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OPERATIVE SURGERY

TH. KOCHER

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TEXT-BOOK

OF

OPERATIVE SURGERY

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TEXT-BOOK

OF

OPERATIVE SURGERY

BY

DR. THEODOR KOCHER

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

AUTHORISED TRANSLATION FROM THE FOURTH GERMAN EDITION

BY HAROLD J. STILES, M.B., F.R.C.S. EDIN.

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WITH 255 ILLUSTRATIONS

LONDON
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TRANSLATOR'S PREFACE TO THE SECOND ENGLISH EDITION

THE First English Edition, published in 1895, was translated from the Second German Edition, published in 1894.

This, the Second English Edition, which is a translation of the Fourth (latest) German Edition, is only a few pages less than twice the size of its predecessor. There have also been added 70 new illustrations, many of which are coloured.

The sections dealing with Anæsthesia, the Treatment of Wounds, the Head and Neck, Thorax, Abdomen and Pelvis, have been entirely rewritten, and the same may be said of the sections on Amputations and Excisions. Compared, therefore, with the former English Edition, the present work may be regarded as practically a new book.

Since the publication of the Fourth German Edition there has appeared, in the *Zentralblatt für Chirurgie*, of 10th January, 1903, a paper from the pen of Professor KOCHER, entitled "Mobilisierung des Duodenum und Gastro-duodenostomie." The author speaks so highly of the operation that I have considered it advisable to introduce, in the form of an appendix, a translation of this important paper.

For the time and labour expended in the translation the writer derives 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.

I have great pleasure in acknowledging my indebtedness to my friend Dr. G. LOVELL GULLAND for the valuable help he has again given me with the translation, in which I have also been ably assisted by my former House Surgeon, Dr. H. D. SHEPHERD.

My cordial thanks are due also to Mr. GEORGE STRONACH, M.A., for the literary care with which he has read the proofs, and to my assistant, Dr. CUTHBERT B. PAUL, for preparing the index, and for much general help throughout the work.

HAROLD J. STILES.

8 ST. COLME STREET,
EDINBURGH, *August* 1903.

TRANSLATOR'S PREFACE TO THE FIRST ENGLISH EDITION

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.

It has been found necessary to make a few alterations in the translation of the more purely anatomical descriptions, to keep them in harmony with those employed by English anatomists. Otherwise the aim has been to adhere to the original as closely and as literally as possible.

I desire to express my thanks to my friends Dr. G. LOVELL GULLAND and Mr. ALEXIS THOMSON for the assistance they have given me with the translation, and to Dr. ERNEST FORTUNE for aiding me with the proofs.

I gladly take this opportunity to express my warm thanks to Professor KOCHER for entrusting to me the translation of his text-book, and for the valuable privileges I enjoyed while attending his Clinic.

HAROLD J. STILES.

5 CASTLE TERRACE,
EDINBURGH, *May* 1895.

AUTHOR'S PREFACE TO THE FOURTH EDITION

THE favourable reception accorded to our third edition and its translation into English, French, Russian, Spanish, and Italian, have afforded us substantial proof that the book has met the requirements of many of our colleagues. We earnestly trust that in this new edition they will find some important advances, as we have constantly submitted our methods and the descriptions of them to the test of fresh experience. We desire to draw special attention to the improvements in the descriptions and illustrations in the domain of abdominal surgery. Our methods of resection of the stomach, for example, have now been so far perfected that a greater frequency and certainty of success has been attained, and we have therefore had new illustrations of the operations prepared. With our radical operation for hernia we have also obtained excellent permanent results, and in spite of the objection formulated by Bassini, we would again warmly recommend it on account of its great simplicity.

We believe that we have made an important advance by introducing certain modifications in the operation of extirpations of the tongue and excision of the larynx, and we would draw special attention to these points, as they make the after-treatment much simpler and the result much more certain. The chapters on Anæsthesia, Treatment of Wounds, Trephining, Amputations, and Excisions, and numerous other portions of the volume, have been entirely rewritten. We have adhered to the principle of describing and recommending, to a large extent, only those methods of treatment which we have found worthy of adoption in our own experience. We are conscious that the book suffers from a certain one-sidedness as a result of this; but in the present edition we are confident that we have been able to give the practical surgeon trustworthy guidance, of which we believe he will not be slow to take advantage. Operative surgery, which was formerly in the hands of a few privileged persons, is becoming more and more the common property of medical men. It is, therefore, all the

more necessary that definite rules should be established for the performance of operations, in order that irreparable harm may not be done to patients by inexperienced hands. This may sometimes happen without a penalty being incurred, under cover of the aseptic method, through the agency of which even flagrant errors may escape exposure. The less frequently a practitioner operates, the more necessary it becomes that before each operation he should make himself acquainted with a clear and accurate description of the nature of the procedure. Our endeavour has been to supply this information.

Surgical technique has now attained a much greater importance than formerly, and it must inevitably develop still further. Only he who is a complete master of technique can derive the full advantage from asepsis. It is only by an accurate anatomical knowledge that it is possible to make full use of the wonderful advance in the department of local anæsthesia. Only perfect technique enables us to overcome whatever prejudice against operative interference still exists, now that the dangers of anæsthesia and infection have been effectually removed. May this book further conscientious endeavour in the performance of operations.

AUTHOR'S PREFACE TO THE SECOND EDITION

In expressing our thanks both for the numerous very favourable reviews of the first edition, and also for those written in a more critical spirit, we consider it necessary again to emphasise the fact that in writing this text-book we have aimed at making it not merely useful for teaching purposes, but also, in view of the author's extensive experience, a reliable guide to general practitioners and surgeons in operating on the living subject. It may be that the book loses in this way the definiteness of arrangement desirable for teaching. We are of opinion, however, that the student ought to learn everything in the way in which he will require to do it in practice.

We have described the methods of exposing some of the less important nerves and arteries because they run in the lines of incisions which have frequently to be employed. We refer especially to those incisions which we have described and illustrated as "normal incisions." Considering the serious functional results which often arise in consequence of incisions made by unskilful and unpractised hands, it does not appear to be superfluous to lay down definite rules for every part of the body. As it is probable that technical mistakes will be subjected to severer criticism in the future, we have in the case of the more important operations mentioned only those methods concerning which we possess reliable personal experience. Part of the descriptions have been taken down to dictation in shorthand by an assistant during the performance of the operation on the living subject. That which is of no practical use has not been mentioned, because the text-book ought to be a preparation for that examination to which the practitioner has daily to be subjected in his calling.

We crave indulgence from our specialist colleagues for not being able to do full justice to the work of other authors; but the complete recasting and extending of the work, especially as regards the illustrations, which have been mostly reproduced from operations on the cadaver and on the living subject, have occupied all our available time. Should a new edition

be called for these omissions will be filled in. Meanwhile, for comparative methods we must refer the reader to the excellent recent works of HEINECKE, BERGMANN, ROTTER, TREVES, and especially to the admirably illustrated work of ESMARCH and KOWALZIG.

The illustrations have been drawn with great skill, partly by the former artist, Mr. KEINER, drawing-master in St. Imier, and partly by Mr. WESSER. The woodcuts are the work of Mr. G. FISCHER'S able engraver. Our former first assistant, Dr. LARDY, now chief surgeon to the French Hospital in Constantinople, was good enough to construct the plate showing the normal incisions, which have since been somewhat supplemented. In the investigations upon cranio-cerebral topography I have been assisted chiefly by Dr. LANZ, and in the performance of the operations for the illustrations, in addition to him, by Drs. DUMONT, FLACH, DE QUERVAIN, MOSSIMAN, ARND, and others.

I am greatly indebted to my publisher, who has spared no sacrifice in perfecting the production of the book.

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SECTION I

GENERAL CONSIDERATIONS

A. INTRODUCTION

THANKS to antiseptics, we are now able to procure rapid healing in all sutured operation-wounds, no matter how extensive; and the result has been that operative surgery has made extraordinary strides.

As soon as we are certain of our antisepsis, we may cut down upon any part of the body, not only with a therapeutic but also with a diagnostic intent. It is all the more our duty, therefore, in view of the marvellous widening of the indications for operative treatment, to make our technique as perfect as possible, so that the first maxim of therapeutics—"*nil nocere*"—may be observed. A complete mastery of technique, which depends chiefly upon a minute knowledge of anatomy, is, next to a reliable antiseptic wound treatment, the condition most essential to the practice of operative surgery. In practice it is not possible to study anatomical handbooks and atlases previous to every operation; moreover, these text-books are generally written from the purely anatomical standpoint, and do not pay that close attention to details which the surgeon desires. It is not, therefore, our intention to add to the many excellent text-books of operative surgery one still more detailed, but we purpose to produce a book, after the plan of Rosser's excellent *Vade mecum*, which shall be as succinct as possible, and suitable for rapid reference regarding any particular operation.

Although this book may be used as a guide to operations on the cadaver, the performance of operations on the *living subject* has been especially kept in view, and therefore only those methods which the author's large clinical experience has proved to be trustworthy and reliable have been recommended. We do not wish, however, to put forward our methods as better than those of other surgeons; on the contrary, we hope to introduce methods which have been overlooked, and also to give due credit to the originators of operations which we have described, as well as to those who have proposed other methods. We crave indulgence also for having omitted to deal more fully with the historical development and significance of different methods of operation.

The most important task entailed in the production of a text-book of operative surgery, which is to be of value as a guide to operations on the living subject, appears to us to be to place the reader in a position to obtain ready and accurate information regarding the route which the knife has to follow in cutting down, however deep, into every region of the body.

The most important point to be considered in surgical interference is the making of *incisions* in a direction most calculated to give free access, and at the same time to avoid unnecessary injury, to adjacent structures. We must learn to avoid not

only the vessels, but also the large and small nerve branches; in other words, we must choose for our incisions the frontier between neighbouring nerve distributions.

From this point of view, therefore, we regard certain incisions as typical for special regions of the body; that is to say, they are the only incisions permissible when a free choice is open to us. It is the laying down of simple rules for the performance of more accurate and more sparing procedures that we consider valuable in our contributions.

Excisions or *resections* constitute a second group of operations. Here we have to deal, not merely with incisions made for the purpose of reaching a deep structure by the most direct route, but with the removal from the body of a portion of tissue or an entire organ; the deeper parts must therefore be so exposed as to render the diseased area sufficiently visible and palpable.

Resections of bones and joints furnish the type of excisions, and along with them may be grouped the extirpation of internal organs and tumours.

The third group deals with the removal *in toto* of a terminal portion of the body, of greater or lesser extent. These operations are spoken of as *amputations*. A new indication is here added, namely, the provision of a definite form and skin-covering to the region from which the part has been removed. In consequence of the complete absence of the parts from one side of the wound, the steps to be taken in order to secure rapid union of the divided tissues are more complicated.

In the case of incisions, however deep, it is enough—antiseptic treatment being taken for granted—to bring the divided tissues into apposition again, so that they occupy the same position as before the operation.

In excisions, and still more in amputations, tissues are brought into apposition which were not previously in contact.

In incisions, all that is required in order to bring the parts into accurate apposition is the introduction of simple sutures throughout the entire depth and length of the wound-surfaces. This is best done by using a continuous suture and making alternately deep and superficial penetrations of the needle.

In excisions and amputations it is not possible, by means of sutures, to bring the surfaces of the wound in contact in such a way that parts which belong to one another are brought into apposition.

We have omitted all directions concerning the choice and form of instruments, the holding of knives, the handling of forceps, scissors, saws, etc., and the different methods of suturing. It is our conviction that no written instructions, however exact, are sufficient to educate a surgeon. These numerous details can be learnt only by looking on and by practising under skilful guidance in hospitals. The statements also, when and why vessels are to be tied, nerves to be stretched, joint-cavities to be exposed, joints to be resected and limbs to be amputated—in a word, the discussion of the indications for operations—must all be learnt clinically.

As we have written our text-book especially with the view of its being employed in operating on the living subject, we must say a word regarding the two chief conditions of every operative interference, namely, anæsthesia and antisepsis. It is no more justifiable to give a person pain during an operation than to endanger his life by the introduction of infective agents into the wound.

B. THE PREVENTION OF PAIN DURING OPERATIONS

1. Local Anæsthesia

The greatest advance made in the subject of anæsthesia since the publication of the last edition of this work is the marked improvement in the methods of producing local anæsthesia, and the widening of its sphere of usefulness. It is owing to the persistent advocacy of Schleich that cocaine, introduced into ophthalmic work by

Koller, is now so extensively employed. Schleich has proved that anæsthesia may be produced over a comparatively large area by a dose of this substance which is in no sense dangerous. If absolutely no risk is to be run, 1½ grains must be regarded as the maximum dose permissible at one time, as a lessening of pain can be obtained even with a ½ per cent solution; this allows of the administration of a sufficient quantity of a 1 per cent solution to permit of amputation, should it be desirable to perform such an operation under local anæsthesia.

H. Braun of Leipzig, and his colleague Heinze, published very important observations as to the methods of using cocaine, and also of *β* eucain, a substance introduced by the former. They have shown that it is necessary to employ an isosmotic solution in order to produce a successful and pure anæsthetic action without damaging the tissues by swelling or by the withdrawal of water. The determination of the freezing-point gives a measure of this isosmotic tension. The freezing-point of the fluids of the body is 55° C. A 0·9 per cent salt solution has a similar freezing-point. A pure cocaine action is obtained, therefore, by injecting cocaine dissolved in a 0·8 per cent solution of sodium chloride at the body temperature.

β eucain has the advantage of keeping well and of being easily sterilised, whereas cocaine, if it is boiled more than once, loses its anæsthetic properties.

Cocaine is generally used as a sterilised solution of the hydrochlorate in salt solution, warmed to the body temperature; it is introduced either by the infiltration method described by Schleich, or, for the production of regional anæsthesia, by the method described by Corning and Oberst.[1] In the first case the anæsthesia affects the peripheral nerve endings; in the latter it inhibits conduction in the nerve trunks supplying a section of a limb. In the first case a weak (1 : 2000) solution is employed, and the tissues to be divided are infiltrated by means of a syringe as the operation proceeds; in the second case (regional anæsthesia) a stronger solution (1 per cent) is required.

The infiltration method is much more easily carried out, since it is independent of anatomical knowledge, and is on this account very popular; but its application is troublesome, as it greatly prolongs the operation. Its chief fault lies in the fact that, as one cuts deeper, reinfiltration is necessary to avoid causing the patient pain, and, as we shall show later, rapid completion of an operation is of such great advantage that it is not lightly to be renounced.

For regional anæsthesia an exact knowledge of the topographical distribution of the nerves supplying the various sections of the body is imperative. This method is of the greatest service in the hand and foot, and especially in the fingers and toes. To render it useful for the other parts of the body an exact study of the course of the nerves is required. Dr. Cushing has been working in this direction in connection with abdominal operations, and has given exact directions as to the points at which the injection is to be made in order to be certain of involving the nerves.

A compromise between these two methods is the indirect method of peripheral anæsthesia of Braun, especially worked out and previously employed by Reclus. Here 1 per cent solutions are injected so as to act not only on the parts immediately involved in the injection, but also for a certain distance on the neighbouring tissues. To procure such a diffuse action requires, according to Braun, a 1 per cent solution at least; and this method has the advantage over those in which weaker solutions are employed that the anæsthetic action is maintained for a much longer time.

Kummer, Hölsher, Berendt, and Braun have drawn special attention to the value of simultaneously cutting off the blood-flow to the part in producing complete regional anæsthesia by Schleich's method. Schleich considers that regional anæsthesia is merely a variety of infiltration anæsthesia; he advises infiltration of the skin to allay the pain at the site of application of the tourniquet, and that the infiltrated fluid should then be massaged downwards towards the site of operation. By this means amputations may be performed painlessly.

[1] Krogius seems to have employed the same methods before Pernice's publication, and independent of these authors.

We have employed Reclus's method almost exclusively, and have used it very extensively when a general anæsthetic was contraindicated, for example in operations for goitre when there is marked dyspnœa. After we saw how well the operation was borne in cases under a local anæsthetic, we have, like Roux and Juillard, dispensed with choloroform or ether in hundreds of operations for goitre. We are generally able to comfort anxious and nervous patients by promising to induce general anæsthesia should they find the pain unbearable, and it is only very exceptionally, in quite unreasonable patients, and often to their detriment, that we have had to carry out our promise. The area to be anæsthetised is marked by scratching the skin with the point of the knife, so that the incision may be made exactly where the injection was introduced. The injection, which must correspond to the whole length of the incision, is introduced just under the epidermis, 1 to 6 syringefuls of a warm and sterilised 1 per cent cocaine salt solution being employed. The effect appears in less than one minute. In a thyroid operation of not very great difficulty, and therefore of short duration, the anæsthesia lasts long enough for the sensibility to be only very slight during stitching.

It has been a great satisfaction to us to find that the majority of the more deeply situated tissues are practically insensitive, and that when injured the sensation produced is unpleasant rather than actually painful. Only tearing, splitting, and crushing cause pain, while careful operating is often so absolutely painless that even intelligent children state that they have felt no pain. Nerves, and a few tissues such as serous membrane and certain fasciæ, afford exceptions. Tearing of serous membrane may produce unbearable pain, as is often evidenced in disease or swelling of the viscera.

We are indebted to Lennander for some extraordinary facts regarding the sensitiveness of the peritoneum. By careful observation during operations under cocaine, he has demonstrated that the sensitiveness of the parietal peritoneum is to be attributed to the twigs of the intercostal, lumbar, and sacral nerves which ramify in the subserous coat; and he has also proved that the stomach and alimentary canal, with their serous coverings and mesenteries, and also the gall-bladder, are not provided with nerves for perception of pain, touch, heat, or cold.

We have had exceptionally wide experience in the sensibility of the structures of the neck. Of the patients operated on for goitre there are not a few who remain quiet throughout the whole operation, although warned beforehand to give a sign immediately they feel pain. Yet certain parts, as we shall show elsewhere, are exquisitely sensitive, a fact which is demonstrated by the occurrence of very characteristic shooting pains. To prevent these, repeated cocaine infiltration, according to Schleich's method, may be employed when there is time for it. Indiscriminate infiltration of all the tissues is a procedure which both wastes time and increases the difficulty of recognising anatomical landmarks, and for many operations it is useless.

Provided one uses a properly heated, sterilised, and isosmotic solution of cocaine, no fact prejudicial to local anæsthesia can be brought forward. In this form cocaine causes no general symptoms, for the doses recommended have no poisonous effects, and, as the operation rapidly follows the injection, only a very small quantity is absorbed. Cocaine anæsthesia has for this reason superseded all other forms of local anæsthesia. Should it be desired to spare the patient the pain of the initial prick, or should a strong solution of cocaine not be available, one of the freezing methods may be had recourse to. In place of the ether spray, the ethylchloride (Kélèn) spray has recently come to the fore on account of its easy application. It is sold in little flasks with a fine opening and a simple stopper. Braatz has introduced an apparatus of his own for freezing the point of puncture. Where the operation is to be performed with a thermo-cautery, Kümmel strongly recommends fluid carbonic acid.

Cocaine is of no use in relieving the after-pain of an operation. Its action passes off within an hour or so, according to the strength of the solution. According to Braun, the addition of morphia, as used by Schleich, is inadvisable. The morphia acts merely after absorption, and not locally; it is, moreover, injurious on account of its different isosmotic properties. The older plan of treating post-operative pain

by subsequent injection of morphia is therefore preferable. The chief factors in avoiding post-operative pain are a pure aseptic technique, the avoidance of injury to the tissues, whether mechanical, thermal, or chemical (by the use of isosmotic solutions at the body temperature), the closure of the wound in such a way as to avoid abnormal pressure and tension from the stitches, the proper position of the injured part, and the prevention of accumulation of blood serum.

