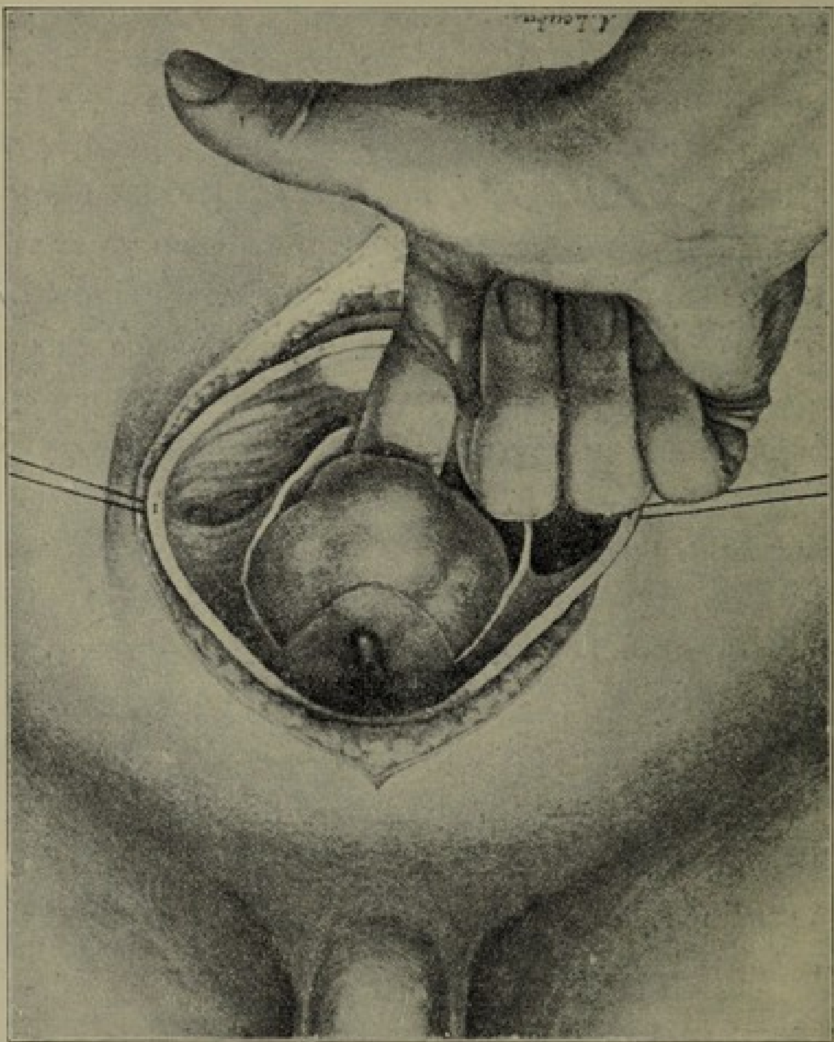


FIG. 408.—Transvesical enucleation of prostate (Legueu). The mucous membrane behind the internal urinary meatus is incised and the posterior surface of the prostate freed by pushing the finger between the capsule and the sheath.

to cases where there is a high degree of urinary decomposition, and in these cases it is probable that the perineal operation would be better.

Legueu checks the bleeding by packing the cavity left by the removal of the prostate with gauze soaked in peroxide of hydrogen, and inserts a double tube, after the Guyon-Perier pattern, through which the bladder is syphoned and irrigated. The gauze is left in for four days.[2]

[1] White (*Annals of Surgery*, Dec. 1904) regards suprapubic total enucleation without injury to the urethra as the only correct operation.

[2] Thomson (*Brit. Med. Journ.*, July 1906) employs calcium chloride as a prophylactic against bleeding. We consider the very efficacious "Klysmen" with 2 per cent gelatine solution (to 200 g.) still more valuable.

The retention is always relieved and natural evacuation of urine commences in the second or third week. Very rarely does a fistula form. This, however, does not apply to partial prostatectomy which Rovsing recommends in cases where the middle lobe is especially prominent. The results of partial prostatectomy are no better than those obtained by Bottini's operation, which is still approved by Freudenberg, Jaffé, Giordano, and others.

(*b*) *Perineal Prostatectomy*. This was the earliest form in which prostatectomy was performed. It is now restricted to cases which are unsuitable for enucleation, *i.e.* diffuse, hard, and comparatively small prostates, the removal of which has to be carried out with the knife instead of by blunt dissection. It is also employed

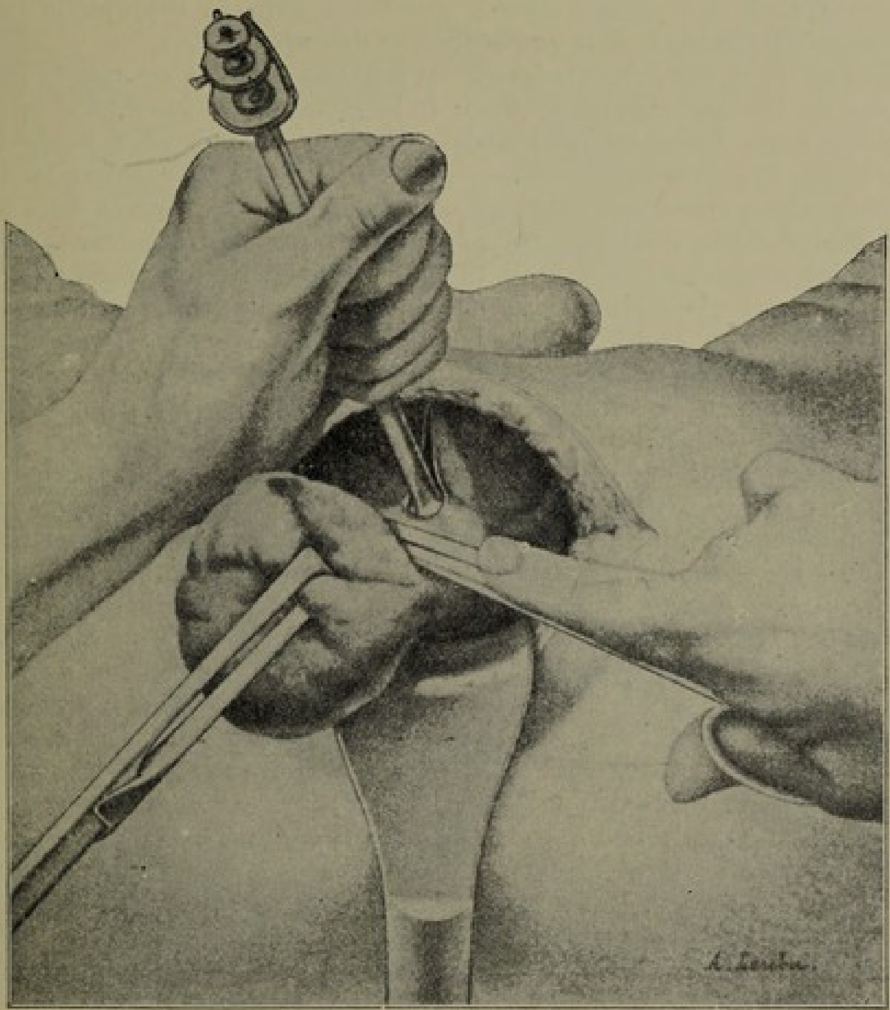


Fig. 409.—Perineal prostatectomy (Legueu). The prostatic tractor, which has been inserted into the bladder through an incision in the urethra, forcibly depresses the floor of the bladder.

in cases where the general condition of the patient is not good, and where there are marked changes in the bladder accompanied by fever. In such cases one has often to consider whether it would not be better merely to treat the urgent symptoms in the first instance and drain the bladder.

If there is a doubt whether prostatectomy is feasible, the perineal operation is the more suitable, as it is attended with less danger. Although the prognosis as regards mortality is better, Legueu, who collected the cases reported by Watson, Escat, and Proust, has shown that in 1026 cases [1] a fatal issue occurred in 9 per cent.

[1] The causes of death after prostatectomy are fully considered in a paper by Teuney and Chase (*Journ. of American Med. Assoc.*, May 1906). Uræmia is the most frequent, then hæmorrhage and pneumonia. The authors emphasise the great importance of the preliminary and after treatment and the necessity of letting the patient up early.

When enucleation from below is impossible and the gland has to be removed with sharp instruments, in addition to loss of sexual function the rectum is liable to be injured, an accident which may lead to the formation of a fæcal and urinary fistula. It is in this class of case especially that the perineal method is useful. If we follow Young and Rydygier's advice and employ the perineal method in cases that are suitable for enucleation, two lateral incisions are made, and then the lobes are reached and removed by forcible blunt dissection, the above disadvantage being thus avoided.

The last objection to the perineal operation, viz., that incontinence of urine often results, is removed if the enucleation is performed only through an incision in the sheath. Incontinence occurs when the membranous urethra has been injured. The musculature of this portion is not interfered with in suprapubic enucleation, and thus closure of the bladder is guaranteed as described above.

Technique of Perineal Prostatectomy. When the perineal operation is employed in preference to the transvesical method, it is essential to have good access. The mesial incision must therefore be abandoned. This applies all the more to those cases where the hypertrophy is diffuse and firm, where the gland is difficult to enucleate, and where there is a suspicion of malignancy. According to Young[1] one-seventh of the prostatic enlargements in men over fifty are cancerous. The cancer may remain intracapsular for a long time, grows slowly, and rarely gives rise to local metastasis and glandular disease. Good access in these suspicious cases is essential if a thorough excision is to be performed. We agree with Zückerkandl and adhere to the incision we described in the first edition of this text-book. Albarran and Watson use a similar incision, while in malignant cases Young uses a V-shaped incision.

As in the suprapubic operation, perineal prostatectomy may be performed under local anæsthesia (Tinker) with a very short administration of a general anæsthesia. Novocain and adrenalin are injected in front of and internal to the tuber ischii. The adrenalin limits the bleeding. A curved incision is carried from one ischial tuberosity to the other, its convexity reaching forwards to the lower border of the pubic symphysis (Fig. 410). After division of the skin and thin superficial fascia, the incision comes down laterally upon the fatty tissue which is continued upwards into the ischio-rectal fossæ between the pelvis and the rectum. This fatty tissue is now dissected through as far as the under surface of the levator ani, the fibres of which extend from before backwards and from without inwards towards the rectum. By this means the inferior hæmorrhoidal vessels and nerve situated posteriorly, and the transverse perineal vessels and nerve, the artery and nerve to the bulb, and the transverse superficial perineal muscles, all situated anteriorly, are pushed forwards and drawn out of the way. The bulb of the urethra, and the muscular fibres of the accelerator urinæ, which extend forwards and outwards from either side of the median raphe, are exposed at the anterior part of the wound. The fibres of the transverse perineal muscles extend from the posterior end of the bulb outwards towards the ascending ramus of the ischium. The fibres which connect the external sphincter ani, the accelerator urinæ, and deeper, the recto-urethralis muscle (Roux), at the central point of the perineum are divided transversely close to the bulb, which is then drawn forward along with the transversus perinei. By cutting transversely and more deeply towards the posterior surface of the bulb, we expose the posterior fibres of the compressor urethræ muscle, which covers the under surface of the membranous urethra. Above this muscle is the prostate, which is covered on its postero-inferior surface by a dense layer of connective tissue (part of the capsule of the prostate, derived from the pelvic fascia) containing non-striped muscular fibres. This layer must be drawn downwards and divided transversely, the smooth posterior surface of the prostate being thereby exposed, so that the finger can now be pushed upwards upon it as far as its upper border. The vasa deferentia may be easily recognised still deeper, converging downwards and forwards (Fig. 411). Lying immediately outside these are the vesiculæ seminales, which may be dissected out with a blunt instrument.

[1] *Journ. of American Med. Assoc.*, March 1906.

By drawing backwards the rectum with a long blunt hook, a layer of connective tissue with fibres of the levator ani is put on the stretch upon either side.

The subsequent steps of the operation vary. Those surgeons who prefer the perineal method even for enucleation, divide the sheath laterally (Nicoll, Pyle, Young, and Rydygier), grasp it with forceps, and then remove first the lateral lobes and then the middle lobe, generally without dividing the prostatic urethra, sometimes dividing it as is the practice of Albarran and Watson.

Here again the difference between enucleation and excision of the prostate must be stated. The conditions are analogous to those of colloid goitres. One may either excise, *i.e.* remove the gland which is compressed and atrophied in places

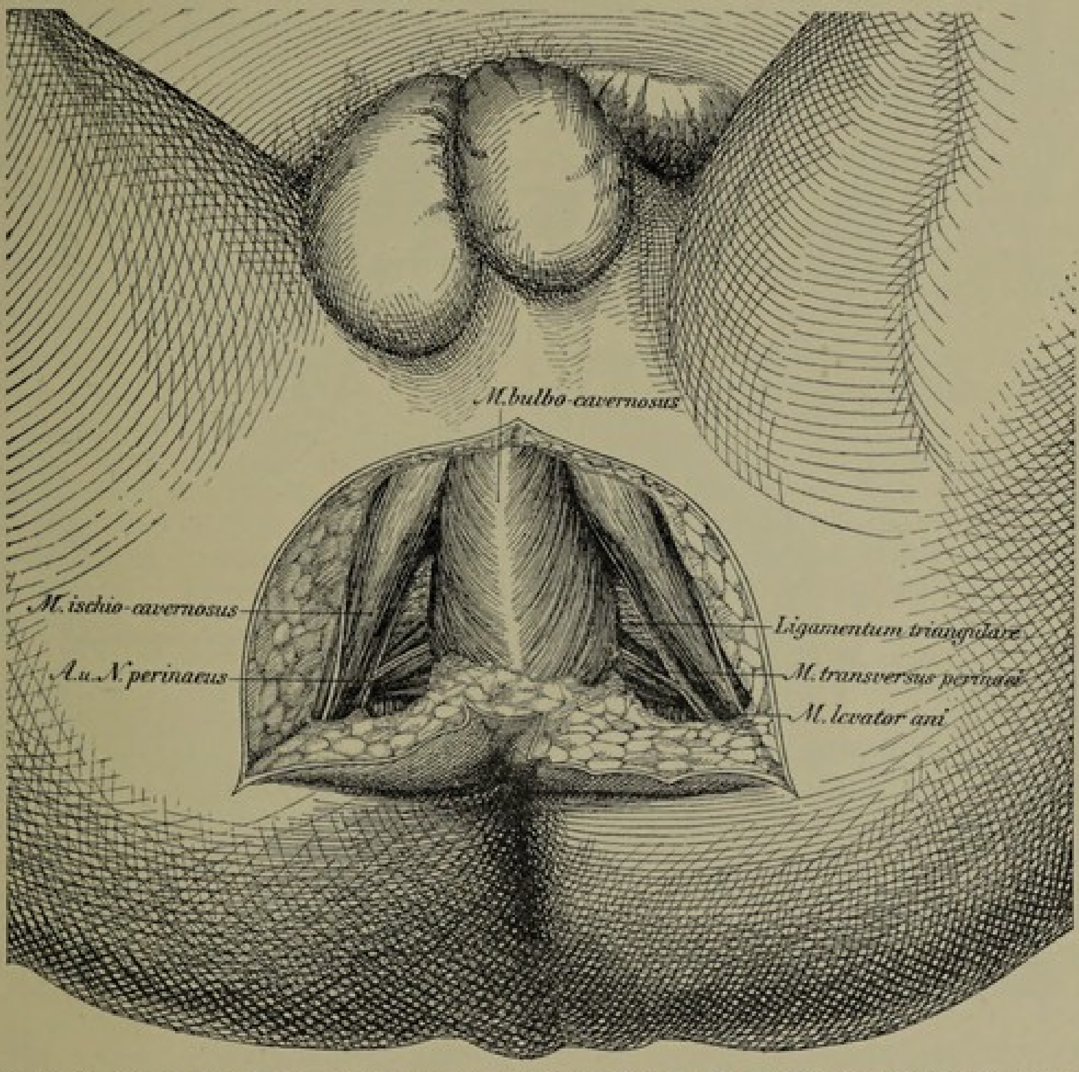


FIG. 410.—Dissection to expose the prostate, seminal vesicles and vasa deferentia through a curved incision in the perineum.

by the development of the colloid masses, and which is spread out over the latter like a capsule, merely leaving the connective tissue, the outer capsule, as is done in our intracapsular excision. Or the masses may be shelled out not merely from the outer capsule, but also from the inner, the gland capsule being left behind (as Burkhardt has shown) *i.e.* enucleation is performed.

The removal of the adenomatous masses of the prostate by blunt dissection should also be called enucleation. For as Legueu emphatically states "every prostatectomy is incomplete" in so far as the prostate is left behind. Examination of the preparations made by him and also by Motz, shows that prostatic tissue is always left behind like a glandular capsule, after removal by blunt dissection. It is often atrophic and compressed by the new formation of the nodules.

In cases in which the prostate might be easily enucleated by the suprapubic method, but in which for some reason the operator prefers to employ the perineal route, the technique of the operation after exposing the prostate and retracting the rectum with a broad retractor, is usually the following :—

The urethra is opened on a grooved staff as near to the prostate as possible (avoiding the compressor urethræ). A finger is pushed into the bladder to determine the length of the prostate and whether there is a middle lobe. Young's instrument or Legueu's " desenclaveur " is inserted through the opening, and the floor of the bladder