Infiltration and regional anæsthesia have their limitations. There are a large number of cases in which it would be impossible to induce true analgesia over the whole field of operation. For a number of these resort may be had to direct cocainisation of the large nerve trunks. Dr. Cushing has amputated through the leg after exposing the great sciatic nerve through a small wound and injecting the nerve trunk with cocaine. The long saphenous nerve was anæsthetised by a separate injection.

This procedure is worthy of consideration, since it is free from any special disadvantages; but its application is limited to the extremities where the large nerve trunks can be exposed at the attachments of the limbs. It is only occasionally applicable for operations at the junction of the limbs with the trunk or on the trunk itself, although it must be admitted that, by careful study of the course of the nerves, its field of usefulness might be much increased, for even small nerves close to their exit have a definite anatomical position. It is, for example, difficult to understand why, in the light of Lennander's demonstration, the parietal peritoneum, which alone is sensitive, should not be rendered sufficiently insensitive, by cocainising the trunks of the intercostal, lumbar, and sacral nerves, to render an abdominal section perfectly painless.

A fourth form of local anæsthesia, known as *medullary anæsthesia*, promised a complete solution of all difficulties. Bier conceived the ingenious idea of rendering a large number of nerve trunks (even the spinal cord itself) insensitive by injecting the lumbar subarachnoid space.

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 (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, 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, due to wounding of the extradural plexus of veins.

When the injection has been accomplished complete anæsthesia of the parts of the body below the level of the injection results in from ten to fifteen minutes. This includes the parts supplied from the lumbar and sacral regions, and in exceptional cases may include 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 the patient feeling anything.

There is no doubt something very attractive about it. In the first case in which we employed this method we did not tell our students anything about the injection. We performed an excision of the ankle, which was very much inflamed, in a child much given to screaming. During the operation the patient ate and discussed his family affairs with an assistant behind a curtain which hid from him his diseased foot.

Unfortunately, not only is the anæsthesia not always so complete, but symptoms

appear in a few hours which far exceed in unpleasantness the sequelæ of general anæsthesia. The principal disturbance is severe headache, often lasting several days, and frequently accompanied by vomiting. To this is almost invariably added a rise of temperature (to 104° F.), which is particularly liable to cause an erroneous impression of the state of the wound. It generally falls the next day.

In isolated cases more severe after-effects have been noted. These 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

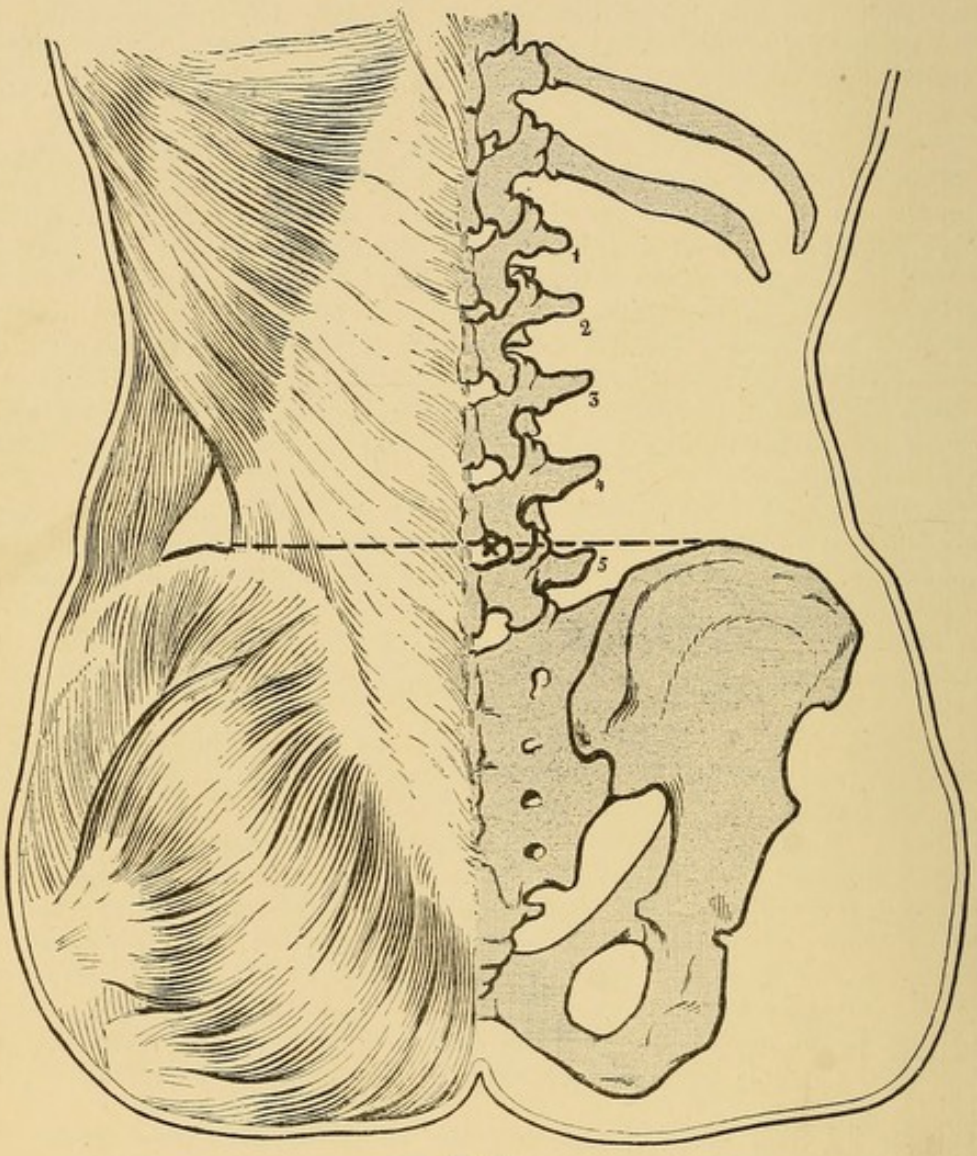


FIG. 1.

extremities. Fever and rapid respiration and pulse continued in one case till the third day. In a few cases transitory motor paralysis was observed.

Two serious results of this form of anæsthesia still require to be noted. The first may seem questionable to many, but we have noticed 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 did not 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 which cocaine has 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 general anæsthesia.

Every one is not so fortunate as Bier to be able, in their 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 bad results from using tropa-cocaine, as strong as 0·05, instead of cocaine.

2. General Anæsthesia

For many patients general anæsthesia has the advantage over mere local anæsthesia that they neither hear nor see the preparations for the operation. Fortunately the advances of research have put us in possession of substances which, in the vast proportion of cases, render general anæsthesia quite as safe as local anæsthesia, and certainly less injurious than medullary anæsthesia. Confidence has gradually come to be placed in certain definite contraindications for the use of this or that anæsthetic, and attention to them helps to remove that distrust of general anæsthetics which even experienced surgeons have formerly felt.

Schleich is certainly right when he points out that the possibility of effecting local anæsthesia makes it, for us, a matter of conscience to ascertain, in every case, that the anæsthetic we choose is free from danger to life. But when he makes the statement that in his experience it is never necessary to employ a toxic dose of cocaine, we too, on the grounds of our experience, maintain that the same holds true for general anæsthetics, for chloroform as well as for ether. Some very experienced surgeons (*e.g.* Kümmel) have had unpleasant experiences with cocaine. With any anæsthetic whatever, the toxic dose for the particular case must not be reached if unpleasant results are to be avoided.

Extensive and impartial statistics, such as those of Gurlt, published by the German Surgical Society, have proved that, if attention be paid to certain very definite contraindications, which can be precisely ascertained, ether, however administered, is a comparatively safe anæsthetic. A few medical schools, such as those of Lyons and Boston, have remained loyal to this substance (introduced by Jackson and Morton in 1846) in spite of all the advantages of chloroform [1] (first used by Simpson in 1847), and a number of surgeons, especially Juillard (Comte), have joined (since 1875) in praising ether on the ground of long experience.[2] Quite recently a number of German surgeons—Dumont, Roux, Steltzner, Bruns, Garré, Trendelenburg, and others have turned their attention to ether, and have studied the most advantageous method of administering it. The relative safety of ether is now so well recognised that patients who have to undergo an operation not infrequently ask what anæsthetic is to be given, and are reassured on hearing that ether will be used. A large number of competent surgeons have in recent years expressed the opinion that they never understood how quietly patients would take an anæsthetic until they said "good-bye" to chloroform and introduced ether in its place. Anæsthetists who, like Freemann in Bristol General Hospital, have had much experience of both drugs, also express this opinion.

[1] Collins Warren has made some interesting observations on the history of ether anæsthesia. As early as 1805 Warren ordered inhalation of ether to relieve the breathing in phthisis, and starting in 1842, Dr. Long induced ether narcosis for small operations, but it was not till 1846 that J. C. Warren, at Morton's instigation, performed the first large operation under ether.

[2] Schiff claims to have "induced the first true and complete ether anæsthesia" in Geneva.

Where, as often happens, an anæsthetic must be given under very unfavourable circumstances, or where at any moment an anæsthetic may be required, or where it is necessary, as in a teaching hospital, to give an opportunity of practising the methods of giving anæsthetics, an occasional unfortunate occurrence with chloroform cannot be avoided. One proof of this is the number of deaths from chloroform in a few countries where they are very conservative in the use of this substance. Another proof is that in hospitals the greater number of deaths occur in small operations because the patient is chloroformed by young and inexperienced doctors. Our experiences on this point are very striking.

Chloroform is a much more intense poison than ether, and there are exceptional individuals who show an idiosyncrasy to every poison. All experiments (Hyderabad Commission) which seek to prove that chloroform always causes first an arrest of respiration, and through this an arrest of the heart, are contrary to the experience of surgeons, even in persons in whom after examination no defect of the heart or respiratory system has been demonstrable. 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. Some 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 even a few additional 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 be brought about even if the influence of the brain be excluded, and Winogradoff and Schmidt have referred it to disease of the heart ganglia. Besides these, numberless other experiments (English Chloroform Committee, Wood and Hare, Schmey, Kronecher, and others) have produced proof that chloroform can cause death as a pure cardiac poison. Kronecher and his fellow-workers have shown that the co-ordination centre of the heart itself is paralysed, and in dogs does not again recover.

Nevertheless, all these experiments which appear to disprove the possibility of cardiac paralysis of medullary origin do not preclude the possibility 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 stand. The action of chloroform too little diluted with air is the cause of the bad effects, which may be referred to reflex influences through trigeminal and vagus twigs in the nose, larynx, and lungs on the cardiac and respiratory centres, but 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 chloroforming, as long as the access of fresh air is allowed. According to Cushny, also, death from cardiac arrest is avoided by administering chloroform in proper dilution. It only then 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 Kronecher). 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.

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 persons 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]

We prefer to use our own mask (Fig. 2), which, 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 used. This method, which was recommended by us a year before the publication of Zuckerkandl's paper in the *Correspondenzblatt fur Sweizeraerzte*, in ignorance of Leon Labbe's publication, is now, employing Kappeler's apparatus, the method in general use. It permits of such a dose being administered to any patient as will induce narcosis without risk. Yet even with this safe method of administration, which gives protection against immediate danger to life, chloroform being a strong poison to the organs is attended with secondary dangers. The worst calamity is sudden death at the early stages of narcosis in relatively healthy individuals. That these deaths may be avoided, every surgeon who has seen thousands and thousands of chloroform cases without one such accident will affirm. Bardeleben, after 30,000 cases, had his first experience of such a death. But, at the same time, 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.

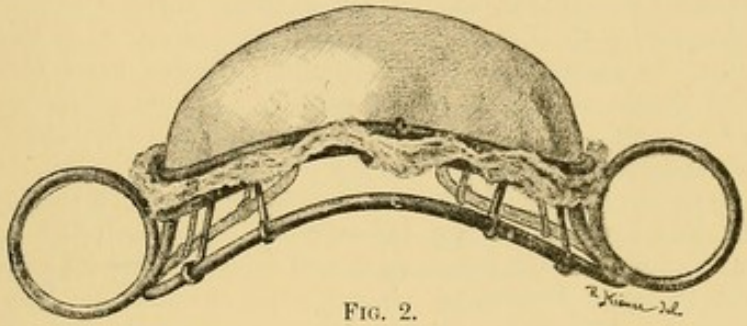


FIG. 2.

Even careful surgeons are still confronted with the great difficulty of keeping up 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 continued for a long time, degenerative processes are set up in the vital organs. These changes appear in certain subjects with chronic constitutional or nutritional disturbances, and generally pass off without permanent effect within 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 have only recently received the attention they deserve. Since Fischer and Thiem drew attention to them from having experienced an unfortunate case, a number of observers have furnished experimental proof of their causation.

[1] Ratimoff, working under Kronecher, 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 kept up for several hours, and for a longer period this required increasing 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 required 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.

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 most 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 found that the different narcotics act by combining with the lecithin and cholesterin-holding constituents of the cells, whereby they bring about a change in the physical condition of these cerebral fatty matters, even the loss of the function.

Kast and Mester have shown that there is destruction of albumen, 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. This may be counteracted by naphthol, washing out of the stomach, and 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 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.

That individuals with fatty livers, kidney disorders, digestive disturbances, chronic poisonings, such as Basedow's disease, etc., should be especially liable to the dangerous sequelæ of general anæsthesia is therefore easily 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 brings about 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, when administering chloroform, to guard against the occurrence of syncope, it is equally important not to expose the patient's life to the risk of these after-effects when the operation to be performed is likely to be a

lengthy one. And 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. To persons with cardiac disease, and in those who are reduced by illness and are anæmic, and whose cardiac action is weak, it should not be given. It is dangerous in operations of long duration, in those involving considerable hæmorrhage, in subjects with chronic digestive disorders, as well as in those suffering from blood intoxication or constitutional disease. 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; he uses an apparatus devised by himself, which allows of the administration of air with the chloroform.

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 to whom, 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.

The dangers of chloroform can therefore be avoided, but experience, and a thorough examination of each individual case before its administration, is 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 the use of which 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 of chloroform. Respiratory disturbances and pathological changes in the respiratory organs are the contraindications of prime importance, as ether causes more severe and more lasting damage to the respiratory organs than chloroform does.[1] 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; 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 I have seen following ether occurred after operations on cases with marked tracheal stenosis, diseases of the lungs, or empyæma.

In cases dying shortly after the operation, with steadily increasing dyspnœa, it

[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 kept in the light.

was remarkable to observe how great was the hyperæmia of the tracheal and bronchial mucous membranes of even the finest tubes.

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, like chloroform, be credited with producing a tendency to pneumonia, though to a more marked degree than as Gottstein argues, these pneumonias should cease to occur when local anæsthesia is employed. But Gottstein (Mikulicz's clinic) has found that out of 74 non-abdominal operations under cocaine, 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 done under cocaine 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-Oietrozowski theory, viz. that pneumonia in these cases results from emboli, which reach the lungs either through the liver, or through direct 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 of great importance, however, is the fact that the bad effects of ether on the lungs is in large part avoidable, since it depends on 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 of some impurity (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.

Grossman 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, colours 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.

[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.

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 also no hyperæmia. He finds, too, that however marked salivation may be, no mucus is secreted.

In cats, on the contrary, 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 and ether (does he make an exception in the case of cocaine?), but for the most part he considers them the result of aspiration of infected material, and of this he brings forward 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.

We 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 narrowing of the respiratory passages contraindications to the use of ether. 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. Schmidt (Kronecher) points out how well animals, which otherwise suffer from severe catarrhal affections of the air passages, bear ether administered by Kronecher'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. These evils 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 (Kronecher) 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 $7\frac{1}{2}$ 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 (5 to 7 per cent vols.), ether has no bad effects on the respiratory organs, but that in this form it is not always powerful enough to induce complete anæsthesia. In cases where the properly diluted mixture is not strong enough, 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 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 children by 10 to 15 grams of bromethyl, and in adults by 20 to 30 grams, 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. To administer bromethyl we use a medium-sized impermeable mask.

We are well aware that deaths have been recorded from its use, *e.g.* those of Köhler, Billroth, and others. We have never seen anything to cause us any anxiety when using Haffter's doses; but we use only one small dose, and never pour on more, as it is only by prolonging the bromethyl narcosis that we feel there is any danger.

Regli has described a deleterious action on the kidneys and lungs after the use of bromethyl alone, and, in the case of drunkards, he has entirely failed to induce narcosis deeply enough to ensure muscular relaxation. Abouig and Baraez 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 slight depression caused by bromethyl, chloroform rather accentuates it.

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

The drop method of administering bromethyl prior to ether should remove the last objection to this procedure, if the maximum dose is never exceeded. We do not consider it adapted to all cases. Partsch's (Larisch) experiences are very much in favour of its use as a precautionary measure in all cases of heart disease and cardiac weakness where general anæsthesia is unavoidable. Under other circumstances 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) 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 far superior to medullary anæsthesia.

With ether alone there frequently occurs a period of marked excitement with screaming, struggling, and clonic and tonic contractions of the muscles, accompanied by difficulty in respiration and cyanosis. With the aid of bromethyl, on the other hand, the anæsthetist, after one or two trials, easily succeeds in avoiding any of these dangers. The period of excitement, the reflex action on the heart and respiration, spasmodic respiration, or arrest of both heart and respiration, are likewise excluded. We have never seen them occur.

Riedel obtained rapid and quiet ether anæsthesia with relatively small doses by

injecting $\frac{1}{12}$ to $\frac{1}{6}$ grain of morphia half-an-hour prior to the administration of the ether. Alcoholics require $\frac{1}{2}$ grain. These observations have been confirmed by Juillard.

Comte and Dumont consider pure ether anæsthesia faultless when induced in accordance with the Juillard-Dumont rules and with the Juillard-Dumont mask, but Kümmel gives preference to Czerny's mask.

For operations on the mouth and pharynx, or on the face, an apparatus such as that of Arnd and Souchon is to be recommended. Fig. 3, illustrating Arnd's apparatus, explains itself.

In a certain number of diseases there are absolute contraindications to the use of any general anæsthetic, as such could only be administered with uncertainty, and 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 (Baxer has collected twelve cases of death from diabetic coma following anæsthesia), and particularly the status thymicus.

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 generally 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. 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,[1] fatalities are particularly frequent.

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 undergone, as suggested by Escherich.

From our experience, our present position regarding the selection of an anæsthetic is as follows:[2]—

1. Every patient to be subjected to a general anæsthetic must be most carefully examined for the presence of organic disease. In all those conditions set forth above as acknowledged contraindications to general anæsthesia, an endeavour must be made to perform the operation under local anæsthesia; while in complicated cases it may be necessary to combine the different forms of local anæsthesia, from Schleich's infiltration method to anæsthetising the large nerve trunks, or nerve roots, by means of medullary anæsthesia.

In cases in which these methods do not suffice, or are not possible, and a general

[1] In these subjects a combination with the status lymphaticus is, according to Mobius, Spencer, and Schnitzler, frequently found.