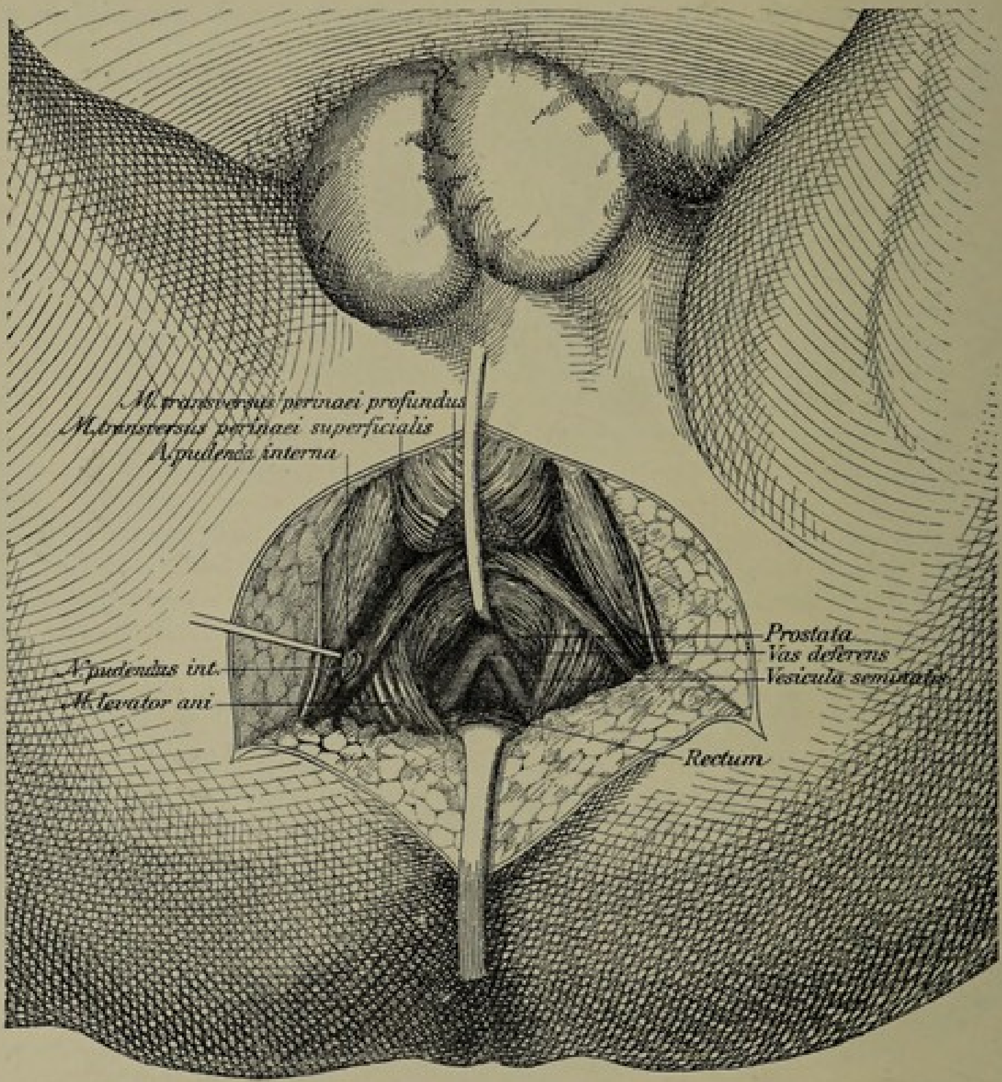


FIG. 411.—Dissection to expose the prostate, seminal vesicles and vasa deferentia through a curved incision in the perineum.

is pressed firmly downwards. The prostatic urethra (Albarran and Watson) is divided in the middle line as far as the neck of the bladder.

If, contrary to expectation, it is found that the prostate can be enucleated from the incision in the urethra, one proceeds to remove it by blunt dissection with the finger or dissector, possibly even pulling out the nodules with Museux's forceps. If it is found that enucleation is impossible, or if there is a suspicion of malignant growth one proceeds to a real total excision of the prostate.

(c) *Real Total Excision of the Prostate.* Young[1] describes the following method for carcinoma of the prostate. After insertion of the instrument for depressing the floor of the bladder, the gland along with the seminal vesicles

[1] *Bulletin of Johns Hopkins Hospital*, October 1905.

is separated behind from the rectum, Denonvillier's fascia being removed along with it.

The membranous urethra is cut across and the puboprostatic ligaments are divided. The prostate is then freed laterally, the bladder pulled well forward, and incised behind the prostate, so that we expose the trigone and orifices of the ureters. The bladder is divided transversly 1 cm. in front of these, after which the seminal vesicles, glands, and the vasa deferentia are separated (high up) and cut across.

Young states that it is easy to suture the membranous urethra to the bladder, and to close the latter in a sagittal direction. After uniting the edges of the levator we partly close the skin wound, insert a tampon down to the site of suture and maintain a catheter in the bladder for some time.

180. External Urethrotomy with Excision and a Plastic Operation. If it is desired simply to expose the urethra, a short mesial incision is all that is required, the so-called raphe-incision. It inflicts much less damage than a lateral incision which involves branches of the internal pudic artery and nerve as they run towards the middle line (inferior hæmorrhoidals, perineal arteries, and the artery to the bulb).

This is the principal operation performed on the perineum for diseases in the region of the urinary passages, as it often suffices to give the necessary access in cases of bladder disease. The operation is performed for relapsing stricture, for strictures complicated by fistulæ and abscesses, and in cases which are combined with infection and infiltration of urine.

Reginald Harrison reports cases in which rigors and other threatening symptoms following internal treatment of a stricture immediately disappeared when external division was performed.

The operation is also indicated in dense and impermeable strictures, especially those of traumatic origin. These require either simple external division, or excision of the narrowed portion along with the surrounding cicatricial tissue, which forms a fibrous mass in the corpus spongiosum. Harrison points out that, in cases of rupture of the urethra, division of the canal from without lessens the amount of cicatricial tissue on account of the free drainage which it establishes.

As regards the operation, Harrison employs Wheelhouse's method. Unless the stricture is completely impermeable, with a fistula behind it, he will not operate without previously performing internal urethrotomy. He considers that any stricture which allows of the passage of urine will also admit a small sound, and consequently a preliminary operation with Maisonneuve's instrument can be performed so as to admit of the introduction of a suitable grooved staff. If the stricture is not dilated it may be a difficult matter to discover the urethra behind a stricture or a tear. It is even necessary occasionally to open the bladder above the symphysis and perform retrograde catheterism. A preliminary internal urethrotomy, followed by the introduction of a grooved staff, renders the operation as simple as the division of a normal urethra for digital exploration of the bladder, as in Harrison's method. It should be done with a median incision.

For excision of a cicatrix, or for resection of the urethra, the canal should be opened in front of and behind the stricture and the fibrous mass excised. The ends of the divided urethra are carefully united with fine silk and catgut, after which the wound should be completely closed with sutures (preferably Socin's fine aluminium bronze wire) which extend down to the urethra. No drain should be introduced. Primary union is obtained along with an excellent passage for the urine. A soft catheter should be kept in till the wound is healed, *i.e.* for fourteen days, and the bladder maintained empty by syphon drainage into a vessel containing carbolic lotion. Irrigation should also be carried out.

If it is impossible to pass an instrument through the stricture beforehand, the urethra should be opened in front of the stricture by cutting on to a silver catheter, and the edges retracted with fine sharp hooks. A fine silver probe may then be passed through the narrow portion and the stricture be divided. The callous cicatrix (usually situated in the corpus spongiosum) is then excised and the healthy edges of urethra behind are grasped with hooks, and stitched to the urethral mucous membrane in

front with three or four silk sutures with intermediate ones of catgut. The deep soft tissues covering the urethra are then very carefully united with several sutures, which are passed deeply so as to take a good grip, the Nélaton catheter having been previously introduced. Finally the skin is closed without drainage. Traumatic as well as gonorrhœal cicatrices can be accurately excised in this way.

Forgue[1] exposes the posterior urethra without using a staff through an incision similar to our pointed incision (the anus being closed with clamps). He lays particular emphasis on the importance of Roux's muscle the "recto-urethralis," which according to Proust and Gosset is the key to the situation in the recto-prostatic space. It is divided, care being taken to avoid injuring the rectum. The fibres of the levator ani are separated at the sides of the prostate, and the prostato-peritoneal fascia is pushed back. The point of exit of the urethra is well seen at the apex of the prostate.

v. Hacker and Beck were the first to make use of mobilization of the urethra, together with the corpus spongiosum, for covering in by "distensionsplastik" large gaps (up to 6 cm.) left after the excision of strictures, fistulæ, new growths, and after rupture of the urethra.

In all cases where the urethra is united by suture success can only be looked for if strict asepsis is adhered to, including the internal use of urinary antiseptics and irrigation of the bladder. In the case of an impermeable stricture, and especially if there is incontinence at the same time, this can only be obtained by puncturing the bladder above the pubis, emptying it, and thoroughly washing it out, as otherwise, after division of the stricture, there is a free flow of infective stagnant urine, and if the wound is sutured, very acute infection may result. We have seen the temperature remain at 42° C. for days, and progressive infection only arrested by cutting the stitches.

C. Beck, v. Hacker, and Bardenheuer first employed "distensionsplastik" in hypospadias; Beck dissected up the urethra with the corpus spongiosum along with a strip of skin at the abnormal meatus, mobilized it and implanted the urethra into the glans after dividing the skin in front and preparing the glans. It is as well to bring the urethra out rather high up in the glans as it has a tendency to become displaced downwards. Vuillet makes a preliminary perineal incision.

(p) The Surgery of the Male Reproductive Organs

181. General Considerations. The surgery of the male genital organs is so simple that no detailed description of the individual technique is required. One incision is applicable for all operations on the testicle and spermatic cord—our inguinal incision. Although we described this incision in our earlier editions, it has been repeatedly rediscovered since, most recently by Pasquimangali, and is even referred to in the *Centralbl. f. Chir.* No. 47, 1906, as something quite new.

We have shown that the incision over the inguinal canal, whether combined or not, according to the nature of the case with opening of the canal, enables one, after dividing the infundibuliform fascia (covered by the cremaster) to dislocate upwards moderate-sized tumours of the testicle, and *a fortiori* of the spermatic cord, and to incise or excise them, without encroaching on the skin of the scrotum, which does not heal readily by first intention. It is only when there are adhesions and fistulæ that a corresponding portion of skin must be cut out. If the latter is extensive, the inguinal incision is not necessary.

The inguinal incision presents, moreover, the great advantage that the spermatic cord is exposed at a point where it can be readily ligatured, temporarily compressed, or shortened (as in cases of varicocele); and at the same time it allows one to reach the vas higher up (in cases of tuberculosis) and to deal with a hernia which is frequently associated with affections of the testis. It has the further advantage that enlarged glands can be reached not only in the groin, but in the iliac fossa and extending up into the pelvis. Hence we include the latter operation here.

[1] *Deutsche Zeitschr. f. Chir.* Bd. 75.

182. Castration. An oblique incision is carried downwards and inwards over the inguinal canal a finger's-breadth above and parallel to the inner half of Poupart's ligament. This incision corresponds exactly to the line of cleavage of the skin, and therefore comes together very easily. Two large veins which descend in the superficial fascia, the one at the outer and the other at the inner part of the wound, require to be ligatured. When the incision is prolonged outwards the superficial epigastric vessels are divided. The external spermatic fascia, which is prolonged down upon the cord from the edges of the external abdominal ring, is then divided; next, the muscular fibres of the cremaster (from the internal oblique) are similarly treated; and, lastly, the strong infundibuliform fascia, the continuation of the fascia transversalis. Within the latter lie the spermatic cord, or the round ligament, according to the sex, and possibly a peritoneal diverticulum in the form of a hernial sac.

In *castration* the testicle is pulled upwards, the vas deferens is cut through, and the vessels (spermatic artery, artery to the vas deferens, and the venous plexus) are individually caught up and divided. When this must be done higher up, on account of the presence of tumour nodules, or of disease (tubercle) of the vas deferens, the anterior wall of the inguinal canal (aponeurosis of the external oblique) must be slit up. Should the disease extend still deeper subperitoneally, the posterior wall of the canal must also be slit up and the canal very carefully sutured again.

Provided the testicle is not adherent to the scrotum, or markedly enlarged, it may easily be pushed upwards out of the wound and removed. Even when this cannot be done, it is well to begin by dividing the spermatic cord through an inguinal incision, for then, if the tumour is a large one, the size of a head (*e.g.* sarcoma), it can be removed without practically any bleeding. Only a few large veins between the tunica and the skin need be tied. When the cord is thickened either as a result of tumour infiltration or inflammation, it is quickest to divide it between two pairs of forceps. The large vessels are then easily seen and can be caught and tied separately.

When the skin is adherent, *castration* is performed by means of a *transverse incision in the coronal plane* at the lower end of the scrotum. After division of the skin and dartos between the larger visible scrotal vessels the testicle is shelled out. As the incision is parallel to the scrotal vessels, and parallel also to the branches of the spermatic vessels which ramify upon the surface of the tunica vaginalis towards its lower pole, it is a much more suitable incision than that which is generally employed, viz. a vertical incision, descending upon the anterior surface of the scrotum.

That castration is the correct treatment for malignant new growths is universally conceded, but there are many opponents to its adoption in tuberculosis. In spite of this important opposition, the fact remains that, in every case showing clinically undoubted tuberculosis of the testicle or epididymis, there is a danger that severe tuberculous infection may be set up by the disease spreading along the vas deferens to the seminal vesicles and prostate. The remarkable researches of Baumgarten, which met with so great approval at the thirtieth Congress of the German Society of Surgeons, 1901, show that, in animals, spread of tuberculosis can only take place upwards from the testicle, and never from the prostate downwards. All Baumgarten's pathological and anatomical researches in the human subject agree with this. Moreover, as cure without operation is very rare, and frequently imperfect, and, further, as it only occurs, as a rule, after long and troublesome suppuration, and, after all, usually results in destruction of the function of the organ, we may consider that the necessity for early unilateral excision of the testicle for tuberculosis is well established. Bruns lends his entire support to this view. In many discussions which have been held on this important subject, a sharp enough distinction has not been drawn between true castration with removal of both testicles, and the removal of one testicle only. All the disadvantages which are put forward refer only to the double operation. The unilateral operation alone has advantages, and can hardly be performed too early.

In early excision the inguinal incision is the ideal method. It allows the vas deferens to be exposed high up, and to be divided where it is healthy. The testicle can easily be freed and pulled upwards into the inguinal incision. If there are scrotal fistulæ present they can be cauterised, then excised, and the thermo-cautery applied to the wounds. The method of exposing the vas deferens and carefully inspecting it is to be preferred to Büngener's evulsion method, although the latter is very simple, because when the vas deferens is diseased it is not only of importance to divide it above the disease, but also to prevent a dissemination of tuberculous material into the surrounding tissues, in case part of the disease be left behind. To attain this object it would seem a more satisfactory procedure to expose the vas freely and to divide it with the thermo-cautery, after compression with pressure-forceps, rather than to tear it, a process which is open to the element of chance. It seems to be a good plan to inject some iodoform, or formol-glycerine, into the part of the vas which remains. Such an injection has been shown by Büngener's researches to fill the seminal vesicles.

This method will not satisfy those surgeons who adopt extreme measures and excise the seminal vesicles as well. In cases where such a thorough procedure is demanded, even this is generally not thorough enough, and the operation requires to be extended to the prostate and prostatic part of the urethra.

183. Operation for Varicocele. The incision is made parallel to Poupart's ligament, passing inwards over the external abdominal ring through skin and superficial fascia. The veins passing upwards towards the middle line are ligatured. The prolongation of the fascia of the external oblique muscle, which surrounds the cord under the name of Cooper's fascia, is divided. The looped fibres of the cremaster muscle which now appear are divided, together with the tunica vaginalis communis (infundibuliform fascia), which lies below it. Traction is made on the cord till the testicle is pulled out of the wound.

The spermatic vein, which may be as thick as a pencil, is now isolated at the external inguinal ring. The higher up this is done the more easily is it performed. The isolation is then carried downwards, and the branches joining it from time to time are ligatured and divided. In this way 4 to 6 ins. of the vein can be isolated. The tributaries begin to get more entangled and more numerous just before the testicle is reached. The main vein is now ligatured above and below, the ends of the ligatures being left long. These ends are tied together after the vein has been resected so as to shorten the cord and suspend the testicle higher up.

The results thus obtained are very good. In 25 of our cases treated in this way, whose history Hauswirth was able to trace a number of years afterwards, 23 were found to be quite cured; in no case did any atrophy of the testicle result. In none of our 47 cases collected by Hauswirth (Berne Dissertation) were there any evil consequences. Vince (*Journal de chir. belge*, Sept. 1904) tries to improve the function of the cremaster by resecting a transverse strip of it about 2 inches broad. In our opinion, the innervation of the muscle would be destroyed by this procedure: at the most plication and suture might be permissible.

Should a much dilated vein be found at the external abdominal ring closely associated with the vas deferens it must be tied as high up as possible.

Finally, if the scrotum be particularly lax, a part of it should be resected so as to shorten it. The wound is closed, and no drain is inserted. The operation may quite well be performed after the injection of cocaine. Narath slits up the inguinal canal in order to apply the ligatures higher up, but this we consider unnecessary. The principal object to be attained is to interrupt the pressure of the column of blood extending from the left renal vein to the vessels of the cord.

184. Operation for Hydrocele.—The sac is reached by the incision described for castration. If very large it may first be partially emptied by puncture. The tunica vaginalis communis (infundibuliform fascia) is very carefully divided, and the tunica vaginalis propria, which is tense and translucent, is freed up to the testicle by stripping off the tunica communis. The propria is now opened, the fluid evacuated, and the condition of the testicle and epididymis is carefully examined.

The parietal layer of the tunica propria is then removed, with exception of just enough to cover the testicle closely when united with a fine continuous silk suture. We have always obtained a radical cure after this operation.

185. Orchidopexy for Retention of the Testis. Lanz[1] has shown that a retained testis is at the same time imperfectly developed, and that this is the cause of the incomplete descent. He has in addition discovered atypical gland epithelium in the retained testis. He was not able to demonstrate the presence of strong peritoneal adhesions.

On the other hand we have seen the descent of the testis very considerably interfered with by a short and generally patent processus vaginalis, as well as by adhesions between it and the tunica vaginalis communis (infundibuliform fascia).

By careful incision and division of Cooper's fascia, the cremaster, infundibuliform fascia, and above all the processus vaginalis peritonei all round, the testicle can often be pulled well down and fixed by sutures to the surrounding parts. It is not always possible, however, to bring the testicle down to the bottom of the scrotum (as we found recently in the case of a man aged thirty-four) and still less to keep it permanently there.[2]

Numerous attempts have recently been made to keep the testicle down by fixing it to some unyielding part in the thigh. Stitching to the scrotum or to the other testicle (Gersuny) is not sufficient. Lohnhard and Katzenstein have adopted the most drastic measures. They push the testicle out through a slit in the bottom of the scrotum and stitch it to the thigh. De Beule stitches the scrotal wound as well to the edges of the incision in the thigh so as to cover over the testicle.

Lanz transfixes the lower pole of the testicle with a loop of thread, which is brought out of the scrotum and fixed to a strip of adhesive plaster on the thigh. More recently he has used elastic thread for the purpose, which he passes through the tunica albuginea of the lower pole of the testicle, so that the latter is pulled downwards and the cord put on the stretch.

We regard it as very important to divide thoroughly all the attachments in the neighbourhood of the spermatic cord, as if there is too great tension the circulation in the cord is injured. Like Lanz, we have simply brought the thread fixed to the lower pole of the testicle through a small opening in the bottom of the scrotum, but after fixing it there and closing the small wound, we then pull the scrotum down by means of the thread, the ends of which are left long and stitched firmly to a fold of skin lower down on the thigh. In this way absolutely no wound is left.

186. Vasectomy. Of all the various methods employed from time to time to diminish the size of the prostate, vasectomy has yielded the best results. The important observations of Ramm and White (the original discoverers of the castration treatment of prostatic hypertrophy) show that castration exercises a marked influence on the size of the prostate, and have led to the development of a procedure which avoids all the deleterious effects and dangers of castration, and in nearly all cases produces the same beneficial result.

Vasectomy has the advantage of not causing atrophy of the testicle although the prostate decreases in size. It can be performed without a general anæsthetic, and without confining the patient to bed—matters of great importance where elderly people are concerned. Under cocaine anæsthesia a small incision is made down on to the cord, which is first fixed between the finger and thumb. The tunica vaginalis communis is divided, a loop of the tough vas deferens is drawn out, and a portion of considerable length is excised. It is unnecessary to tie the ends. The wound is stitched and a collodion dressing applied.