[2] We need hardly point out that we presuppose absolute purity of each anæsthetic, proper storage, etc.

anæsthetic must be employed, this must only be entrusted to experienced hands, and should be limited, as far as possible, both as to the duration and depth of the narcosis. In such a case it may be advisable to give a preparatory injection of morphia, in order to limit as much as possible the dose of the anæsthetic to be used. The injection should always be given half-an-hour beforehand, in order that its action and any unpleasant effects which it may produce may be observed before the

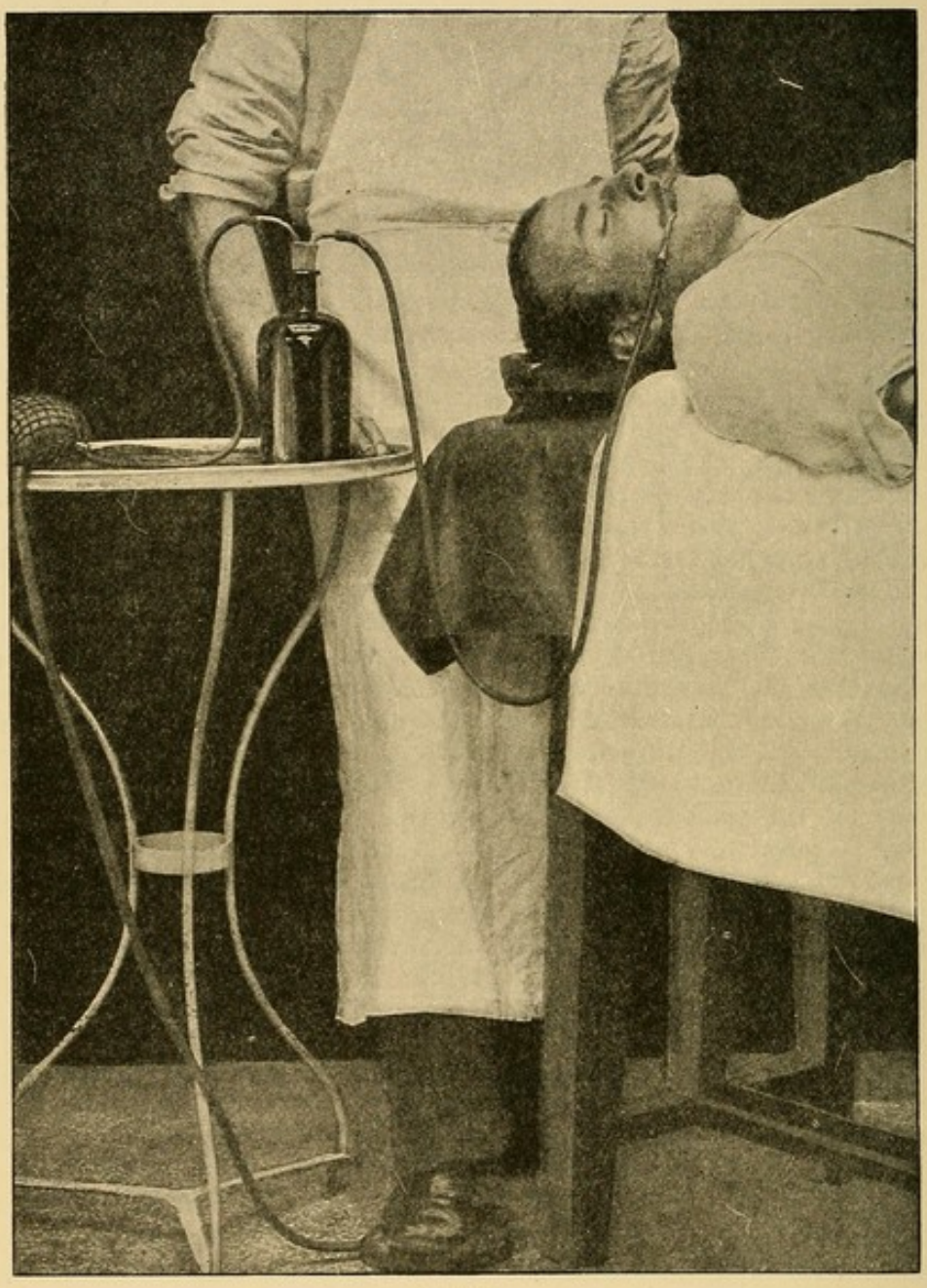


Fig. 3.

anæsthetic is administered. We have pointed out elsewhere that we always endeavour to avoid the use of morphia when respiratory troubles exist.

Up to a certain point local anæsthesia admits of combination with general anæsthesia. The use of chloroform is contraindicated in those operations of long duration in which temporary cessation of narcosis may occasionally be desirable, as experiments have shown that the heart becomes extraordinarily susceptible to the poisonous action of chloroform when it is administered repeatedly at short intervals.

Ether should therefore be substituted, and even this must be diluted with a definite proportion of air, and only administered in small doses.

The subcutaneous injection of brandy ($\frac{1}{3}$ to $\frac{2}{3}$ water), recently advocated by Poncet (Longe), or, better still, the method which we long ago adopted, viz. of administering stimulants, either tea or alcohol, is admirably suited to such cases. Poncet gives ten to a hundred injections during the operation, and Kümmel also recommends the combination of chloroform narcosis with large quantities of alcohol. Prolonged fasting should be avoided in these cases prior to operation; it is better to empty the stomach immediately before the operation.

2. Having excluded all contraindications to the employment of a general anæsthetic, the choice of the anæsthetic to be adopted depends on the presence or absence of disease of the respiratory passages. 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.[1] 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 usually sufficient, but success is generally ensured by pouring on measured quantities of ether, according to the effect produced on the patient.

By this method a quiet narcosis is generally obtained in five, or at most in ten minutes, and it is sufficient to carefully watch the conjunctival reflex and the respiration. The condition of the pupil is a valuable indication of the degree of anæsthesia. According to Kappeler, as sensibility disappears the pupil becomes small and immobile, 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 appears enough has been given; to give more is to court danger. Slowing of the breathing is also a sign to be cautious in giving more.[2]

Finally, stertorous breathing, complete muscular relaxation, and irregular pulse, indicate that the full permissible dose has been given. It is frequently difficult to obtain quiet and complete narcosis in alcoholic subjects. The difficulty is best overcome by a previous injection of $\frac{1}{3}$ to $\frac{1}{2}$ grain morphia. We, nevertheless, even in these cases, restrict the use of morphia as far as possible, 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. We have not made use of the addition of $\frac{1}{3}$ grain atropin, as suggested by Dastre, although this would appear to guard against dangerous reflexes (*e.g.* cardiac arrest) acting through the vagus; it certainly acts advantageously 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, injury to the respiratory organs is suspected. It should always be given by the drop method, beginning with minimum doses, and always with sufficient access of air; and its administration should be regulated by the condition of the pulse and the state of the pupils.[3] Inexperienced chloroformists should use Kappeler's apparatus.

[1] Special attention must yet be drawn to that contraindication to ether depending on its action in causing excitement and a rise in the blood pressure. Horsley avoids ether in brain operations on account of the severe hæmorrhage, and De Quervain has pointed out the danger of apoplexy. We wish expressly to state that we quite recognise that surgeons who have at their disposal reliable chloroformists have remained true to chloroform as the anæsthetic *par excellence* for inducing a quiet anæsthesia.

[2] Koblank has drawn attention to athetotic movements of the fingers as a signal for caution.

[3] Mikulicz points out that patients are very frequently much too deeply anæsthetised, far beyond the mere state of analgesia generally required.

Chloroform anæsthesia of long duration (*i.e.* in operations of more than one hour's duration) must be avoided under all circumstances.

3. The other conditions for safe general anæsthesia, besides strict attention to contraindications, are, avoidance of asphyxia and syncope; the former 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 must be guarded against by avoiding 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), 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 Francois 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. 2) for the thumbs, the fingers being kept in such a position that they are ready to grip the jaw. Obstruction from blood, saliva, or mucus is avoided by inclining the body with the head downwards, a position which also affords the chief means of preventing cerebral anæmia.

Food may be prevented from entering the larynx by keeping the stomach empty, either by fasting 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. Attacks of syncope are far graver than the danger of suffocation, and must be guarded against by prophylactic measures. 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. For some time past we have been in the habit of using an operating table which is constructed on this principle. 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 not be carried too deep at the commencement, and should be immediately stopped. In such cases general anæsthesia should, whenever possible, be replaced by local anæsthesia. 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 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. Operations should, therefore, be performed in a room pleasantly warm, and what is even more important is, that the patient's body should be kept warm. We use for this purpose a special operating table heated by filling it with warm water. To operate in that tropical heat so long fashionable is a mistake.[1]

Lastly, 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 better. 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.

Lastly, 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 Cirle has quite recently shown. Cushing has also noticed similar shock during anæsthesia when large nerve trunks are severed.

4. 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 two reliable procedures, viz. artificial respiration and transfusion. Artificial 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 Kronecher'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-laryngeal 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 it.

Of the methods in vogue for inducing passive respiratory movements, that of Schüller is, according to Djelitzin, the most efficient. 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.

[1] According to Allan a higher temperature is dangerous. In animals anæsthetised in a heated room the temperature rises while the blood pressure falls markedly.

Sylvester's method, also very effective, 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 ; this causes inspiration. For expiration he presses the approximated elbows with increasing force against the chest wall.

Of the methods of pumping air into the lungs Kronecher'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 beautiful 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 stopped.

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 go on beating after the brain is paralysed depends on the fact that the circulation may persist longer in the coronary arteries, owing to their relation to the heart.

It is worth keeping 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 much better 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.

We direct attention to the description of the operation table we use for this purpose.

According to Hill it is far more important 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. On this account Hill recommends pressure on the thorax, with the heart to be filled and 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 a general anæsthetic, especially when chloroform is used and 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.

Attempts at resuscitation, in all cases in which the blood pressure has fallen, should be conducted with the body inclined at a moderate angle, and should be furthered by regular compression of the abdomen and mechanical emptying of the heart. König 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 direct massage of the exposed heart, as recommended by Prus and carried out by Tuffier 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 out of forty-four artificially suffocated, although respiration had ceased for one hour. 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 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 Kronecher's direction.

Some of our clinical experiences are 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 espiration 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 bad. 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. Mention must also be made of Gottlieb's experiments. The blood pressure may be permanently improved by repeated injection of a 10 per cent sol. of suprarenal extract. He got 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 a few c.cm. of 1 per cent solution of suprarenal extract is more efficacious than any other means of resuscitation.

How far we are called upon to use powerful electric shocks in the treatment of cardiac arrest must, in the present state of our knowledge, be left to further experiments.

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 vaso-motor paresis (Hill), transfusion is more strongly indicated than any other treatment. If, as Winogradoff and Schmidt-Kronecher 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.

The improved methods of giving ether have rendered the use of methylchloride 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.cm. 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. Aertze.*

In 1896 Soulier discussed the subject and recommended it. Several years ago we gave it a trial for general narcosis, with ungratifying 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.

With regard to mixtures of different anæsthetics little need be said. As 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, given 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 upon the fact that they are comparatively safe anæsthetics. If used separately a much more reliable opinion of their value would be formed.

Braun has recently introduced an apparatus for giving chloroform and ether mixtures. It has this advantage, that 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 deeply enough under with the mixture, the chloroform cock can be opened more, and the patient can, if desired, be anæsthetised by Junker's method. 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.

A double bottle is used (150 c.c. of ether and 40 c.c. of chloroform) and 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 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, ether is contraindicated, and chloroform should be substituted. This is the principle on which his apparatus is constructed.

Braun has thus reintroduced, in an improved form, a method which we used some time ago, viz. of giving chloroform followed by ether; and in spite of the deprecatory opinions expressed by some, our procedure has been justified by this eminent experimenter and authority in the realm of anæsthesia.

Quite recently Matthaei has recommended alcohol narcosis. The alcohol is administered at a temperature of 50° to 60° C. by means of Kappler's apparatus, an enema of $\frac{1}{3}$ alcohol in water having previously been given. An alcoholic requires to take beforehand a bottle of strong wine. It is a method which may be tried when there are positive contraindications to the use of chloroform or ether. We have had a death during an excision of the thyroid in a cretin with marked tracheal stenosis. The operation was commenced without an anæsthetic, but on account of his unruly conduct it had to be continued under a general anæsthetic. In cases like this, where there is a double contraindication, alcohol narcosis might possibly be of value.

3. On Position

Although the question of correct position of the patient has been touched upon in several places in connection with the subject of narcosis, yet it is well worth adding a few remarks on this highly important subject under a separate heading.

Position is not only of great importance during narcosis as a general precaution against inspiration of saliva, etc., through the sensitive larynx, but also as a preventive to cerebral anæmia, when the blood pressure is lowered. Its importance is greatly increased, both during and after operation, in cases where blood and exudations are liable to be inspired and carried into the lungs along with the natural fluids of the mouth.

In considering resection of the upper jaw, at the Surgical Congress in Berlin in 1901, Professor Krönlein justly laid stress on the incomparably better immediate result of the operation at the present time in the hands of experienced surgeons in all countries as compared with that of earlier times. This great improvement is due to the precaution taken against pneumonia. The dangers may be readily surmounted by avoiding the use of a general anæsthetic during the whole or the second part of the operation. But we have had twinges of conscience every time we have, for fear of complications, allowed a patient to suffer the severe pain of a jaw operation. In operations in the area of distribution of the trigeminal nerve, anæsthesia requires to be particularly deep.

To operate on a patient held in a sitting position, as Gussenbauer does, is open to criticism, on account of the risk of cerebral anæmia.

The inclined posture is therefore the only other position in which complete

anæsthesia may be induced without danger from cerebral anæmia or fear of aspiration, but it must be specially noted that this inclined position of the body is not to be confounded with Rose's "hanging-head" position.

Rose, in his method, did not make full use of his originally excellent idea, for the chief importance of this position does not lie in the "hanging" of the head, but in the inclined position of the trachea, its upper end being at a lower level than its lower end; there is thus, as Hölscher showed, very little flow into the bronchi except at the end of a deep inspiration. In the inclined position the head is placed higher than the throat, so as to avoid the great disadvantage of operating with the head hanging; venous hæmorrhage, which occurs when the head is in this position, may be so excessive as to demand a hurried change of position in the middle of the operation.

The above advantages of a sloped position of the body should be made use of in all operations in the region of the head. As Riedel points out, it is particularly serviceable in hare-lip operations, and it is the correct position for operations on the tongue. This simple means at once rids us of the trouble of blood, etc., flowing down into the larynx. It is equally useful in operations on the larynx, pharynx, etc. In considering these operations later, it will be pointed out that, by this position, Trendelenburg's preliminary tracheotomy, as an expedient to secure quiet anæsthesia and as a preventive to aspiration, may be dispensed with. Many surgeons agree with this view, as tracheotomy decidedly predisposes to pneumonia, and should therefore be avoided as far as possible.

The inclined position of the body, introduced by Trendelenburg, was recommended, not on account of its influence on narcosis and as a preventive to aspiration pneumonia, but because it greatly facilitated the operation in other ways. By the simple inclined position, the abdominal viscera can be kept at a distance from, or close to the field of operation; either may be required, depending on circumstances, but it is more frequently the former which is desired, and it is with good reason that gynæcologists have made full use of the possibilities offered by this procedure. It is no less useful in operations on the intestine, especially those on the rectum and bladder. But, as we have pointed out, if full benefit is to be derived from position, we must not stop at inclining the whole body, as, for instance, in the case of elevating the head while keeping the throat low; in many operations it will be found advantageous to elevate only limited parts of the body, while other parts are left dependent.

There is nowadays hardly a clinic or an operating room in which there is not a table that can, according to requirement, be depressed either at the foot or at the head; but if full use is to be made of such a table, individual parts of it must be capable of elevation, not only the head end, which was always movable in the older tables, but also sections for the throat, the upper part of the thorax, the upper part of the abdomen, the waist region, and the pelvis. A consideration of thyroid operations, cholecystotomy, nephrotomy, and operations for deep pelvic tumours, will show the advantage of such segments.

A good operating table should be so constructed that it can be heated, that the body may occupy a sloped position (the opposite to that of the old tables, where the head lay highest), that the slope can be increased or decreased as desired; further, it should consist of several divisions, each capable of being separately elevated by a simple mechanism.

The advantages to be derived from correct position of the patient after operation are not universally appreciated. Even after the most serious operations in the region of the throat, we have found that aspiration pneumonia may be avoided by maintaining a dependent position of head and thorax until swallowing is again possible.

Fenger Just and Alfred Madsen, of Copenhagen, have designed an operation table capable of being heated, the top of which can be moved in its long and transverse axes after the fashion of Doyen's table, and which, at the same time, allows the head and pelvis to be raised independently of each other.

C. TREATMENT OF WOUNDS

The *principles* of the treatment of wounds which are laid down in the third edition of this work have, of course, remained unchanged. We can only repeat that all operative skill is entirely wasted unless sufficient attention be paid to the prevention of wound infection.

After Fr. Schultze, Schwann and Helmholtz, Schröder and Dusch 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 kept away from it, Pasteur laid down the broad principles of the observation that no decomposition of organic material occurs without the presence of living germs. Numberless 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 principles of 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." Lister, with due caution, pointed out that these organic particles are really germs capable of development.

Koch has enabled us to discover, in individual cases, the germs which cause wound infection, and to study their action more closely. 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 improved methods have enabled us 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 without.

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, thanks to Volkmann's enthusiastic initiative. But in spite of the enormous amount of work contributed in the last decade to advance the methods of treating wounds, a complete understanding of the best means and methods has only been reached in a few directions. In other directions the views held are various and uncertain. So much has, however, been ascertained that we can with absolute certainty prevent infection of our wounds by antiseptic precautions, in other words, by disinfection of all the materials necessary to the treatment of wounds, and especially of everything which falls 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 very simple ones, which enable us to observe the requirements mentioned above, not only in the elaborately furnished cliniques and operating theatres, but also in the simplest and most humble conditions in practice.[1]

As regards the instruments, dressings, and lotions, they can be completely sterilised by 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

[1] We are not, like Walcher, much 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 are hanging round 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 commotion made to prevent menstruating nurses from attending operations was most just. The demarcation of our aseptic field of operation, as we understand it, is best illustrated by the accompanying figure. It shows in an operation for goitre how the rest of the body is shut off from the site of operation by means of sterile sheets.

Lister's antiseptic treatment, is thus abolished. 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 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. If this be allowed to act for fifteen minutes at 120° to 125° C. perfect sterilisation is obtained, as Tavel and his pupils have demonstrated.[1]

The prevention of infection of the dressings after sterilisation and before use was for long overlooked and neglected. Only those materials can be regarded as

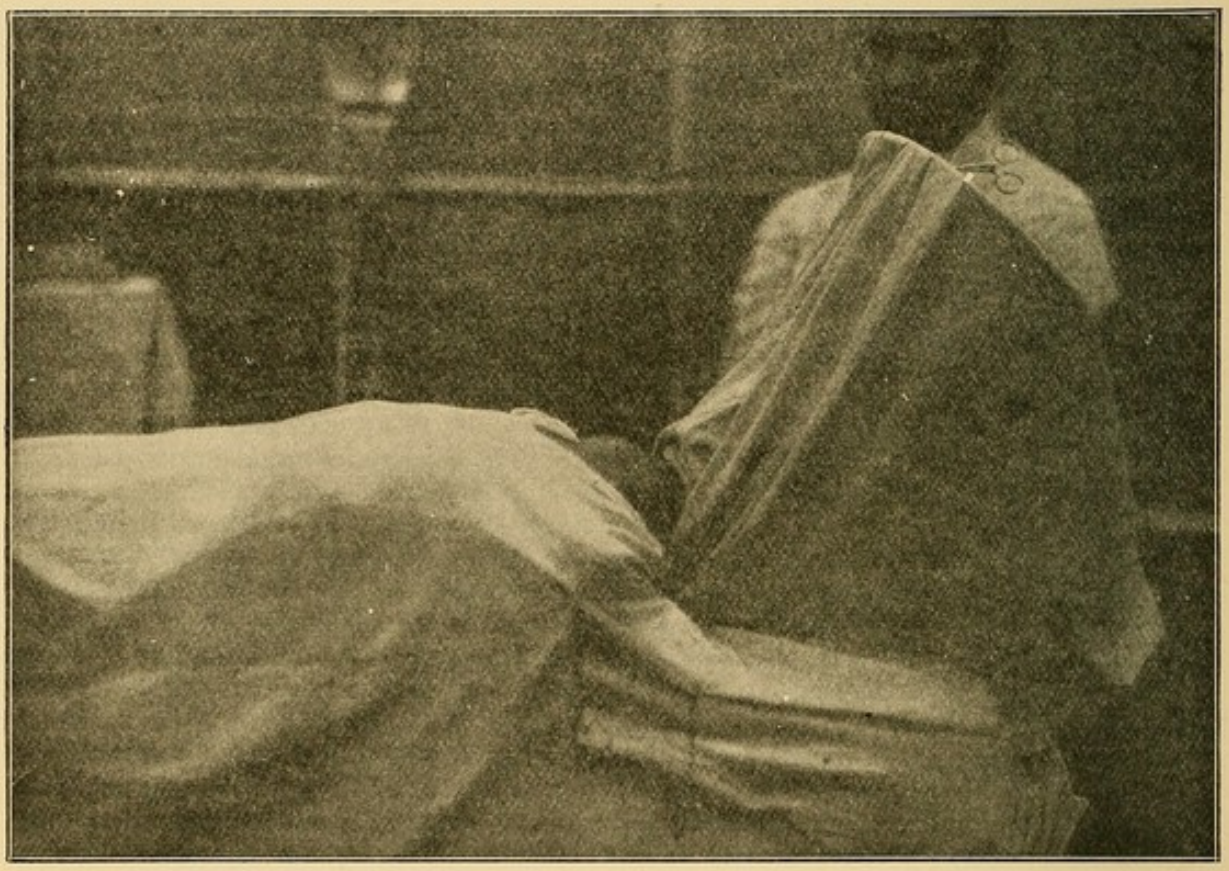


FIG. 4.

completely sterilised which have been taken directly from the boiling or steaming apparatus and applied to the wound. It is a mistake to store the dressings for any length of time. The same rule holds good for instruments and lotions, and the latter especially must be taken direct from the boiling apparatus and applied to the wound without being poured from one vessel into another for storage.

Cases in which sterilisation of the materials to be used immediately before performing an operation is impracticable very 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 can be carried out with an apparatus which, at the end of the disinfection process, can be completely shut up and easily carried without disturbing the contents. Schimmelbusch's apparatus[2] is,

[1] Braatz has directed attention to an important point in sterilising by steam. The dressings should not be warmed beforehand as is customary. If this is done, the steam becomes further heated, and is thus no longer saturated, but rendered useless. This also applies to steam not under pressure.

[2] It has been improved by Braatz.

on account of its simplicity, deservedly popular. The best procedure, however, is to sterilise the whole of the requisite materials immediately before the operation.

It is, unfortunately, impracticable to extend sterilisation to every object coming into contact with a wound, for the human body will bear neither boiling water nor steam. Owing to these circumstances, the patient's skin, as well as the surgeon's hands, which are brought, during the operation, into such 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 questions are generally grouped under the heading of purification of the hands, and the question of the possibility of a perfect disinfection of the hands has given rise to the most lively discussions at the meetings of various learned bodies. The grouping under this title does not seem to be a very happy one, since the question involves not only the cleansing of the surgeon's hands and those of his assistants, but also 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, and receives at the last a few douches of corrosive lotion. Such proceedings imply a contradiction. It can only be partially excused on the grounds that infection carried by the surgeon's hands is wont to have much more serious results than infection originating in the patient's skin. We shall return to this point later; in the meantime we shall only point out 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. This conclusion, which has been arrived at as the result of the most careful research, has led to an attempt to entirely avoid direct contact with the wound by putting on gloves.

The question of operation gloves has found as many supporters as opponents, and the want of agreement is to be explained by the fact that the two factions have set about their tests in different ways.

There is, however, scarcely a single dissentient from the view that by wearing sterilised gutta-percha gloves all danger of infection from the hands is done away with. Halsted was probably one of the first to employ gutta-percha gloves regularly. But no one can deny that these gloves (even the improved form introduced by Friedrich) have their disadvantages, for not only are they very costly, owing to the fact that they wear out so quickly, but they interfere with the sense of touch and also with the finer movements of the hands and fingers. Nevertheless, gutta-percha gloves have maintained their reputation on account of the certainty with which they guard against infection, a certainty which should assuredly be sought in other directions than in preventing contact of the hand with the wound.

The objections against gloves are especially directed against the permeable ones introduced by Mikulicz. No one would wish to maintain that cotton or linen gloves are able to keep out germs from the wound; certainly no one could who had made a series of experiments on the number of germs in gloves during and after an operation. We can assert definitely that it is the rule, after an operation performed under the most approved and correct technique, for gloves sodden with fluid or blood to be full of germs, generally the staphylococcus albus, the one most commonly found in human skin. This, of course, does not prove that a permeable glove may not be of use in virtue of this very power of absorption during an operation. For if germs are present and remain entangled in the glove, there can be no question but that so many less will be left in the wound; and since it is an established proof that practically no multiplication of germs takes place in the gloves during the time occupied by an ordinary operation, we might even admit that the absorptive property of gloves is an advantage, although we do not care to pay too much attention to such a possi-

bility. 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 each 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.

There are no micro-organisms on the surface of gloves when they are removed from the steriliser. For this reason they are of great value, and in my 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 I 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. Haegler [1] has proved that even when the hands have been most carefully cleansed and sterilised, 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.

In addition to this particular use of gloves, namely, during the application of ligatures and sutures, by far their most important application is to be found in their general use as a prophylactic measure. This brings us back again to the subject of disinfection of the skin without gloves.[2]

Although we must definitely admit that no method at present in use can render our hands free from germs, yet it is universally held that at every operation, and whenever a wound is touched, the skin and hands require purification in a special sense. If the distinction between *sterilisation* (freedom from all germs) and *disinfection* (freedom from pathological germs, or germs capable of development)—a distinction which seems both practical and useful—be maintained, it is possible that we may yet get as far as 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 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.

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

[2] We put such high value on repeated thorough washing of the hands at an operation, on account of the chance of contamination, that we have not yet been able to bring ourselves to try varnishing our hands, as advised by Menge (paraffin), Kossman (chirol), and Levai.

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.

Bruner 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? We place the highest importance on that which gynæcologists have designated "abstinence." But we use the word in a much wider sense, 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 gutta-percha 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 Sweife points out, on the grounds of Krönig and Reinike'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 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, either from want of water or of the necessary adjuncts.

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 1-500 sublimate solution for ten minutes. It can be proved that virulent organisms are in that way rendered sufficiently innocuous, 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.

Our methods of disinfection are based upon Fürbringer's procedure, which has received much furtherance in the clinics of Reinecke and Zweifel, and has found so enthusiastic an advocate in Ahlfeld.

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. Every uncovered particle of skin is then thoroughly scrubbed with 85 per cent alcohol, 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. Lastly, the alcohol is washed off with a stream of warm sterile water. 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 cleansed after use, are placed in it. With the above precautions taken we have never been able to find any necessity for 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; a brush with soap and hot water, followed by alcohol, suffices to clean even the dangerous crevice beneath the nails.

In this method we do not ascribe the chief importance to any disinfecting property peculiar to the alcohol, although, according to several authors, alcohol diluted with water undoubtedly has this attribute.[1] 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. We do not think that the same result can be obtained by using spiritus saponatus (Mikulicz),[2] or a strong alkaline marble dust soap (Schleich's) without alcohol. And, moreover, our hands suffer far more from repeated washing with strong alkaline soap than from the method of treatment detailed above.[3]

After what we have said it is hardly necessary to point out that the skin of the

[1] Braatz has recently attached great importance to the alcohol treatment, because he says that the alcohol renders the air in the skin ten times more easily absorbed, and so exposes the skin much more thoroughly to the action of disinfectants. It should be noticed, however, that we employ no disinfectant after using the alcohol. Schiller has pointed out that alcoholic colouring solutions are much more rapidly washed out of threads than are aqueous ones.

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

[3] 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 through a layer of wax easily, while it was proved to materially hinder the action of chemical antiseptics, exactly as Paul and Sarwey had described.

patient requires cleansing for some distance around the field of operation, in exactly the same way as the operator's hands. 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. 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), it would be as wrong to forbid preparation with antiseptics as in the case of accidental contamination of a wound during operation. 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 thermo-cautery. Otherwise a severe infection is very liable to occur. When coarse, wrinkled, scaly skin is involved in the area of operation [1] it must be thoroughly saturated with an antiseptic, since a mechanical removal of the organisms is impossible. The skin should be washed in sublimate lotion, or an antiseptic fomentation of carbolic or formol-glycerine should be applied one to two days beforehand, and even then the prognosis with regard to infection should be very guarded.

It appears to us that 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 himself, 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. To prevent infection by this means, every one taking part in an operation should thoroughly clean his mouth and nose beforehand, and if suffering from a cold or tonsillitis should absent himself. It is important that these pre-

[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.

cautions be taken by the patient also. 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. Fig. 4 illustrates the method we employ 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. We have not seen our way to employing the muzzles introduced by Mikulicz for the surgeon and his assistants, although we would ascribe the same significance to covers for mouth, nose, and beard as we do to permeable gloves; they 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 have always sufficed for us if care be exercised. It is worthy of consideration that the patients, by thorough mechanical cleaning of the teeth and antiseptic gargling, materially lessen the risk of aspiration pneumonia after narcosis.

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;* we shall discuss it later.

That *air infection* is of far less importance than contact infection is certain; experiments, however, show that it has been accorded far too little importance. 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. 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[1] 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, for 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 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 lowering the vitality of the tissue elements and by this means favouring infection.

[1] 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.

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 the wound. 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 us more and more in 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 being readily absorbed 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 chemiotoxic action owing to the inclusion of chemical products which remain active even after sterilisation. Abscesses containing sterile pus may then form [1] and 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 very well 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 (specially Schäffer's formula, boiling in alcohol sublimate), and the cumol-catgut of Krönig. 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, which Keen regards very favourably.

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

[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 considering 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.

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 again that it is only antiseptically prepared silk 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), yet 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 the normal circulation is re-established by perfect union, which brings about the destruction of the bacteria in the neighbourhood and renders those in foreign materials harmless. 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.[1] 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.

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 fresh pair of sterilised gloves, or to prevent the ligature passing from hand to hand by using small glass holders (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.[2]

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 ten minutes in a 1 per thousand colourless neutral solution of corrosive sublimate.
4. Wound with clean hands round spools.
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.

Even though a fresh wound has been treated according to the principles laid down above, we must not imagine that we have necessarily obtained a condition of

[1] 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.

[2] 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 to 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 feared.

absolute sterility. It has been proved by endless recent researches that after an operation conducted with the greatest care and with every attention to asepsis, 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). 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 of the epithelial covering of the skin or of a mucous membrane, be it a purely mechanical rupture of continuity, or an injury due to chemical causes, or 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, and therefore the term "lesion infection" seems to us too general and not explicit enough for what Tavel has in his mind. The important factor which induces a further predisposition to infection in the lesion is 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. Bunn, 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 shall develop to a dangerous extent or not. As above 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." It is most desirable that such a distinction should be maintained.

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. If the results of such experiments be applied to the question of the treatment of wounds, 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. Such an admission is, however, unjustifiable; for in the case of a wound in which 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 distinction 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 adapted for development in suitable surroundings and those which are not, or, to put it in another way, between those which are virulent and those

which, for the time being, are not virulent. 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 much more easily destroyed in the blood and healthy tissues than in the wound. 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.

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 infection appears much more rapidly. The germs are rendered much more virulent by passage through a similar soil.

Further, Friedrich has shown that micro-organisms require a certain time for division, as Koch also found, and consequently serious infection cannot occur until this time has elapsed. This gives us an important indication for the treatment of wounds, which, though as free from germs as possible, are nevertheless always under a suspicion of possible infection.

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. The meaning of this has been made clear by exhaustive experiments. 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 large or small portions of the surface of the wound itself (*e.g.* ligature pedicles), and fluid exudates into the wounds, especially blood. 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.

The second point to be observed, besides refraining from unnecessary splitting, crushing, and tearing of the tissues, is avoidance of chemical or thermal injury.

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 direction, has shown that, in rabbits, wounds caused by infected shot give the best results when they are cleansed with an indifferent solution, whereas the use of the best kinds of strong antiseptics did not save the animal from progressive inflammation with fatal results.

A third factor in the building up of a technique which will deprive germs which have entered the tissues of any assistance, consists in preventing the accumulation of fluids, more especially of blood, in the wound. This is best attained by arresting all hæmorrhage by applying artery forceps to every bleeding point and by closing the vessels at the end of the operation, avoiding the use of ligatures and substituting torsion wherever possible. Torsion is quite sufficient for small vessels, and deserves to be widely employed. Next to torsion, crushing by means of small angiotribes (strong artery forceps) has recently come into prominence as a very useful method of closing vessels without ligatures. But angiotribes are still more valuable because they allow us to squeeze and compress large pedicles of tissue to such an extent that when a ligature is applied the resulting stump is reduced to a minimum. We introduced pressure forceps for this purpose in dividing the isthmus of the thyroid long before Doyen brought out his well-known instrument. It is only in the case of large arteries and veins, especially at the root of the neck where they are subject to the influences of respiration, that ligation should never be omitted.

The second means of preventing the accumulation of fluids which furnish a soil for bacteria is by the avoidance of cavities and by the complete approximation of the surfaces of the wound. Complete closure of a large irregular wound is, however, not always possible, especially when deep sutures endanger important structures. There is then no choice but to prevent the accumulation of fluid in the cavities by drainage. The drainage tube should be introduced at the point where the outflow of blood and serum is likely to be greatest.

Such drainage meets the requirements demanded by Friedrich, viz. that fluid containing bacteria should not be allowed to accumulate under injurious tension. The drainage tube creates a flow of fluid from the wound which carries with it the micro-organisms. To Starcke belongs the credit of having, before Friedrich,

drawn attention to the importance of the flow of serum in preventing the ingress of germs.

For drainage we have long advised the exclusive use of glass tubes provided with large lateral openings. They are easily kept absolutely sterile, and they keep the wound open. In large wounds which are to be completely closed it is desirable to introduce a gauze swab before suturing, and before the last suture is applied to withdraw it, pressure being at the same time applied over the wound.

Lastly, it must not be forgotten that the circulation in the edges of the wound is to be interfered with as little as possible by avoiding tension or injurious pressure, and by facilitating the venous return from the wound by a suitable position. Maintenance of nerve influence would not appear to be a matter of indifference, if only on account of its influence on the circulation; for in cocainisation of the cord, as recommended by Bier, a marked tendency to unfavourable symptoms in the wound has been noticed.

The treatment of primary operation wounds must be considered as entirely different from the treatment of such wounds as are already infected with pathogenic and virulent infective material. Under this heading come all those accidental wounds which have been infected directly with virulent organisms, or which are not brought for advice when recent, and which have not been protected from further infection by spontaneous adhesion. It is customary to designate such wounds merely as "infected wounds," as opposed to operation wounds which are merely "under suspicion of infection."

When we say the treatment is to be entirely different from the treatment of aseptic wounds we feel that it is necessary at once to prevent a misunderstanding and to eradicate the idea that it is a matter of no importance whether or not such an infected wound be treated with sterile dressings, lotions, and properly cleansed hands. Neglect of these rules is often the means of converting a single infection into a mixed infection. Moreover, even with septic wounds the absolute rule to exercise the greatest care and most rigid asepsis in regard to the cleansing of the skin and hands and the sterilisation of instruments and dressings should never be broken.

Opinion is still divided as to the proper treatment for infected wounds, especially in regard to the question as to whether antiseptics should be used or are best left alone. In the light of Schimmelbusch's experiments, which showed that germs which have gained access to a wound penetrate into neighbouring tissues in a few minutes and enter the circulation, no great good can be expected from antiseptic treatment; and since, according to the unanimous opinion of clinicians, rapid growth of germs and their accompanying dissemination in healthy tissues occur chiefly in the case of pathogenic organisms, that is, virulent micro-organisms, antiseptic treatment would appear to be of least benefit in just the worse cases, since it is, as a rule, applied too late.

The method of treating accidentally infected wounds (as recommended by Volkmann in the treatment of compound fractures) by douching with strong antiseptic solutions is still customary.

The majority of doctors consider it their duty to wash out accidental wounds with a 1-1000 sublimate solution, this being regarded as the most rapidly acting antiseptic, and Henle's experiments seem to favour such antiseptic methods from the point of view of experience. The careful researches of Friedrich, and especially of Tavel and his pupils, lead to very different conclusions.

The late Dr. Koller, working under Tavel's direction, proved that in shot wounds in rabbits inoculated with certain organisms, antiseptic treatment not only served no useful purpose, but caused actual injury; the same result occurred whether the wounds were irrigated with sublimate or carbolic lotion, or treated with iodine or the thermo-cautery. The majority of animals subjected to this treatment succumbed, whereas a large number of animals treated on merely aseptic principles recovered. Friedrich obtained like results when using special material for infecting the wounds. Contamination of a wound is favoured by all such measures as tend to lower the vitality of the tissues, and therefore by all unnecessary mechanical, chemical, or thermal injury.

How very differently crushed wounds and incised wounds behave when infected is a matter of common observation. Linser, working under Tavel's direction, showed how distinctly this difference of susceptibility to definite infective material can be demonstrated, as he found that incised wounds healed although contaminated with a large dose of virulent organisms, whereas crushed and lacerated wounds invariably developed the usual sequelæ of infection. A similar difference may be demonstrated between wounds whose surfaces are cauterised with chemical substances and similar wounds left alone. The danger consequent upon admitting organisms after allowing a wound to dry has been demonstrated by Walthard in the case of the peritoneum. The condition common to the surface of the wound in all these injuries consists in the loss of vitality and necrosis of the superficial tissue elements, frequently only to a microscopic but occasionally to a macroscopic degree. All powerfully active antiseptic measures increase the necrotic change in the tissues, and so further the infective necrosis. 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 at the body temperature, because if infection set up inflammation the resulting tension is much greater than that caused by effused blood and exudate.

No measure for relief of tension is anything like 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. 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 infective organisms 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 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 calculated to hinder its development, but not capable of injuring subjacent tissues, and so causing the necrosis to pass deeper. 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, the dabbing on of 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 opening 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 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 secondary sutures should be employed, 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 employed till the secretion from the wound has dried up.

(A) *Résumé* of the indications for the treatment of wounds kept aseptic or merely under suspicion of possible infection.

1. Prevention of *air infection* by operating in dust-free surroundings and by keeping away dried exhalations from the mouths and noses of all participating in the operation, especially in the case of the patient, and, lastly, by expediting the period of operation.

[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.

2. Prevention of *contact infection* by sterilisation of all the dressings and instruments by boiling for half-an-hour, or by means of circulating compressed and saturated steam at 125° C. for a quarter-of-an-hour. Further, by covering up with sterile cloths all parts of the body, clothes, operation and other tables in the proximity of the field of operation.