Appendix.—Vasodidymostomy. Penzo,[3] in support of partial resection of the epididymis and vas deferens, has attempted to anastomose the divided vas deferens

[1] Lanz, *Centralblatt für Chirurgie*, April 1905.

[2] According to Bewan the nutrition and development of the testicle might be seriously interfered with were the vessels to be cut through.

[3] *Rivista ven. di sc. mediche*, Venedig, 1905.

with the parenchyma of the testicle by making several openings in the stump of the vas deferens and implanting the latter into the testicle. In animals he succeeded in obtaining a really functional anastomosis.

187. Excision of the Seminal Vesicles. Total Castration including the Vasa Deferentia and Seminal Vesicles. Spermatocystectomy has to be considered chiefly in connection with tuberculosis of the seminal vesicles while, as we have already indicated, it forms part of the operation for the removal of malignant growths of the prostate and bladder. It is, however, a rare operation. Legueu and Riese have recently published a series of cases of this operation. Experienced surgeons, like Israel and Körte, agree that it is scarcely indicated.

The procedure follows closely that of perineal prostatectomy in regard to exposure of the parts. Since Baumgarten, by his experiments, and Bruns, by clinical observations, have proved that tuberculosis of the genital organs is primarily an ascending one, that is, that it passes from the testicle successively to the vas deferens, seminal vesicles, and prostate, and does not spread in the reverse direction (from prostate to genital organs), total excision of the male organs of reproduction has received special attention. There are, however, many surgeons who even nowadays are opposed to operation in cases of tuberculous disease of the testicle.

Beloseroff, at Roux's request, investigated the historical development of castration and ascribed to Reclus the honour of having, in 1875, distinguished genital tuberculosis as a primary[1] disease, as opposed to Louis' and Dufour's tuberculous diatheses. It is now definitely proved that a number of patients remain quite healthy after castration. Tavel recently discovered a case in which tuberculosis of both epididymes was discovered post mortem, without any manifestation of tubercle elsewhere, even in the lungs. The case was one of primary tuberculosis of the epididymis. But it is undoubted that it is only the minority of cases which reach the surgeon at a time when the affection is still entirely limited to the testicle, and when, therefore, simple castration, or excision of the epididymis (Bardenheuer, 1880), may be performed.

The vas deferens, at any rate, is generally involved, hence it must be removed above the highest diseased focus by dissecting it out high up. If the seminal vesicle is also involved it should be excised. In many cases, of course, tuberculous foci are still left in the prostate: excision of the vesicula seminalis, along with the vas deferens and testicle, is only justifiable when the seminal vesicle is specially seriously involved, and when the prostate is quite healthy.

If the tuberculous process develops quickly, the vas deferens, seminal vesicles, and prostate are sometimes rapidly involved as we saw not long ago in a post mortem. In the individual in question, miliary peritoneal and general tuberculosis led quickly to death from meningitis. Ullmann performed the first spermatocystectomy in 1889.

Villeneuve attempted excision from the groin, while Schede, Fuller, and Routier employed the sacral route, as recommended by Kraske and Rydygier. The proper route is from the perineum, as practised by Ullmann, Zuckerkandl, Büngener, Guelliot, and ourselves. We have performed the operation through the prerectal incision in the form of the sharply curved incision described for the exposure of the prostate. This method may confidently be recommended, and it occasions far less injury than either the inguinal or the sacral methods.

Beloseroff objects to the prerectal incision on the grounds of want of space, of difficulty in arresting the hæmorrhage, and of the great injury inflicted on the parts. We can only admit the justice of the first objection, and then only to this extent, viz. that the incision recommended by Roux certainly gives more room, but either or both ends of the horse-shoe incision may be easily extended backwards. On the other hand, a lateral incision must necessarily divide more of the levator ani and of the nerve twigs passing transversely towards the middle line than does

[1] With regard to primary tuberculosis of deeply-seated organs, it is almost unnecessary to observe that we do not imply that the tubercle bacillus entered at this point, but rather that its effects were first recognised clinically here.

the prerectal incision which gives access in the middle line, and, for this reason, allows of the muscles being held aside.

Roux's Paramedian Method for Spermatocystectomy with Total Vasectomy and Castration. Roux performs castration, frees the vas deferens as high as possible, and divides it obliquely, so that if it is twisted out from below he can exclude the possibility of a tear. In cases where the section passes through caseous mucous membrane we advise that the stump should be cauterised with Paquelin's instrument.

A paramedian incision 4 ins. long is then made in the perineum (about $\frac{3}{4}$ in. from the middle line) as far as the level of the ischial tuberosities, and the fibres of the levator ani are divided. The seminal vesicle is protruded into the wound by a finger introduced into the rectum and is secured by a suture. Its attachments are separated with a blunt dissector, and the vas deferens is pulled out. The neck of the seminal vesicle is divided at the prostate, and the cut end is closed by three layers of catgut sutures. Iodoform gauze is introduced for twenty-four hours and the wound sutured.

Young (Langenbeck's *Arch.* vol. lxii. p. 456) has described a very radical procedure for extirpation of the testicles together with the cord and vesiculæ seminales. He makes a long abdominal incision reaching up to the umbilicus, strips the peritoneum from the posterior wall of the bladder, isolates the seminal vesicles and vasa deferentia from above, and excises them in one piece with the testicles. To gain sufficient room for the procedure, the recti are divided transversely at the level of the umbilicus and united again by sutures. When the bladder is diseased it may be incised, or a part may even be excised. This method is certainly radical, but, on account of the serious nature of the operation, it should be limited to suitable cases.

188. Amputation of the Penis. Removal of the penis is performed almost entirely for malignant disease, which generally originates either in the region of the prepuce or of the corona. Formerly, on account of the danger of infection, it was usual to effect the removal with the galvano-caustic snare or with the thermo-cautery. But, if the parts are properly disinfected, removal with the knife is preferable, because it allows one to make a proper urethral orifice from the first, and the patient is thus spared very great discomfort, and is protected from a secondary stricture.

Hæmorrhage is prevented by tying a thin drainage-tube round the base of the penis. The skin is divided transversely, and, after it has been drawn back, the corpora cavernosa of the penis are divided down to the corpus spongiosum of the urethra. It is easily seen when the thick tunica albuginea of the corpus cavernosum of the penis is divided. On the back of the penis the median dorsal vein and the two dorsal arteries are ligatured, as are also the deep arteries in the right and left corpus cavernosum. The loose tissues covering the corpus spongiosum are then retracted and the latter is cut across along with the urethra 1 to 2 cm. lower down. This stump, from which the radiating folds of the urethral mucous membrane can be easily pulled out, is sutured to the lower edge of the skin wound. Immediately after the arteries are ligatured, the tunica albuginea is stitched vertically over the cut surfaces of the corpora cavernosa and the latter are securely sutured together so that when the tourniquet is removed any hæmorrhage can be controlled.

The rest of the skin edge is united in a vertical direction.

In this way primary complete closure of the wound is obtained, and a well-formed urethral orifice is provided, which does not become narrowed later on by cicatricial contraction. The urine escapes freely without soiling of the wound, and thus recovery is rapid and complete.

Jansen (*Centralbl. f. Chir.*, May 1905) describes a method Witzel has employed so as to prevent the orifice of the urethra retracting downwards and backwards. He sutures the corpora cavernosa together horizontally, curves the urethra upwards, sutures it to the tunica albuginea, and makes a hole in the skin on the dorsum (which is left longer) into which he stitches the mucosa. The edges of the dorsal skin are united to the ventral skin on the under aspect of the penis.

189. Removal of Lymphatic Glands from the Groin, and from the Region of

the Iliac and Obturator Vessels. The typical incision for clearing out the inguinal glands is that recommended by Lauenstein, viz. an oblique incision along Poupart's ligament, with Lennander's addition of a vertical one along the femoral vessels. The operation of complete removal of the lymphatic glands in the groin should only be performed when they are the seat of malignant disease, and thus a source of danger to the life of the patient. On the other hand, in tubercular and various inflammatory conditions the removal should be limited to the diseased glands. Riedel has shown that complete excision of the inguinal glands can give rise to stasis of the lymph flow and consequent elephantiasis of the lower limbs.

If, as in carcinoma, sarcoma, and tubercle, the indications for removing the glands are obvious, we agree with Lennander that they should be followed up into the pelvis along the vessels and removed in the same thorough manner as in dealing with the axillary glands. They extend along the external and common iliac vessels as far as the aorta, as well as along the obturator vessels to the internal iliac.

Lennander, in order to expose the deep glands, recommends that the muscles of the abdominal wall should be freely separated from the pelvis. Poupart's ligament is detached from the pubis and the fascia lata, and the muscles of the abdomen are detached as far back as the centre of the iliac crest, or even farther. In this way access can be got to the glands as far as the aorta, and to those in the cavity of the pelvis.

In such cases we have contented ourselves with the following procedure:—An incision is made just above Poupart's ligament, the superficial fascia is divided, and the superficial epigastric artery and some vertical veins are ligatured. The aponeurosis of the external oblique is split close above the ligament. The internal oblique and transversalis muscles are separated from the ligament and the fascia transversalis is divided.

The muscles, together with the cord (or round ligament), are now retracted and the dissection is continued upwards subperitoneally along the vessels. If this does not give sufficient access, the incision may easily be prolonged outwards and the muscles separated from the iliac crest, a step, however, which makes the operation much more serious. Very thorough access to the deeper parts may be obtained if the divided muscles are forcibly pulled aside after the fasciæ have been divided.