3. Prevention of *inoculation infection* by "abstinence," or by immediate removal of any virulent material which may accidentally reach skin or hands, and by painstaking mechanical purification of the skin and hands by cutting short or covering up the nails and hairs, followed, first, by thorough scrubbing with soap and then rinsing in hot water, and, lastly, with diluted alcohol. This applies to every one taking part at the operation, including the patient.

4. Prevention of *implantation infection* by using antiseptically active sterile silk (silk boiled in 1 : 1000 sublimate solution), and also tampons.

5. Prevention of *necrosis infection* by a technique which avoids crushing, cooling, and drying up; and by purely aseptic treatment of wounds, including the use of warm physiological saline solution for washing off blood, dust, etc.

6. Prevention of *incubation infection* by careful apposition of the edges of the wound, or, if this should be impracticable, by drainage of blood and secretion from the wound by glass tubes, or by using secondary sutures.

(B) *Résumé* of the treatment of infected wounds.

1. Use of all the aseptic measures detailed under (A) for the prevention of fresh infection.

2. Open treatment of the wound by leaving it entirely open, and, if necessary, by complete opening up of the wound by means of incisions to prevent tension and to allow of the formation of a current of fluid from the wound.

3. Frequent poulticing (in open wounds), or douching (in deeper wounds), with mild antiseptics capable of hindering the development of germs, and in order to remove the fluid which has collected.

4. Limitation of putrefaction in the necrotic tissues of the surface of the wound by dabbing with alcohol or other drying agents, by dusting on dry powders, such as iodoform, xeroform, bismuth, etc., or, in deep wounds, by antiseptic tamponage with sterile gauze into which some powder has been rubbed.

D. DIRECTION OF SKIN INCISIONS

In the days when patients could not be anæsthetised, and when the wound could not be protected from infection, it was a good principle to arrange the incisions so that they might be made as quickly and as limited as possible, and at the same time ensure a good outflow of the discharges by the action of gravity.

The latter indication at the present day can be completely fulfilled by making a small special incision through which the drainage tube may be inserted. Even yet, in certain text-books, the student is directed to make the smallest possible skin incision in cutting down to find an artery. Such a procedure is no longer legitimate. The true surgeon makes a free skin incision, but proceeds, as carefully and sparingly as he is able, to make the deeper dissection. A large skin incision produces no additional injury worth mentioning as compared with a small one, because, when carefully sutured, it heals with equal rapidity and certainty; and further, the larger size of the resulting scar is of no significance, provided it runs in the proper direction. This brings us to that consideration which we have for years regarded as essential in the arrangement of incisions.

According to the investigations of Langer upon the planes of cleavage of the skin, the tension of the skin is very different in different directions, and two incisions at right angles to one another display a very different amount of retraction of the

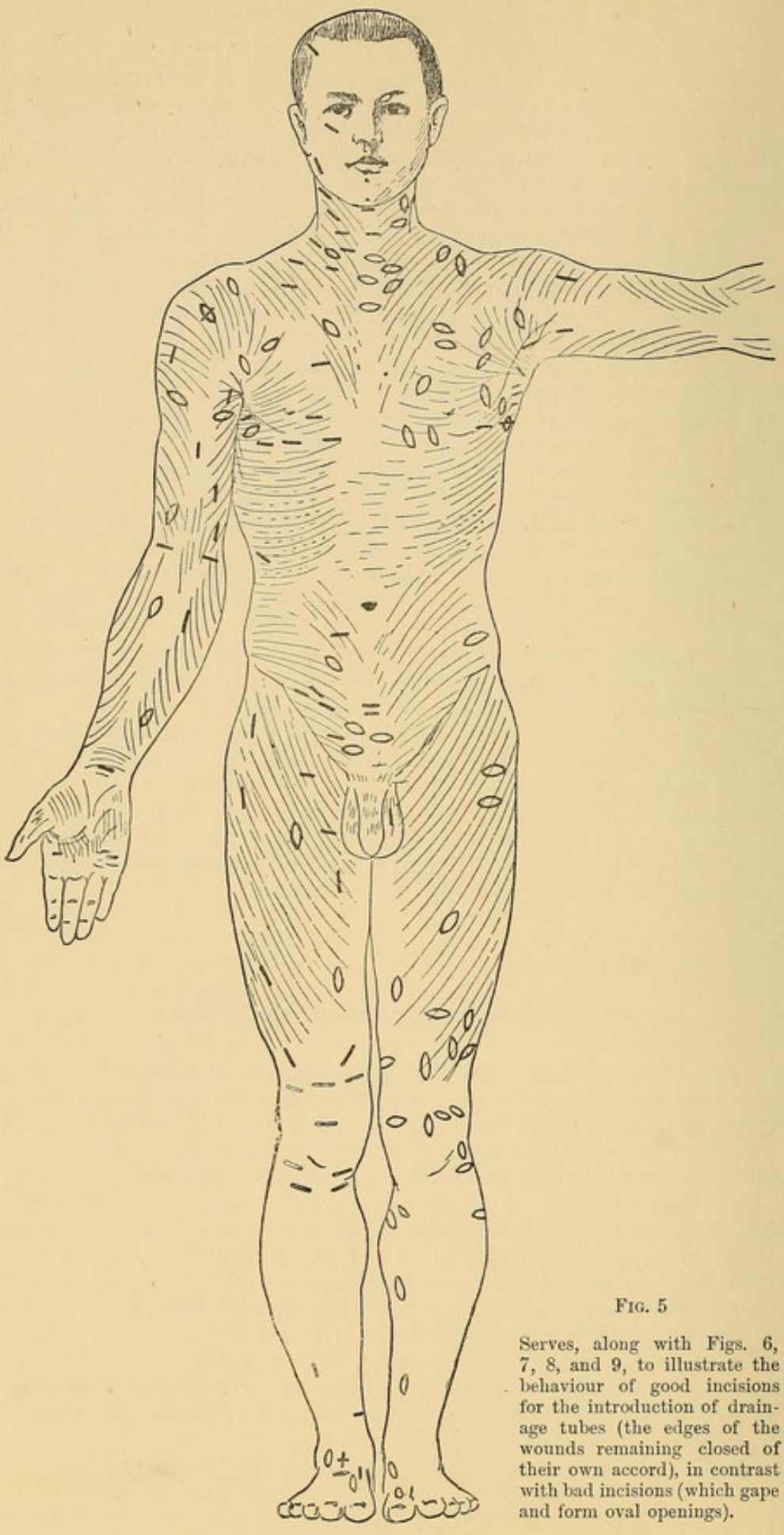


FIG. 5

Serves, along with Figs. 6, 7, 8, and 9, to illustrate the behaviour of good incisions for the introduction of drainage tubes (the edges of the wounds remaining closed of their own accord), in contrast with bad incisions (which gape and form oval openings).

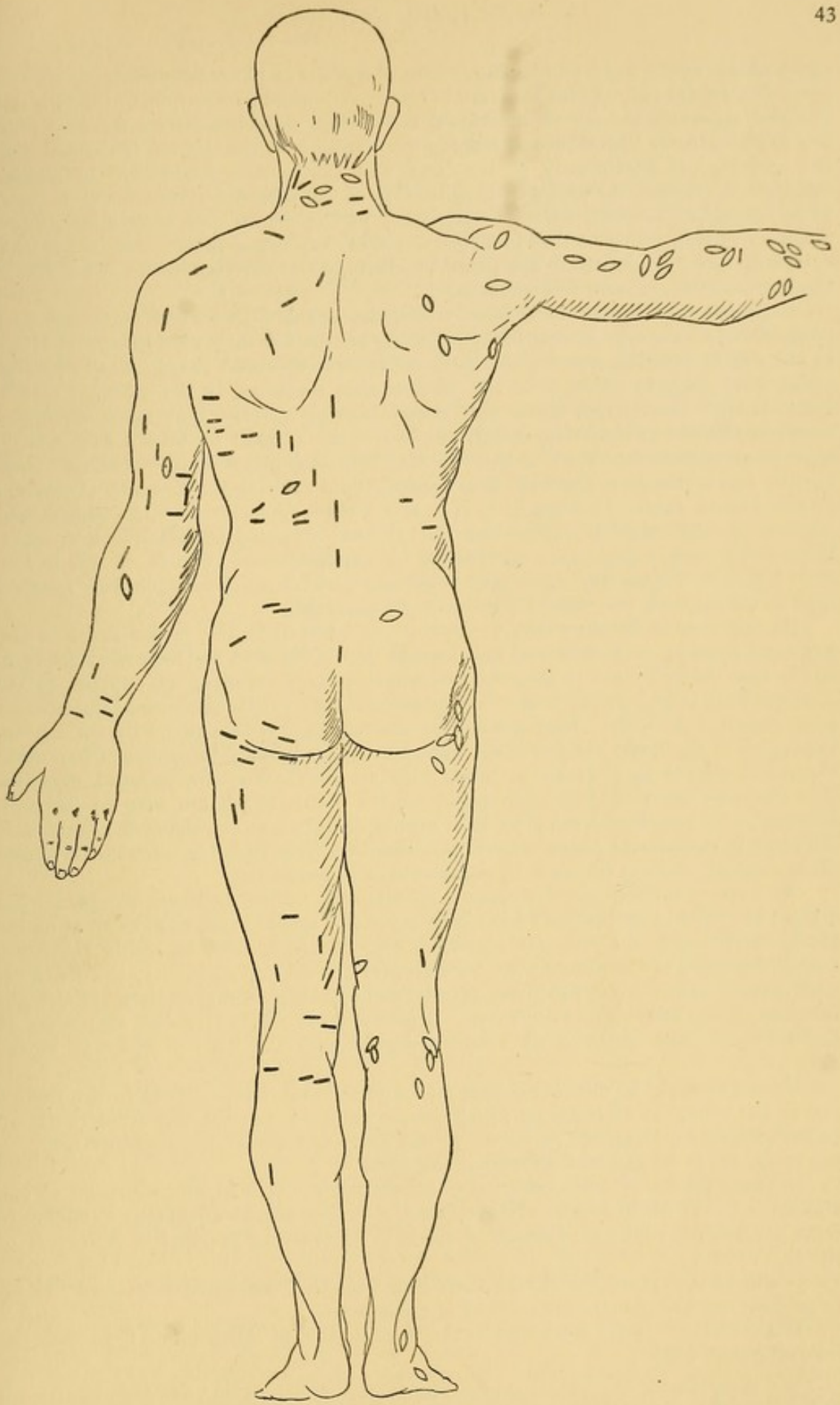


FIG. 6.

edges of the wound : the one gaping, whilst the edges of the other remain in contact without artificial aid. These facts are to be borne in mind in determining the direction of incisions, even although in individual cases other considerations come into play. For of still greater importance as regards the direction of the incision is the course of the vessels, and particularly of the large and small nerve branches. In making incisions in the face, for example, the direction of the branches of the facial nerve is to be taken into account. Fortunately, many of the nerves and vessels ramify in a direction corresponding to that in which the skin displays a greater tension, so that a line of incision adapted to the plane of cleavage also corresponds to the course of the important nerves and blood-vessels.

For years we have recorded upon a diagram our incisions which have not been sutured,[1] and have represented them according to whether they were gaping or closed at the second dressing, and for this purpose we have observed the drainage openings which were made in addition to the sutured skin wounds. If the drainage tube is removed after twenty-four hours and the sutures after forty-eight hours, an opportunity is afforded of observing clearly the behaviour of small unsutured skin wounds after every operation. We reproduce in the following diagrams the result of those records, and introduce at the same time Langer's lines showing the direction of cleavage of the human skin. In Figs. 5, 6, 7, 8, and 9 those drainage openings which come together spontaneously after removing the tube are indicated by a simple line, whilst those which remain gaping are represented by a spindle-shaped figure. It will be seen from Fig. 5 how close the agreement is between good lines of incision and Langer's lines of cleavage, as was indeed *a priori* to be expected.

Having once established this, we have preferred to make the longer incisions also more and more in the direction of the cleavage lines of the skin, and have convinced ourselves that the difference in the scar formation in incisions along or opposed to the cleavage lines is so important that it appears necessary to give the *normal incisions* for every region of the body. They indicate the cleavage lines of the skin for the corresponding region of the body, and are at the same time so placed that the course of important superficial nerves and vessels is taken into account. We have satisfied ourselves that the scars resulting from the operations for goitre, which are here so frequent, become, in the course of time, after such normal incisions, so fine that one has actually difficulty in recognising them, whilst scars resulting from incisions otherwise arranged often seriously deform the neck by contraction and puckering.

We have, therefore, added figures indicating our normal incisions (compare Figs. 10 to 18). The large incisions have been especially mapped out, such as those on the head, neck, trunk, and articular regions. For the remainder, especially the interarticular portion of the extremities, we have, for the sake of simplicity, when dealing with smaller incisions (for ligaturing arteries and exposing nerves) retained the straight incisions in the longitudinal direction. A glance at the figures shows that some of those longitudinal incisions likewise correspond with the lines of cleavage of the skin.

It need scarcely be mentioned that all longitudinal incisions placed in the middle line of the body, *i.e.* all incisions which correspond to a vertical line from the scalp to the symphysis, along the perineum to the anus, and posteriorly upwards again to the scalp, are to be regarded as normal incisions.

In amputations, of course, reunion of portions of the skin which correspond to one another is out of the question. Nevertheless, it is here also an advantage to adhere to some extent to the lines of cleavage of the skin in order to secure less retraction of the flaps.

It will be seen from the illustrations how well this indication is carried out by employing our oblique circular method of amputation.

To the above remarks contained in the third edition of this book we have made the following additions.

[1] The accompanying figures are in great part the diagrams of Dr. E. Lardy, late chief surgeon to the French Hospital in Constantinople, and now in Geneva.

It seems possible to formulate a principle showing the proper direction incisions should take,—that besides the simple mesial incision (which can also be termed symmetrical) there should be a segmental distribution of incisions corresponding to those lines of cleavage in which least injury is done when the knife is introduced into the deep tissues of the body.

In the walls of the thorax and abdomen this is quite obvious, as here the vessels and nerves run more or less in a transverse direction, the lower ones inclining obliquely downwards; and here long incisions made in the proper direction heal far more easily and with less disturbance of function than others placed vertically. It is obvious that muscles and veins which have an oblique direction must be divided if a vertical incision is employed. On this consideration Reidel has objected to our transverse incision in the neck, without good reason, however. Division of the smaller subcutaneous nerves is of no significance, and produces as little harm as division of twigs of cutaneous nerves.

On the contrary, it all depends upon whether the nerve trunks and their branches to the muscles are avoided; if this is done, a divided muscle can contract perfectly with the presence of a fine cicatrix. But what use is it to avoid dividing the muscle

FIG. 7.

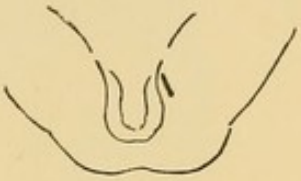


FIG. 8.

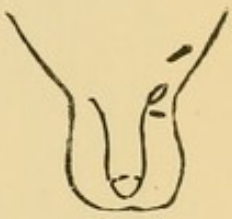


FIG. 9.

and yet injure its motor nerve? When a muscle is divided, it must be done in such a way that neither part of it has its nerve-supply injured; paralysis only follows injury to the nerve. Quervain and Küttner have carried out this principle with great success in their normal incision for the neck. By a method similar to that which we have described for resection of joints, they carry their incision not merely through the skin, but also divide the muscles, forming a large musculo-cutaneous flap. Further, in the abdomen, by adopting the method of M'Burney and others of dissecting with a blunt instrument between the muscles and forcibly separating them, one need not divide the muscles at all.

The same method applies to the larger arteries. They possess a similar segmental distribution, and are best avoided by mesial and segmental incisions.

Whoever will take the trouble to refer to the table we have drawn up of the segmental arrangements of the spinal nerves, will be convinced how simply the principle of segmental incisions can be carried out even in the case of the extremities if they are put in the position of abduction and supination, the position they assume in the early stage of development, and how reasonable is the basis upon which our procedure is grounded.

We would draw attention, in anticipation, to the exquisite and functionally perfect cicatrices which are got by the curved incision in the neck for goitres, in comparison with the oblique incisions that are so generally used; to the results of oblique incisions in the abdomen compared with those along the edge of the rectus; and to the value

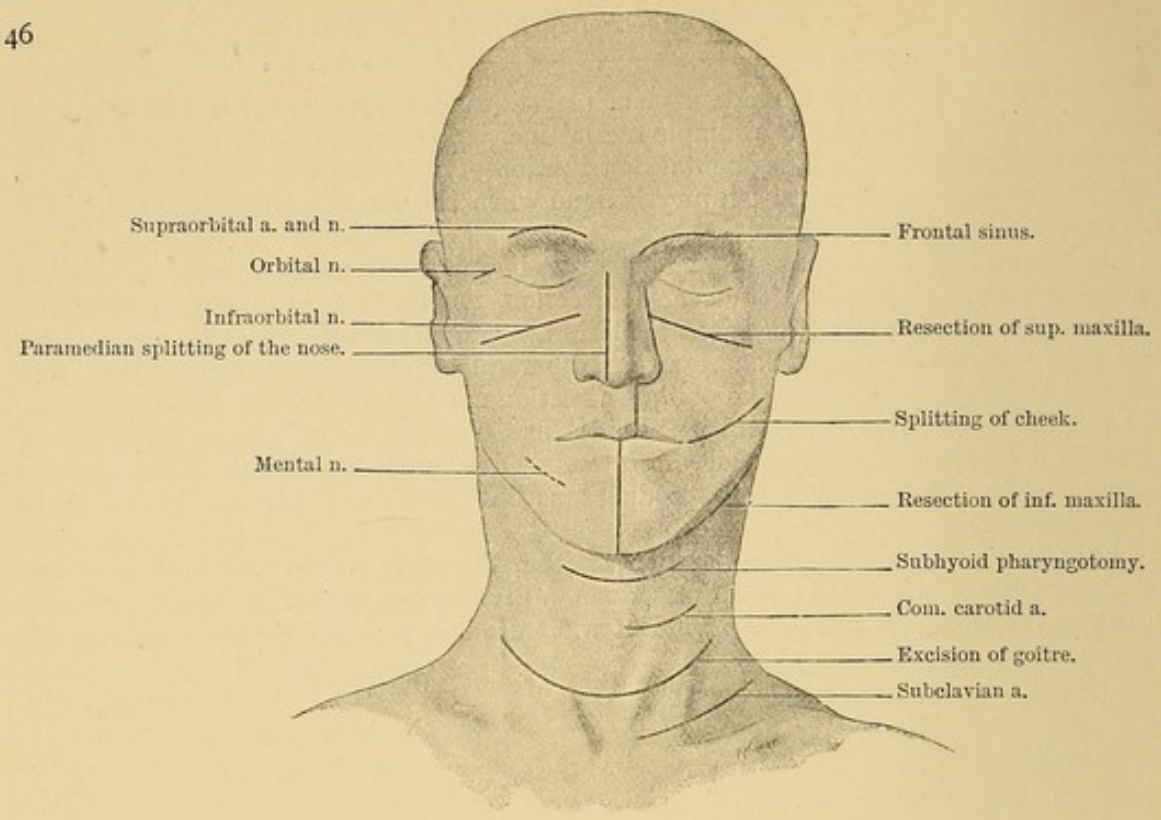


FIG. 10.

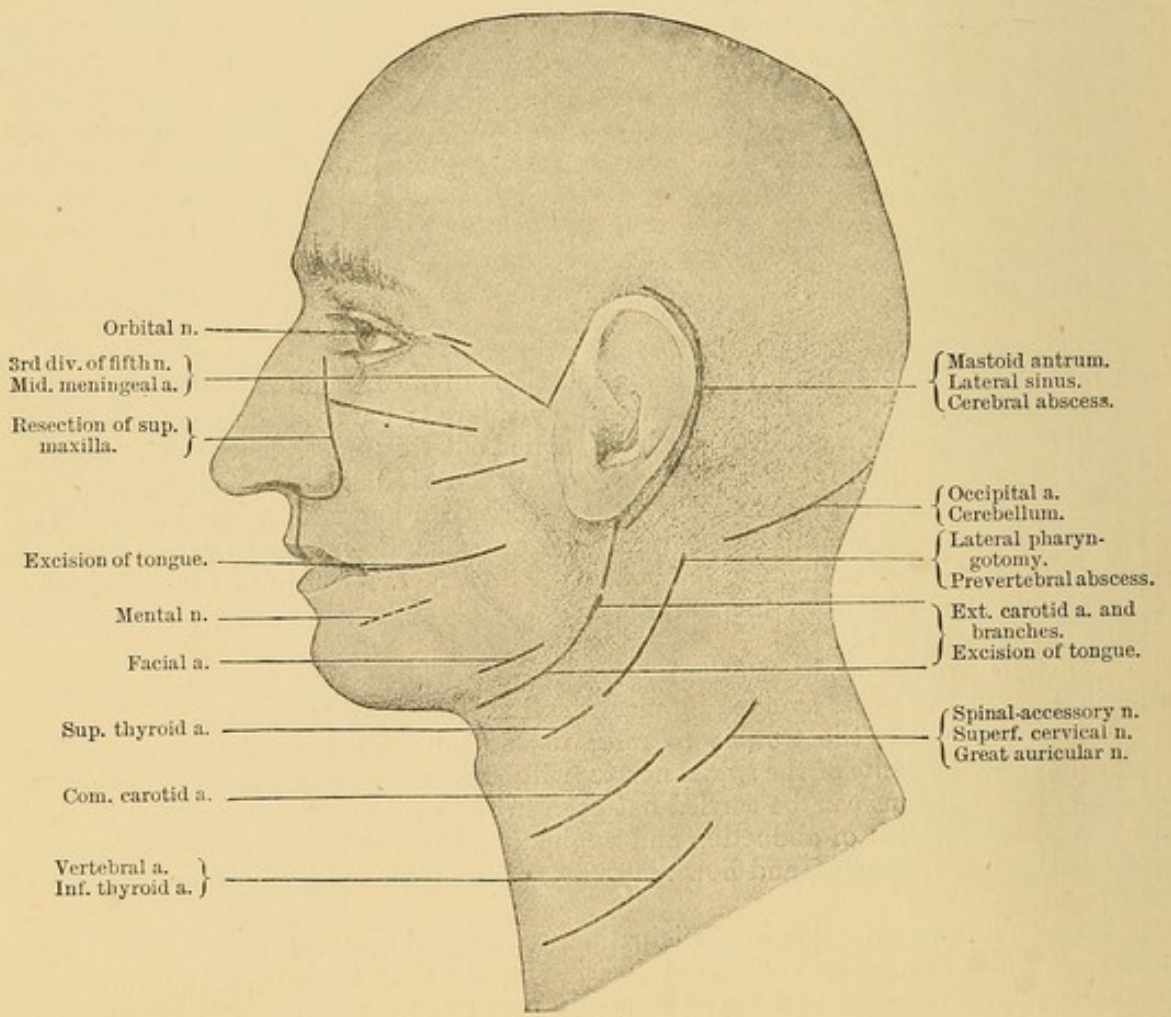


FIG. 11.[1]

[1] To expose the cerebellum the incision is made higher up at the level of the upper linea semilunaris (occipital ridge) with the addition of a median incision downwards on the neck.

of the transverse incision in the axilla compared with those along the border of the pectoral.

Whoever keeps to the rule of making incisions as much as possible mesial, also

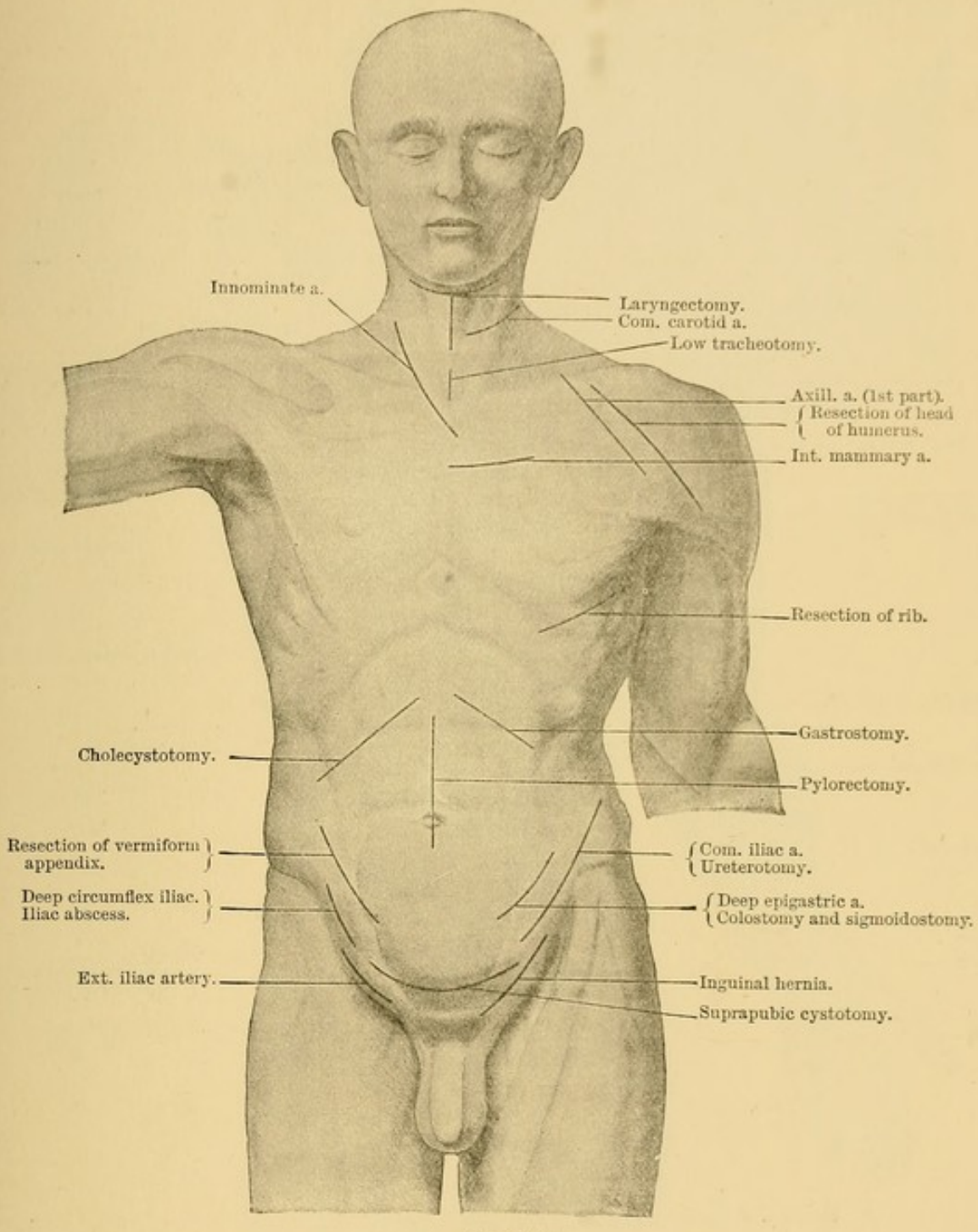


FIG. 12.[1]

following the segmental distributions, can safely enlarge them, and thus be enabled to work more thoroughly in the deeper tissues, a method far more satisfactory than the

[1] The incisions for cholecystotomy and gastrostomy do not correspond to *segmental* incisions. We now always perform gastrostomy through a perpendicular incision in the left rectus muscle, just as Mayo Robson employs a perpendicular incision at the right margin of the rectus for cholecystotomy.

small incisions often recommended for dissecting and scraping out glands. If he uses at the same time aseptic packing, which Mikulicz has made so valuable in the

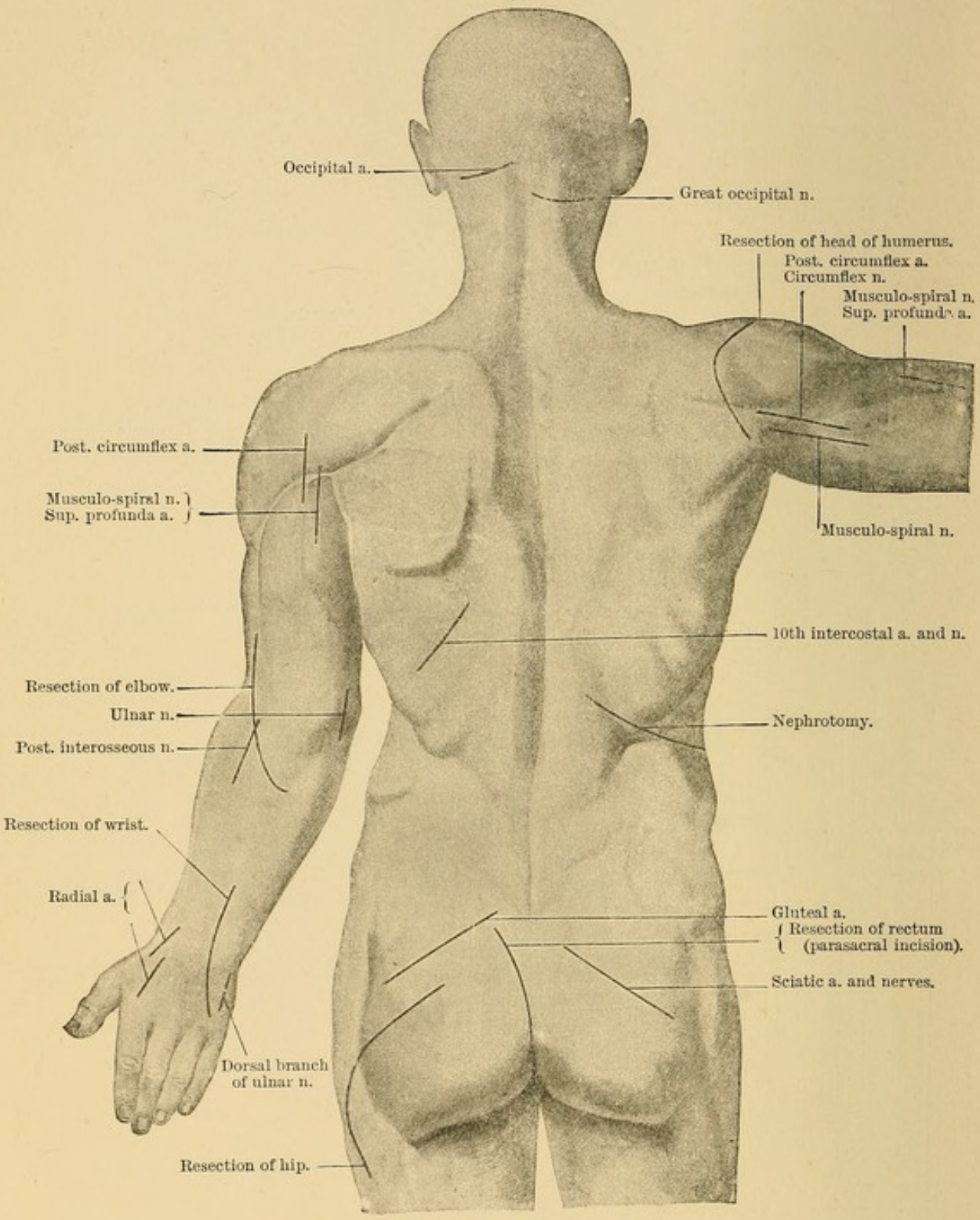


FIG. 13.

case of the abdomen, to protect the deep structures from possible injury, then the last objection to the use of large incisions has been overcome. It is obvious that in septic areas this process must be employed with caution.

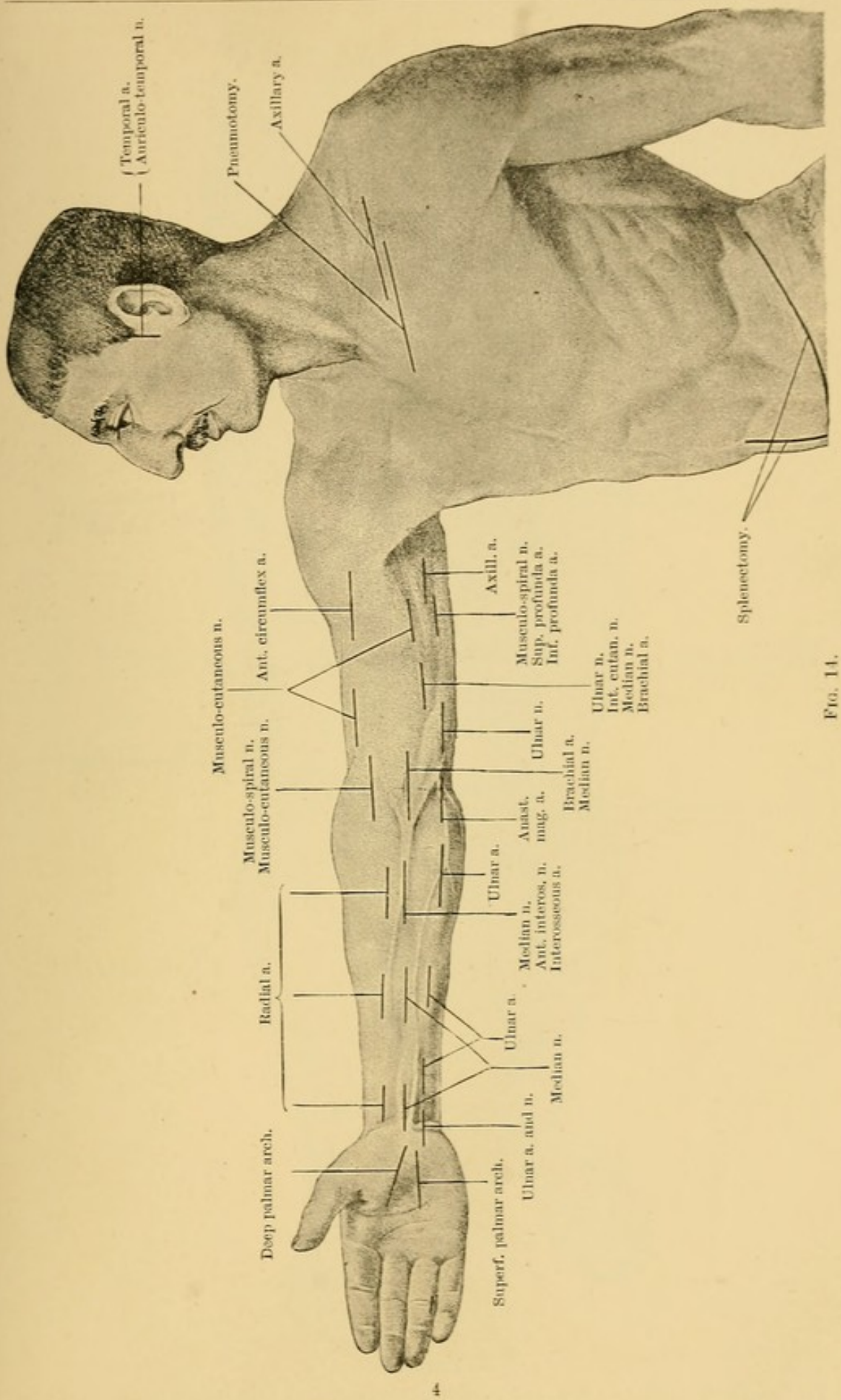

Temporal a.
Auriculo-temporal n.
Pneumotomy.
Axillary a.
Splenectomy.
Musculo-cutaneous n.
Ant. circumflex a.
Axill. a.
Musculo-spiral n.
Musculo-cutaneous n.
Musculo-spiral n.
Sup. profunda a.
Inf. profunda a.
Ulnar n.
Int. cutan. n.
Median n.
Brachial a.
Ulnar n.
Brachial a.
Median n.
Radial a.
Ulnar a.
Anast. mag. a.
Ulnar a.
Median n.
Ant. interos. n.
Interosseous a.
Ulnar a.
Deep palmar arch.
Superf. palmar arch.
Ulnar a. and n.
Median n.

FIG. 11.

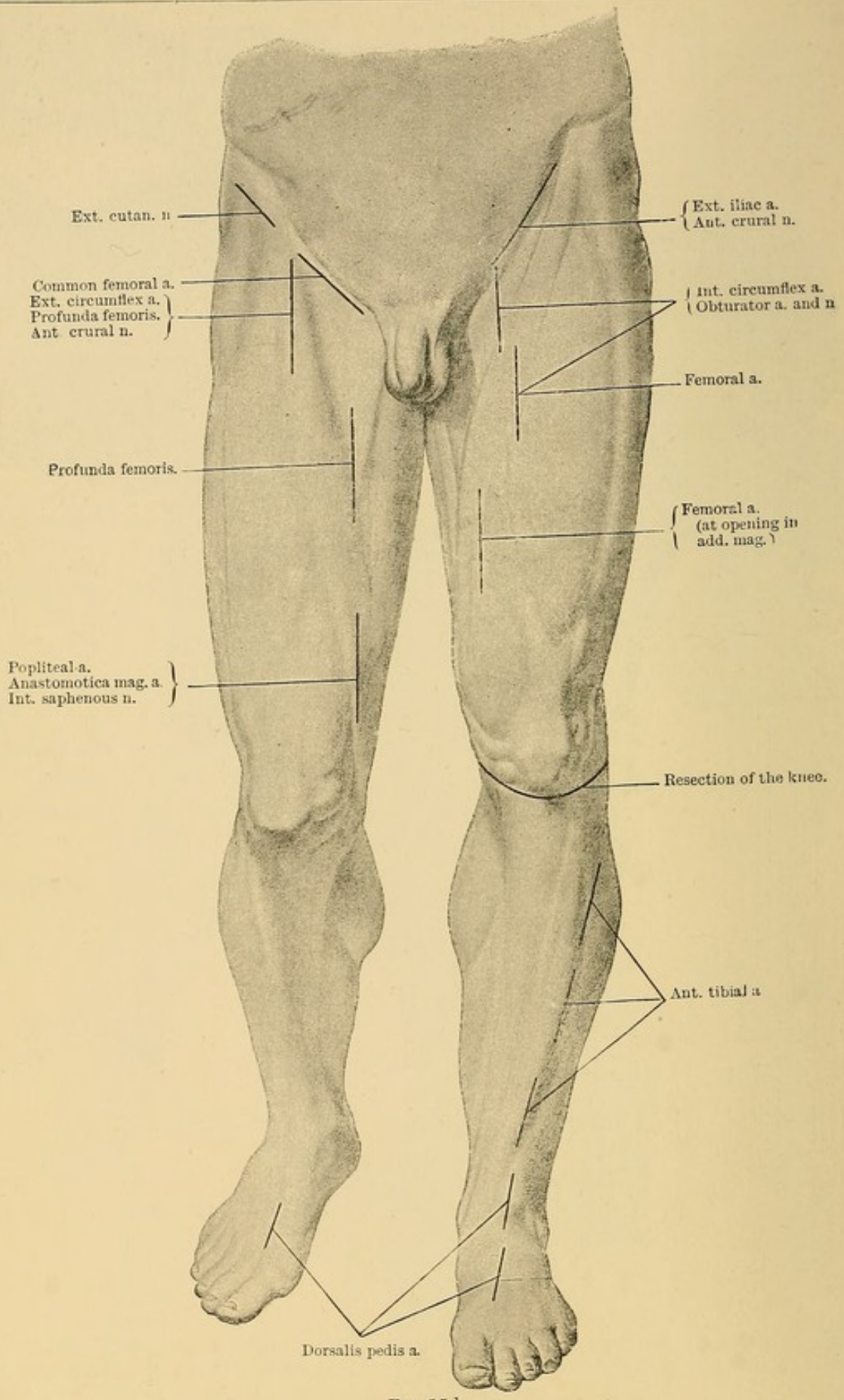


FIG. 15.[1]

[1] For resection of the knee we now employ exclusively the external curved incision (compare the text).