In some circumstances it is better to add a vertical incision upwards to that over Poupart's ligament. By dividing the attachment of the rectus to the symphysis this may be made in the linea alba. When the iliac glands are involved (*e.g.* in malignant disease of the testicle) the parietal peritoneum must be divided all round the tumour so that it may be raised up off the great vessels. In making a thorough dissection of the glands about the sacral promontory it is essential for safety to have plenty of room. In regard to the after-treatment, even when there are large gaps which cannot be covered in with peritoneum, the drain may be removed after two days, and complete primary union obtained.

(q) Surgery of the Female Reproductive Organs

190. The Alexander-Adams Operation. Gynecologists have been slow to appreciate the advantages of the Alexander-Adams operation in the treatment of retroflexion of the uterus, and we are convinced that it does not yet receive the support which the excellence of the results following its employment indicate. We have frequently had to undertake it in women who had for years worn pessaries—a form of treatment which is most inefficient in an uncomplicated easily-movable retroflexion. The explanation of this lukewarm attitude is to be found in the injuries which are reported to have followed its use,[1] *e.g.* cicatricial adhesions of the genitocrural nerve, severe arterial hæmorrhage, thrombosis, etc.

Fehling,[2] in opposition to his colleagues, states that these accidents only occur

[1] v. Hocheisen, *Berl. klin. Wochenschr.* No. 2, 1905.
[2] *Centralbl. f. Gynäkologie*, February 1905.

when the operation is incorrectly performed, *i.e.* when the incision is made too far out. He, however, goes to the opposite extreme and cuts too near the middle line. He employs a curved incision extending from the centre of Poupart's ligament on one side across the symphysis pubis to a corresponding point on the other side, and searches for the ligament after its exit from the inguinal canal. As the ligament is here sometimes very thin, it naturally not infrequently gives way when traction is made on it.

Traction can only be made on the ligament with safety before it enters the

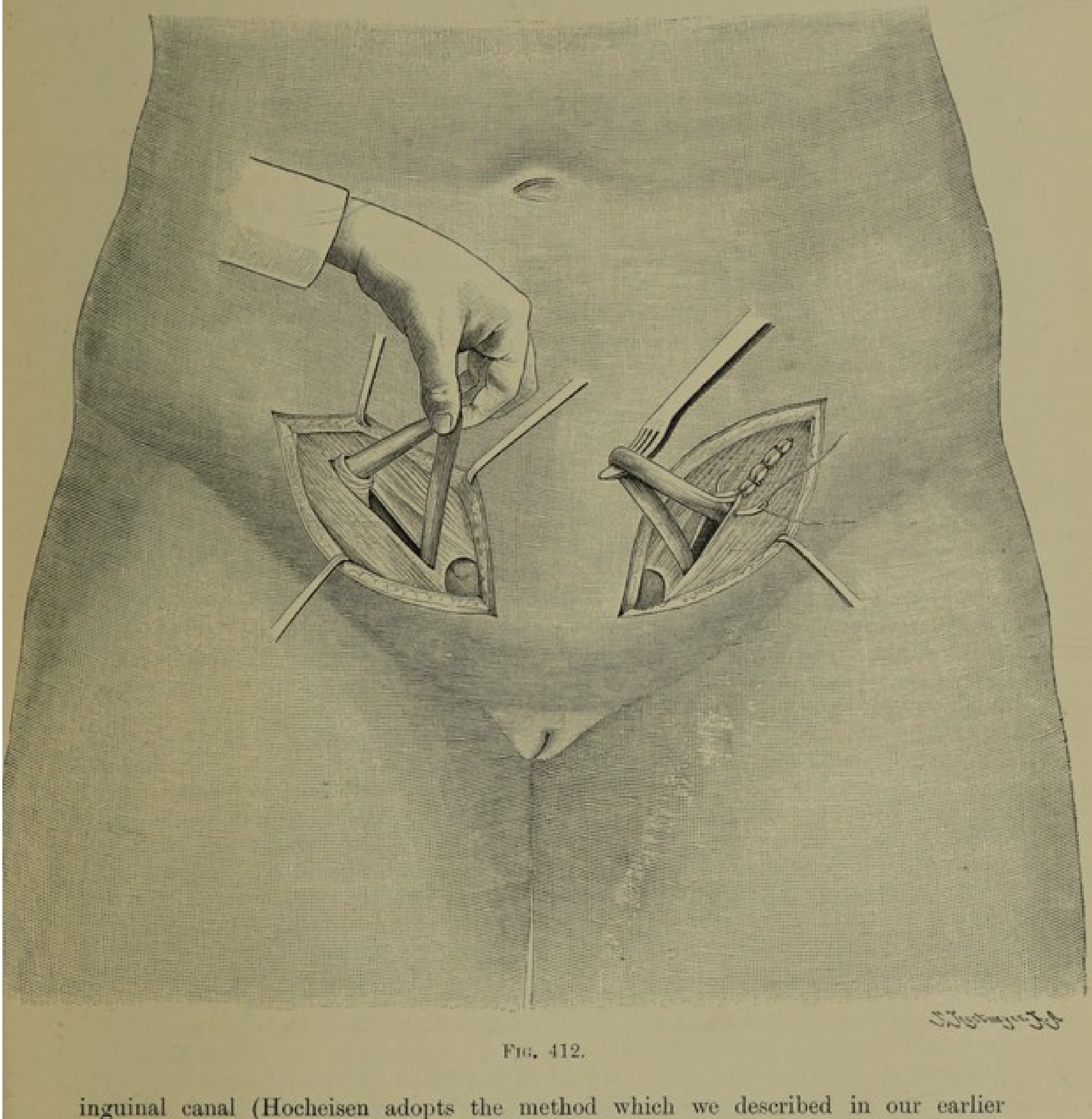


FIG. 412.

inguinal canal (Hocheisen adopts the method which we described in our earlier editions). Even here, if the ligament is thin, it may occasionally give way, but an accident of this sort only occurs in attempting to replace a uterus which is not sufficiently movable, *i.e.* when the examination has been too cursory and the indications for the operation have not been properly established. When the uterus is retroflexed and fixed, and a laparotomy has to be undertaken to free it, the ligament may be shortened intraperitoneally or it may be fixed to the sheath of the rectus by Gilliani's or a similar method.

Technique of the Operation. Our inguinal incision, 5 to 6 cm. in length, parallel to Poupart's ligament is quite sufficient, and in time leaves a barely perceptible scar. After division of the skin and superficial fascia $\frac{1}{2}$ cm. above Poupart's ligament, the aponeurosis of the external oblique, *i.e.* the anterior wall of the inguinal canal, is divided, but the separation is not carried right down into the external abdominal ring (*vide* Fig. 412). In the superficial fascia the superficial epigastric artery is divided as well as a vertical vein which is often found at the inner angle of the wound. A blunt dissector is now passed along the concavity of Poupart's ligament and the internal oblique and transversalis muscles between which the ligament runs are raised up. The muscles are then allowed to slip off the end of the dissector till the ligament is recognised, after which it is grasped between the finger and thumb and held up, care being taken not to put much strain on the distal end, as it is here thin and easily torn. The soft parts are stripped back to the internal abdominal ring, and traction is made on the upper end of the ligament till the cone of peritoneum is brought into view. The latter can be readily pushed back with a gauze swab. The artery which accompanies the round ligament is ligatured, to prevent it being torn, and is then allowed to retract.

A strip of gauze is now passed underneath the ligament, while the ligament on the opposite side is dealt with in a similar manner. When they are both freed, traction is made on them in order to effect the reposition of the uterus, the amount of traction being regulated per vaginam, and, if necessary, assisted by pushing up the body of the uterus.

The method by which the sutures are introduced is illustrated in Fig. 412. Beginning at the outer angle of the wound, a series of interrupted sutures are passed through both edges of the aponeurosis, including one-third of the thickness of the round ligament. The sutures, which should always be silk, are continued till only a small opening is left, through which the redundant portion of the round ligament is replaced in the inguinal canal. The aponeurosis is then united over it and the skin closed with a continuous stitch, a collodion dressing being applied without drainage.

It will be observed that the ligament is neither cut through nor removed. Its normal attachments are retained. It is merely pulled out, and securely fixed to the anterior wall of the inguinal canal. There is no risk of a hernia resulting (we have never seen hernia occur) if one or two stitches are passed through the cone of peritoneum, especially if the peritoneum has been torn.

When the proper cases are selected, the operation affords a certain radical cure, the wound being healed in eight to fourteen days. We cannot therefore understand why so many gynecologists still persist in the use of pessaries for months and years.

191. Exohysteropexy. Exohysteropexy, *i.e.* extraperitoneal fixation of the whole uterus (vide *Deutsch. Med. Woch.*, January 1904) is a very simple and efficacious operation and gives good results (1) in the enucleation of myomata when there is the least danger of subsequent bleeding or sepsis; (2) in cases of severe prolapse in women beyond the menopause.

The following description refers to a simple case of severe prolapse in an elderly woman :—

A mesial incision is made, the length of which is determined by replacing and pushing the uterus in contact with the abdominal wall. The skin, linea alba, transversalis fascia, and peritoneum are divided, the opening in the latter being just sufficient to allow the uterus as far as the os internum to be pulled out. The tubes and ovaries are not brought out. The peritoneum is now sutured above and below the uterus at the junction of the body with the cervix, a portion of the peritoneal covering of the uterus being included both in front and behind. The bladder is, of course, avoided, as it lies lower down. The body of the uterus is laid upon the shelf of peritoneum thus formed and its anterior surface covered over with the fascia transversalis. The edges of the linea alba are united, and a fold of the round ligament on either side is stitched as high as possible to the fascia. In this manner the uterus is securely anchored outside the peritoneum, under cover of the fascia of the anterior

abdominal wall. The skin wound is then closed, a drain being inserted down to the opening in the peritoneum through which the uterus has been brought.