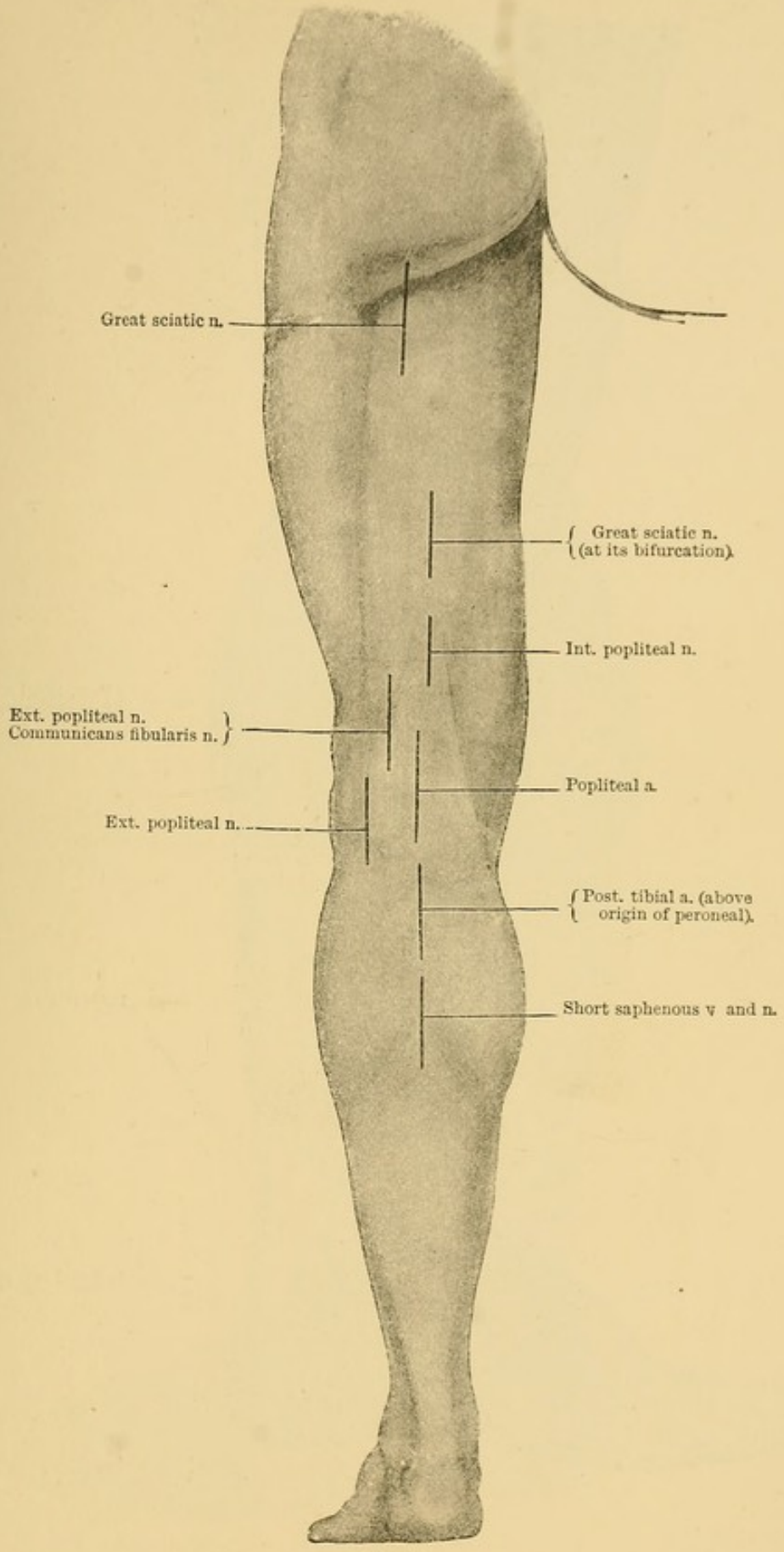

Great sciatic n.
Great sciatic n. (at its bifurcation)
Int. popliteal n.
Ext. popliteal n.
Communicans fibularis n.
Popliteal a.
Ext. popliteal n.
Post. tibial a. (above origin of peroneal)
Short saphenous v and n.

FIG. 16.

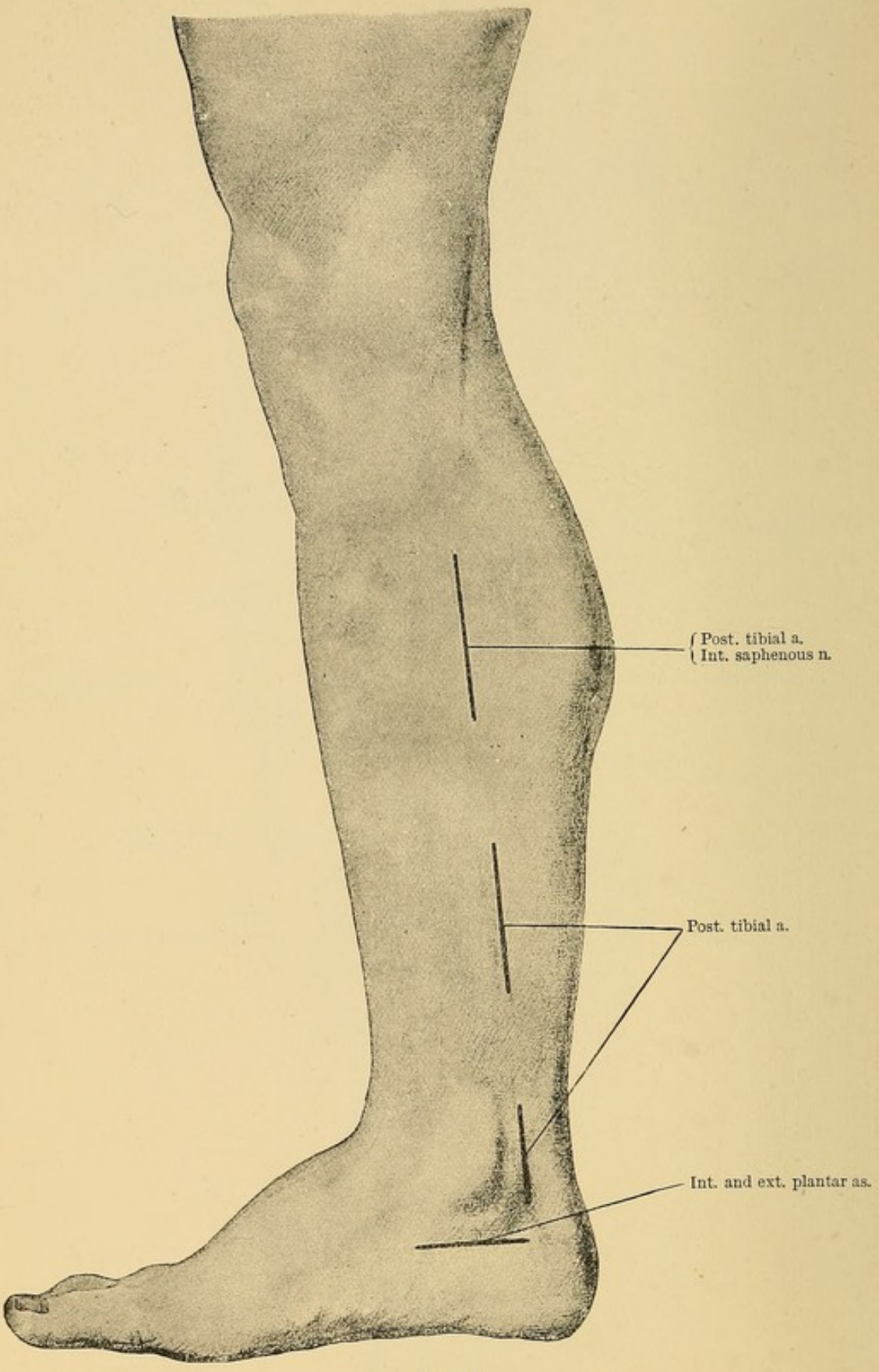

Post. tibial a.
Int. saphenous n.
Post. tibial a.
Int. and ext. plantar as.

FIG. 17.

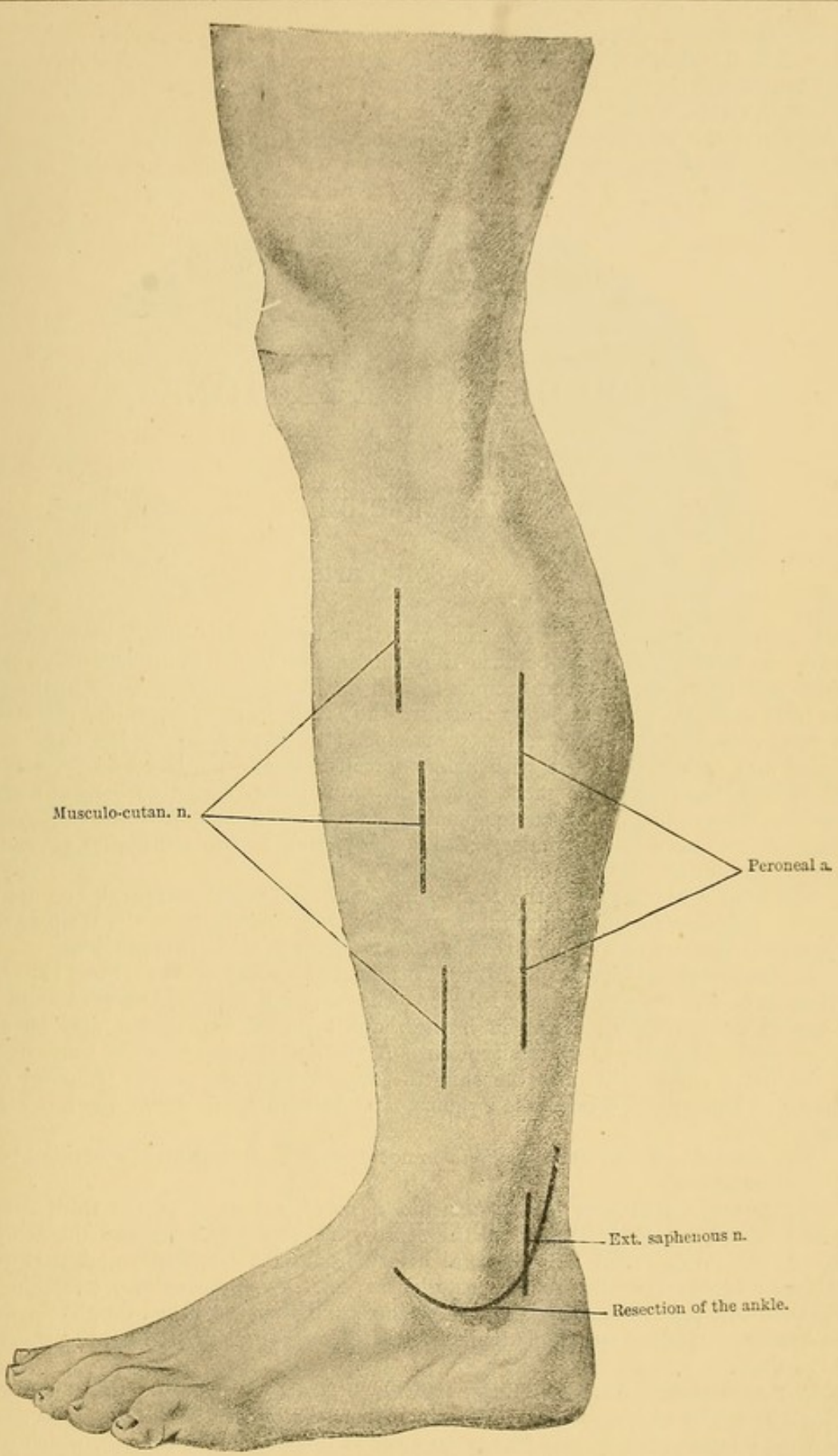

Musculo-cutan. n.
Peroneal a.
Ext. saphenous n.
Resection of the ankle.

FIG. 18.

SECTION II

SPECIAL OPERATIONS

E. CRANIUM

(a) Soft Parts

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.

1. Temporal Artery and Vein: Auriculo-Temporal Nerve (Fig. 19). The pulsation of the temporal artery is felt at the upper border of the zygomatic arch ½ cm. in front of the auricle; in hæmorrhage from its branches it may be either compressed or ligatured in this situation. A vertical incision is made 1 cm. in front of the helix. After dividing the skin the superficial layer of the temporal fascia appears. The artery crosses the zygoma, and is seen lying under the fascia at its upper border.

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

Of greater importance is the *auriculo-temporal*, a branch of the third division of the fifth nerve (Fig. 19); it is the sensory nerve for the ear and the temporal region. It winds round the temporal artery from below upwards and backwards, and then ascends parallel to its posterior aspect. In exposing and stretching the nerve for neuralgia the artery is first identified, and the nerve then sought for nearer the auricle. Higher up the branches of the artery and nerve enter the substance of the scalp.

2. Supraorbital Artery: Supraorbital, Supratrochlear and Nasal Nerves (Fig. 20). 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 shaving off the eyebrow a transverse incision is made over the supraorbital margin.

The same dissection is made to secure the *supraorbital nerve*, the supraorbital notch again serving as the guide. The nerve lies deeper than the artery, directly upon the periosteum, so that it is not an easy matter to divide the nerve without at the same time injuring the artery. The incision along the eyebrow has the advantage

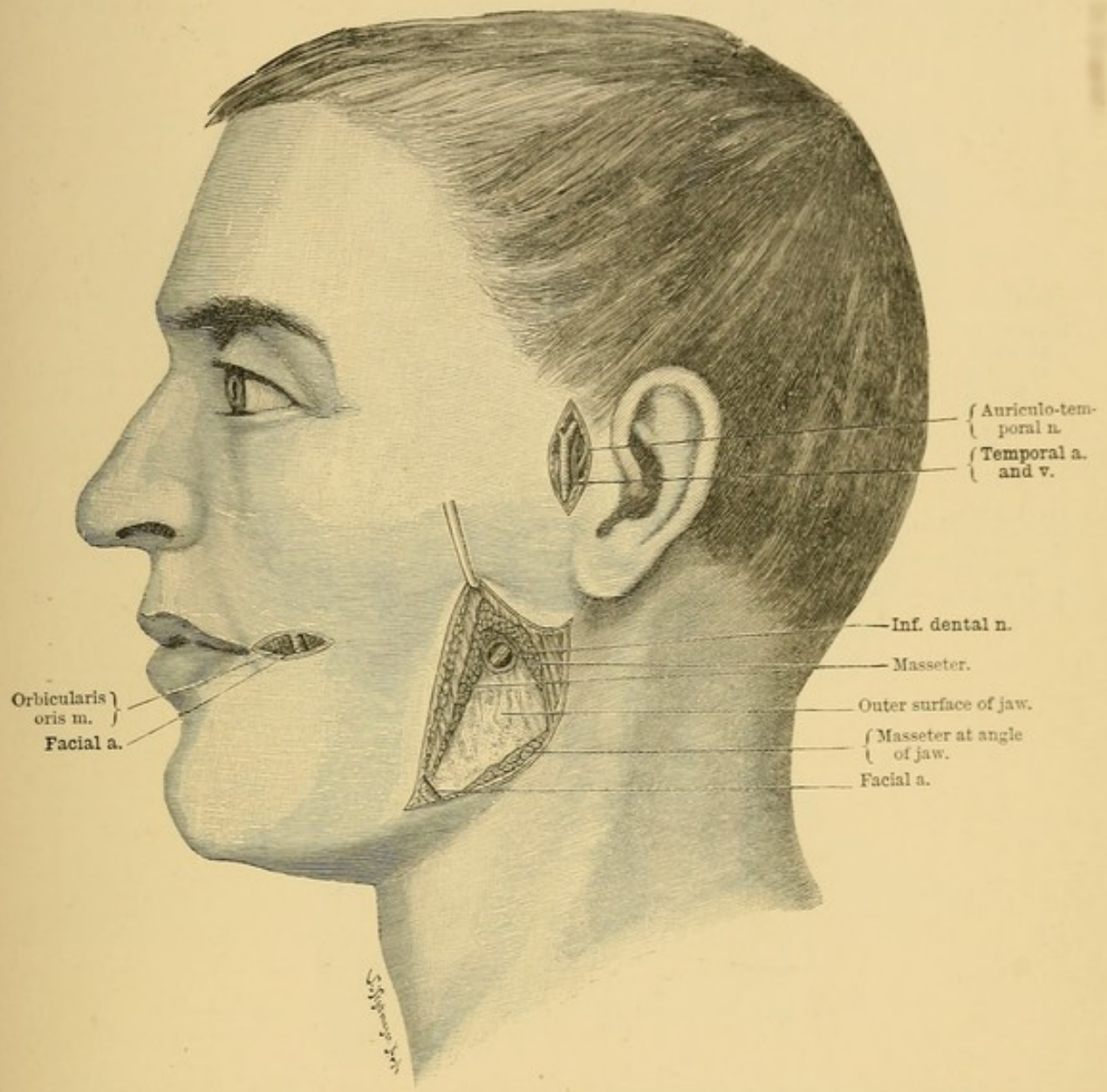


FIG. 19.—Ligature of the facial artery. Ligature of the temporal artery. Trephining the ascending ramus of the jaw to expose the inferior dental nerve.

of avoiding the branches of the facial nerve. The frontal muscles and the orbicularis palpebrarum are supplied by the facial nerve, the branches of which enter from the external aspect, and are not therefore injured by the transverse incision.

3. The Supratrochlear Nerve lies 1½ to 2 cm. (¾ in.) farther inwards than the supraorbital, and runs vertically upwards from the inner angle of the orbit; it is a much smaller nerve, and lies more superficially in the orbicularis muscle. To expose it an incision is made along the inner half of the eyebrow.

4. The Nasal Nerve enters the cranial cavity at the upper and inner angle of the orbit, and leaves it again through the ethmoid bone, to be distributed upon the nasal septum and to aid in supplying the tip of the nose. It is quite easily seen about 2 cm. behind the inner extremity of the supraorbital margin, and here the aneurism needle may be passed round it.