The operation is quite simple and does not inflict the mutilation of a vaginal hysterectomy. Even for old women, therefore, it has not the serious nature of the former operations. We have taken the trouble to follow up our cases, and are able to state that in only one was disturbance of the bladder noted, and in her case cystitis and urinary trouble had existed previously. As all our other patients had absolutely no complaints, we are justified, therefore, in recommending the operation for suitable cases.

If the operation is performed in connection with enucleation of a uterine myoma, the bed of the tumour must, of course, be closed in layers in the usual manner. As is well known, however, the results of enucleation are by no means so assuring as to lead one to confidently recommend the operation, even in the case of young robust individuals. The stitches may give way at the onset of menstruation, and by causing hæmorrhage into the peritoneal cavity may give rise to peritonitis, while a similar complication may be produced by necrosis.

By suturing the uterus to the abdominal wall, a great security is provided against peritonitis—the chief danger of the operation. A drainage tube is passed down to the sutures in the peritoneum, while one or more may be inserted down to the seat of the enucleation. If in addition a gauze tampon is employed, it should be removed in one or two days, the tubes being left for a slightly longer period. The smallest sign of hæmorrhage or sepsis can be at once recognised, and the necessary steps taken for their arrest.

Danger from a subsequent pregnancy need scarcely be apprehended, as, generally speaking, one is dealing with barren women. Should, however, the occasion arise, and the uterus does not replace itself, one need not hesitate to divide the peritoneum and restore it to its intraperitoneal position.

APPENDIX

Excision of the Wrist (Figs. 413, 414, and 415). Excision of the wrist, as practised by the Prussian surgeon Beyer, and by Moreau (one of its earliest introducers), has given better results since Lister pointed out the importance of always performing a complete excision. Treves considers the two dorsal incisions of Ollier preferable to the two incisions recommended by Lister. For the different methods we refer the reader to the exhaustive and historical work of Catterina (Padua, 1893). In practically every case a single dorsal incision is sufficient. Formerly we regularly employed the method most usually adopted, viz. that known as Langenbeck's. Farabœuf states that the dorso-radial incision was employed by Böckel in 1869, and Treves describes it as Böckel's method, but holds that Lister had previously used it. We employed the same incision before Langenbeck, not only on the living body, but also demonstrated it in the operative course upon the cadaver. It is through Langenbeck, however, that the method has become widely known. It has great advantages over the methods formerly employed.

Dorso-Radial Incision. With the hand forcibly flexed to the ulnar side, a straight incision is carried through the skin from the middle of the second metacarpal bone over the middle of the wrist-joint, and upwards along the axis of the forearm for a corresponding distance above the joint. The incision strikes the interval between the tendons of the extensor communis digitorum and extensor indicis on the one side, and the extensor secundi internodii pollicis on the other. The skin is divided gradually so as to avoid the branches of the radial nerve going to the middle finger. The upper part of the incision passes through the posterior annular ligament and the fascia, down to the radius. Opposite the wrist-joint it is carried through the capsule and downwards upon the base of the third metacarpal bone. The tendons of the extensor carpi radialis brevior and longior are now detached along with the periosteum from the bases of the third and second metacarpals respectively, and the posterior surface of these bones with the intervening interosseous muscle are exposed. The tendons are now displaced laterally from their grooves in the bones, and the detachment of the capsule of the wrist-joint is commenced.

The disadvantage of the Böckel-Langenbeck method is, that in order to get sufficient room it is necessary to detach the radial extensors. Even although the subperiosteal method is strictly adhered to (as recommended by Trélat), considerable damage is nevertheless sustained by the chief dorsal flexors of the hand, which is apt to be flexed towards the palm and the power of dorsiflexion seriously impaired. It is therefore preferable, on account of the frequency with which the radial extensors are injured, to place the incision upon their ulnar side.

Dorso-ulnar incision (Figs. 413, 414, and 415). Our incision must be of considerable length, 7 to 8 cm. (3 to $3\frac{1}{2}$ in.), and so placed that with the hand slightly flexed to the radial side, it extends from the middle of the fifth metacarpal bone upwards over the middle of the wrist-joint, and from thence along the middle of the back of the forearm. At its lower end the incision avoids the origin of the posterior

ulnar vein and the dorsal branch of the ulnar nerve, which is not so likely to be injured as is the radial nerve by the dorso-radial incision, because the dorsal branch of the ulnar winds towards the back of the hand at a lower level. After dividing the fascia along with the strong transversely-striated posterior annular ligament, the incision opens the sheaths of the extensor minimi digiti and extensor communis tendons which are drawn to the radial side, while beneath the tendons the ligaments upon the base of the fifth metacarpal, the unciform, the cuneiform, and the ulna are divided. The capsule is now separated towards the ulnar side, and along with it the tendon of the extensor carpi ulnaris, which is attached to the fifth metacarpal.

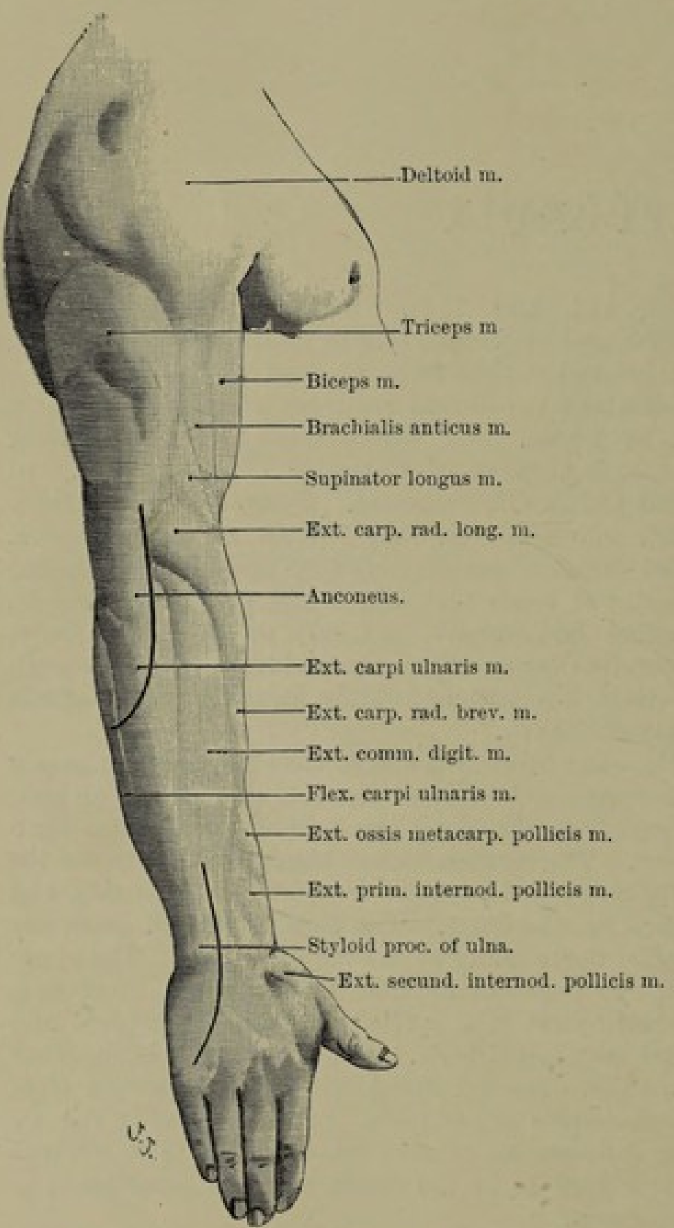


Fig. 413.—Arthrotomy of the elbow and wrist.

The detachment of the tendon of the extensor carpi ulnaris has not the same disadvantage as has that of the two radial extensors. The ulnar extensor has much less share in dorsiflexing the hand than the radial extensors which lie upon the radiocarpal articulation, which forms the main part of the wrist-joint. The extensor carpi ulnaris assists mainly in producing ulnar flexion, which is the very movement which occurs to an undue extent after excision, in consequence of the weight of the hand, which is subsequently often displaced to the palmar and ulnar aspects—that is to say, appears to be contracted in this direction. The division of this tendon, therefore, may act rather beneficially than otherwise. Moreover, in the dorso-ulnar incision the extensor tendons have less tendency to protrude from the wound than in the dorso-radial incision. The special extensor of the little finger is the one most interfered with, but as this finger is provided with a double extensor, and has a far less important function than the index, this disadvantage may be disregarded.

Above, the tendon of the extensor carpi ulnaris is lifted out of its groove in the ulna, and the capsule is separated from around the bone. When the inferior radio-ulnar joint is diseased the miniscus must be excised. The separation of the attachment of the capsule around the ulna is easy. After dividing the capsule at the cuneiform, the joint between it and the pisiform is opened, the tendon of the flexor carpi ulnaris being left in connection with the latter. The hook of the unciform can be more easily exposed and cut across than by the dorso-radial incision. This is a matter of importance, because the deep branch of the ulnar nerve winds round it and must be preserved. The bundle of common flexor tendons can be lifted *en masse* out of their groove

without difficulty, and the ligamentous connections between the three inner metacarpals can be separated upon the palmar aspect, the insertion of the flexor carpi radialis into

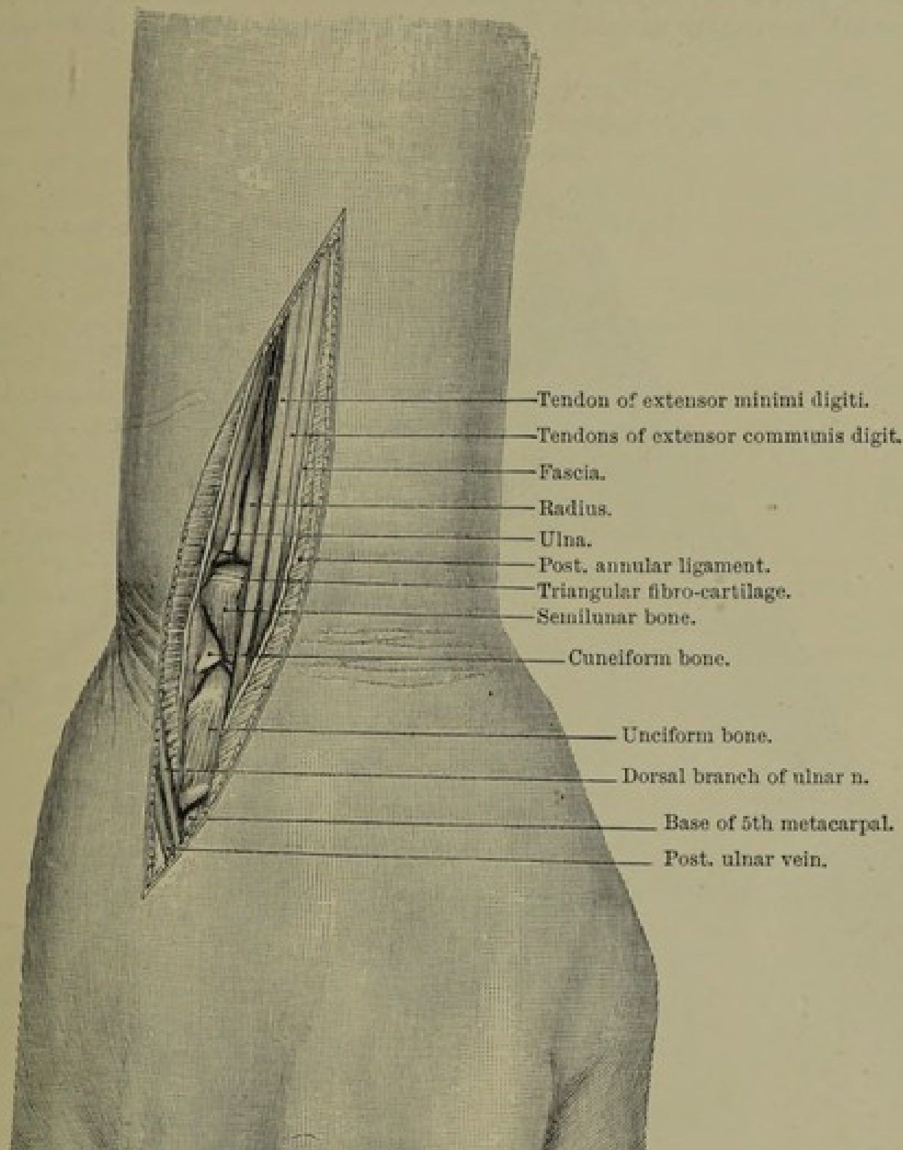


Fig. 414.—Excision of the wrist by the dorso-ulnar incision carried through the capsule.

the second metacarpal being preserved. The attachment of the anterior ligament of the wrist-joint is separated from the anterior border of the lower end of the radius.

Upon the dorsal aspect, the posterior ligament is detached from the lower end of the radius as far as the radial extensors and the extensors of the thumb, and the

tendons are raised from out of their grooves. The tendons of the radial extensors, however, are not detached from their insertions into the dorsal aspect of the third and second metacarpal bones respectively.

The hand is now forcibly and completely dislocated towards the radial and flexor aspects so that the thumb comes in contact with the radial border of the forearm, and

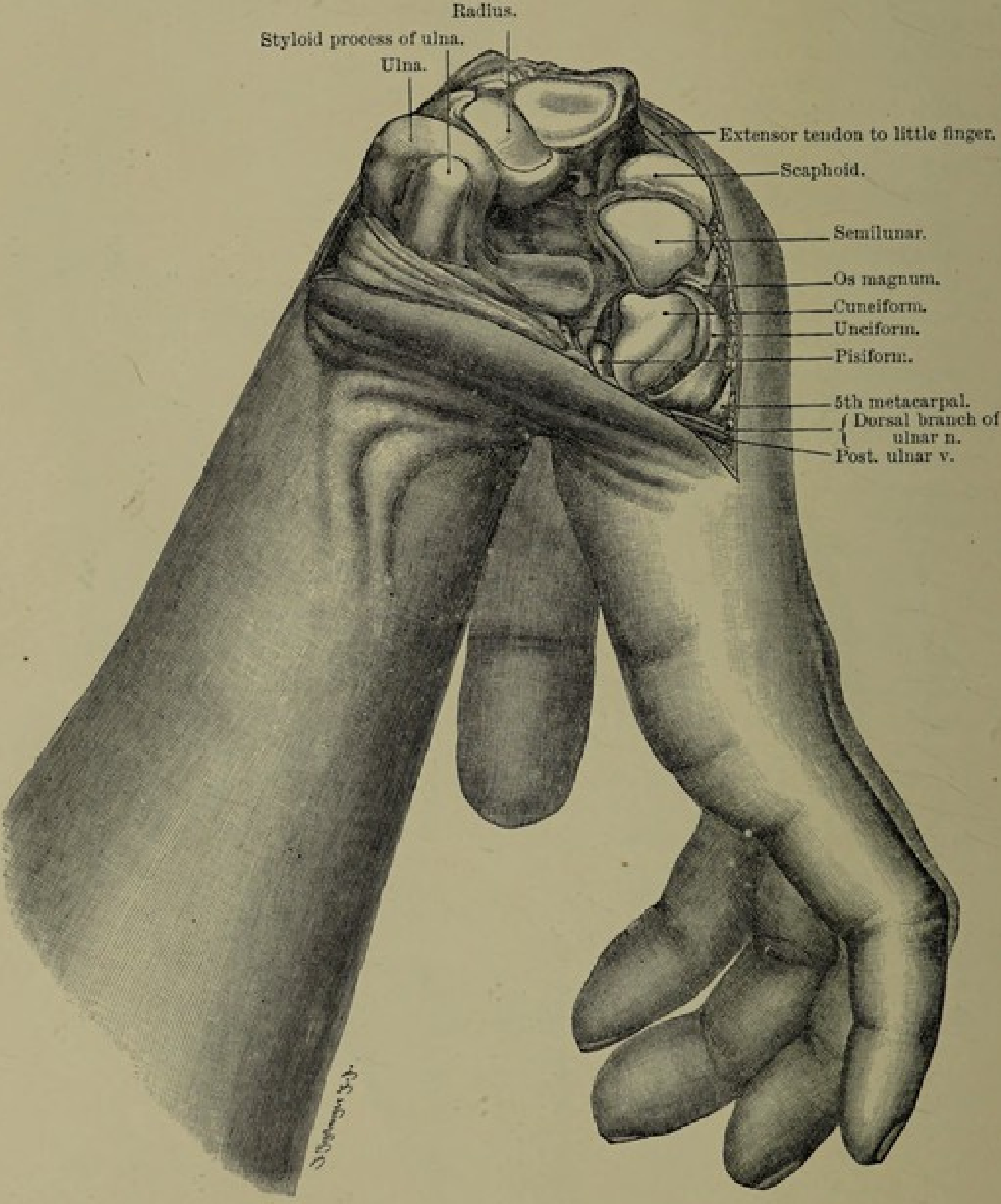


FIG. 415.—Excision of the wrist by the dorso-ulnar incision. Second stage: the wrist-joint is dislocated and the posterior ligament detached from the bones of the forearm.

the extensor tendons come to lie upon the radial side of the radius (Fig. 415). When necessary the capsule may be still more thoroughly detached from the outer border of the radius, and the insertion of the supinator longus exposed. There is now no difficulty in dissecting out the carpal bones, and in removing as thin a layer as possible from the bones of the forearm and from the metacarpals. It is only in the region of the trapezium, the trapezoid, and the bases of the three radial metacarpals that

access is not so readily obtained. In cases where the disease chiefly involves or is limited to the radial aspect of the carpus and metacarpus, the dorso-radial incision possesses advantages over our own method. Especial care must be taken to avoid the radial artery which lies on the dorsum between the trapezium and trapezoid bones, and enters the palm between the bases of the first and second metacarpals to form the deep palmar arch.

The ends of the bones of the forearm and the proximal ends of the metacarpals should be sawn with a surface curved on a transverse axis, as in the elbow, so as to ensure dorsal and palmar flexion.

We especially claim for our method that the tendons of the radial extensors are preserved intact, and that by completely dislocating the joint it is possible to obtain a view of all its recesses, and of each individual bone.

Catterina recommends a method of excising the wrist similar to that of Obalinski for exposing the tarsal joints—that is to say, by an incision extending through from the dorsum to the palm between the third and fourth metacarpals. The palmar incision only reaches to the superficial palmar arch. The dorsal one, however, extends much higher up, but the transverse direction of the palmar arches and of the deep division of the ulnar nerve renders the proper use of this incision difficult.

In the after-treatment it is of importance to secure dorsiflexion of the hand by means of a splint, such as we have been in the habit of using for years, and which, although keeping the wrist securely fixed, still allows of movement of the fingers. As the finer and more important movements of the fingers are associated with flexion, the wrist should be dorsiflexed, so that by stretching the flexors the fingers are kept in a state of passive flexion, which can be rendered more complete and active by comparatively little muscular effort. Active movement of the fingers should be begun early to obtain a good functional result.

INDEX

THE END

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