The eyebrow incision is prolonged somewhat downwards over the root of the

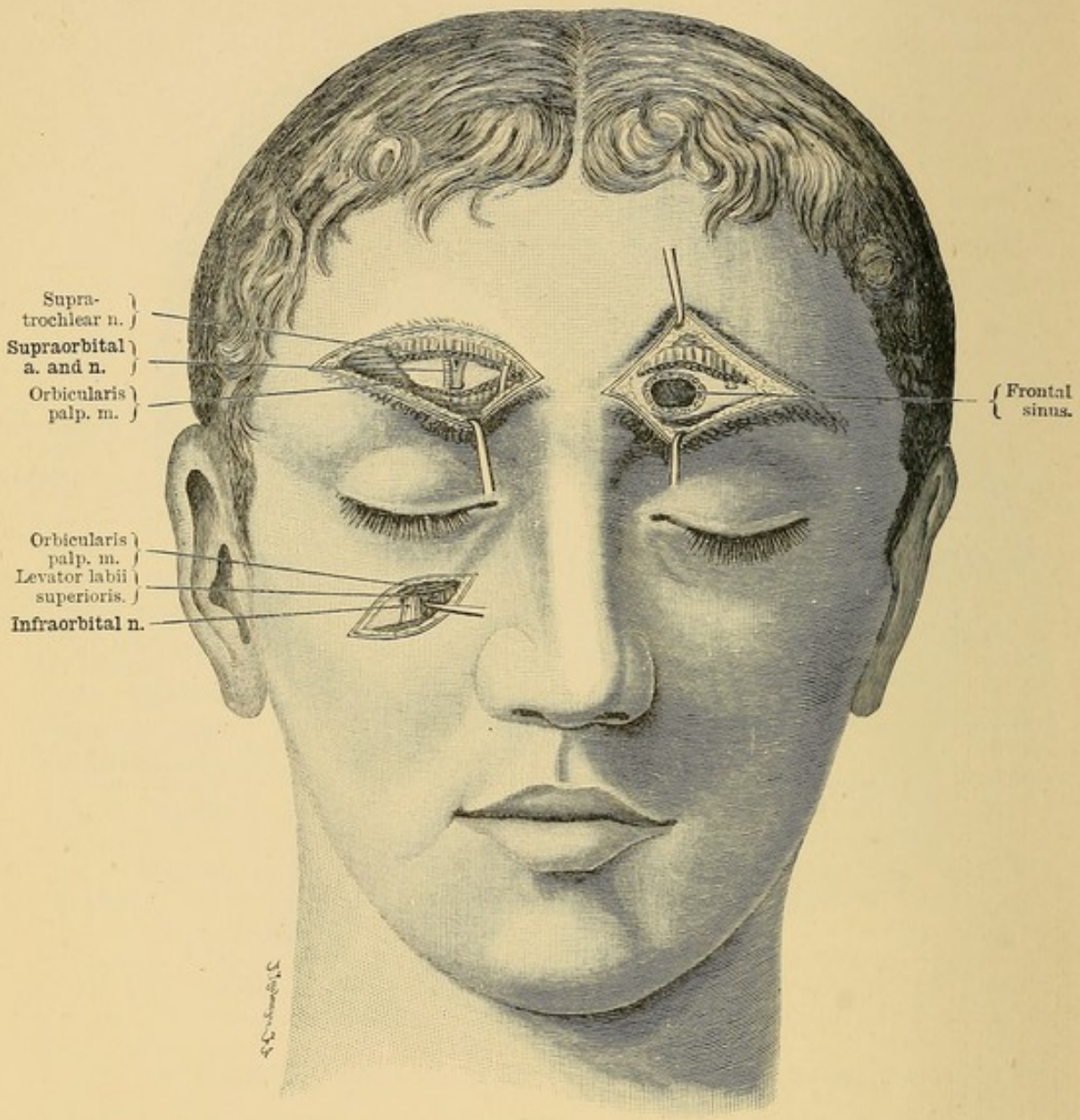


FIG. 20.—Ligature of the supraorbital artery. Exposure of the supraorbital nerve. Infraorbital nerve. Opening of the frontal sinus.

nose (branches of the angular artery and vein ligatured), and the periosteum divided and gradually separated backwards at the upper and inner part of the orbital cavity until the nerve, which runs transversely towards the anterior ethmoidal foramen, is seen to be detached from the orbital roof. The ethmoidal branch of the ophthalmic artery is torn in the process; the bleeding is arrested by plugging.

5. Occipital Artery: Great and Small Occipital Nerves (Fig. 21). The occipital is the largest artery of the scalp; it appears at the inner border of the

splenius muscle, midway between the external occipital protuberance and the highest point of the mastoid process; here it pierces the strong fascia and ascends over the occiput under the aponeurosis. The artery is ligatured where it pierces the fascia. A transverse incision is made from the posterior part of the tip of the mastoid process towards the occipital protuberance, as far as the insertion of the trapezius muscle. The skin is here very thick. After dividing the fascia the posterior edge of the sterno-mastoid muscle is exposed, the small occipital nerve which accompanies it being avoided (Fig. 21). The fibres of the splenius muscle passing obliquely forwards and upwards appear under the sterno-mastoid. On dividing the splenius, in the same

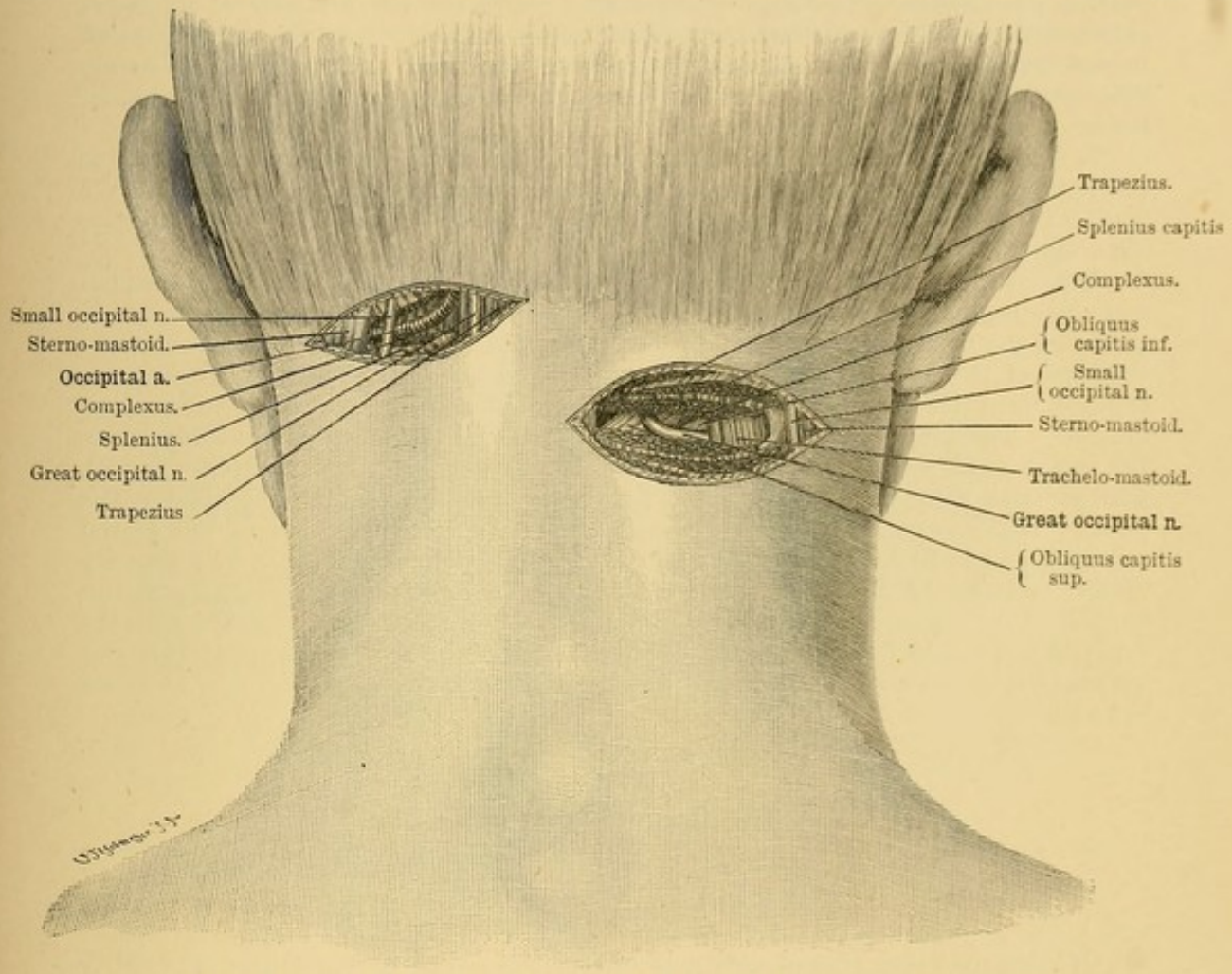


FIG. 21.—Ligature of the occipital artery and exposure of the small occipital nerve. Great occipital nerve.

direction as the skin incision, the artery is exposed, lying at first upon the occipital attachment of the superior oblique muscle and afterwards upon the complexus.

The artery may be ligatured at the *inner border of the splenius* as it ascends to the skin of the occiput, under the fascia, in the angle between the posterior border of the sterno-mastoid and the anterior edge of the trapezius. 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 the same as that for ligature of the external carotid. The occipital vein is not always found lying close to the artery.

6. 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. 20). 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.

7. The Small Occipital Nerve (anterior division of the third cervical) appears at the posterior border of the sterno-mastoid muscle, along which it extends under the fascia to the occiput. It ramifies external to the great occipital. For its exposure see occipital artery (5).

The incision employed by Krause for dividing the occipital nerves in occipital neuralgia begins one inch below the external occipital protuberance, passes outwards as far as the posterior border of the sterno-mastoid, and then downwards as far as the level of the hyoid bone. The incision is carried down to the nerves, which are exposed one after another, and followed down to the depth of the small suboccipital muscles. The first cervical (suboccipital) is found with its ganglion situated outside the spinal canal, and the same is to be said of the ganglion of the second cervical. The posterior division of the third cervical, which crosses the inferior oblique, lies parallel and internal to the great occipital nerve (posterior division of the second cervical), and is to be followed to the third intervertebral foramen. The majority of the branches of the third cervical nerve are to be sought for at the posterior border of the sterno-mastoid and behind the great vessels, which, together with the sympathetic, are to be drawn forwards; the small occipital and the great auricular nerves (Krause does not mention the transverse superficial branch) can now be either cut across or stretched.

(b) The Opening of the Skull

(Craniectomy, Craniotomy, Trephining)

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. The bleeding from these veins can only be arrested by compression, and for this purpose it is best to apply sterilised or antiseptic wax. If larger diploic veins ramify across the field of operation, it may be necessary, in

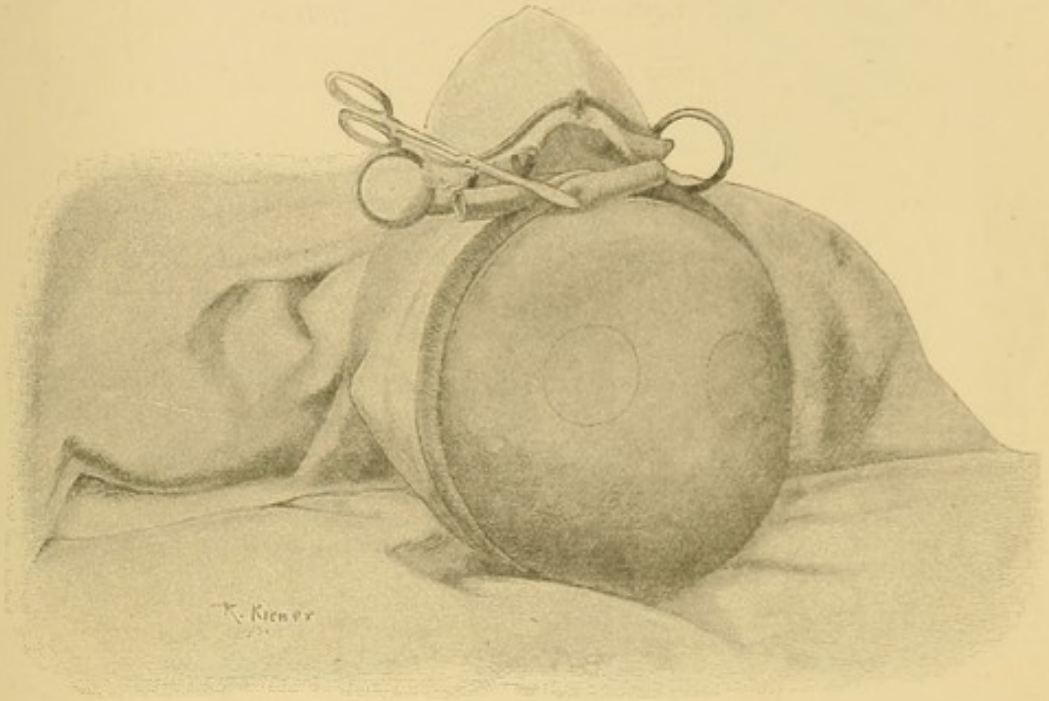


FIG. 22.—The figure shows the application of elastic tubing around the skull; the tubing at the same time fixes the sterilised cloth as a covering for the head.

addition, at once to bore into the vein above and below with a burr, in order that the lumen may be plugged with wax. In cases where more severe hæmorrhage is expected the question of a preliminary ligature of the external carotid has to be taken into consideration. This danger is only associated with extensive craniectomies, and therefore such a procedure is rarely necessary before performing a circumscribed or partial craniectomy.

8. Circumscribed or Partial Craniectomy. First as regards anæsthesia. General anæsthesia is always to be avoided when the patient is more or less unconscious, and, as a rule, one can proceed quite well by injecting cocaine into the skin and periosteum, and, after removing the bone, by swabbing the dura with the solution. If a general anæsthetic must be given, Horsley's method of first injecting morphia and afterwards giving chloroform is to be preferred, because it excites the brain less, and therefore the bleeding is not so profuse. A free incision is made through the skin and periosteum down to the bone, exposing a large area of the skull, so that one may clearly see the veins which run to the area to be trephined. The hæmorrhage from the scalp and the bone, in so far as they are nourished by the external vessels, may

be temporarily arrested by applying an elastic band around the greatest horizontal circumference of the skull (Fig. 22). If some veins in the edges of the wound still bleed, one of our artery forceps should be applied, as its teeth can be firmly fixed to the dense skin of the scalp.

Before the trephine is applied an exploratory perforation is made close to the area to be trephined with a perforator (Kümmel-Sudeck's burr is most suitable),

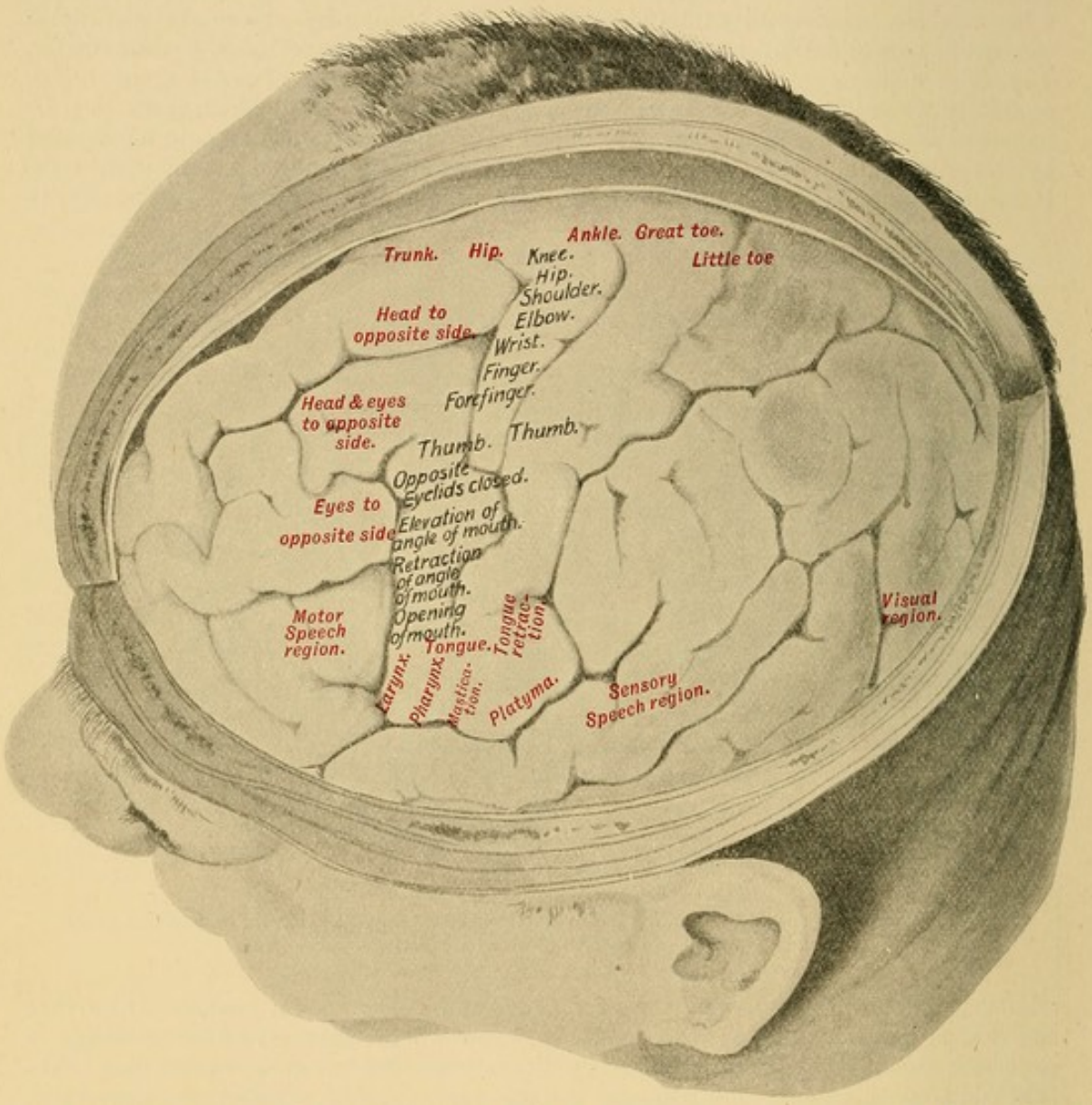


FIG. 23.—The black type shows the cortical areas in man which are definitely known (Horsley), the red type those less definitely known. The importance of the relations of the precentral line to the areas is well seen.

in order to derive information as to the hardness, thickness, and vascularity of the bone. The preliminary exploratory opening has the great advantage that the cutting forceps can be introduced through it to divide the vitrea, and through it also a strong elevator can be introduced to lever out the bone. The circular saw is now applied and the bone sawn down to the vitrea, which can be divided by cutting forceps; the bone is then levered out. The edges of the opening are smoothed off with cutting forceps. Severe bleeding from the bone is arrested by the application of carbolised or sterilised wax.

If the attempt to use the trephine produces at once very considerable bleeding, it is better, after pressing wax into the entire trephine circle, to bore a large number of holes with the rapidly working cylindrical burr; these can be easily plugged with wax, and then by using a chisel the bridges between the holes can be rapidly divided. In certain circumstances it may be advisable to ligature the external carotid.

The dura is, when necessary, opened by pulling it up with a fine hook and nicking it very carefully without wounding the inner membranes. It is then divided crucially nearly up to the bone margin, and the bleeding vessels are clamped.

For permanent relief of tension the dura is cut away, or folded over the edge of the bone and sutured (Beresowsky); otherwise the four corners are placed together again without any suturing. For drainage, where blood or cerebro-spinal fluid is to be conveyed away, a fine bent silver tube is introduced, and so fastened to the skin that it does not come in contact with the brain. The inner membranes of the brain must be carefully avoided when it is not necessary to lay bare the brain substance, because,

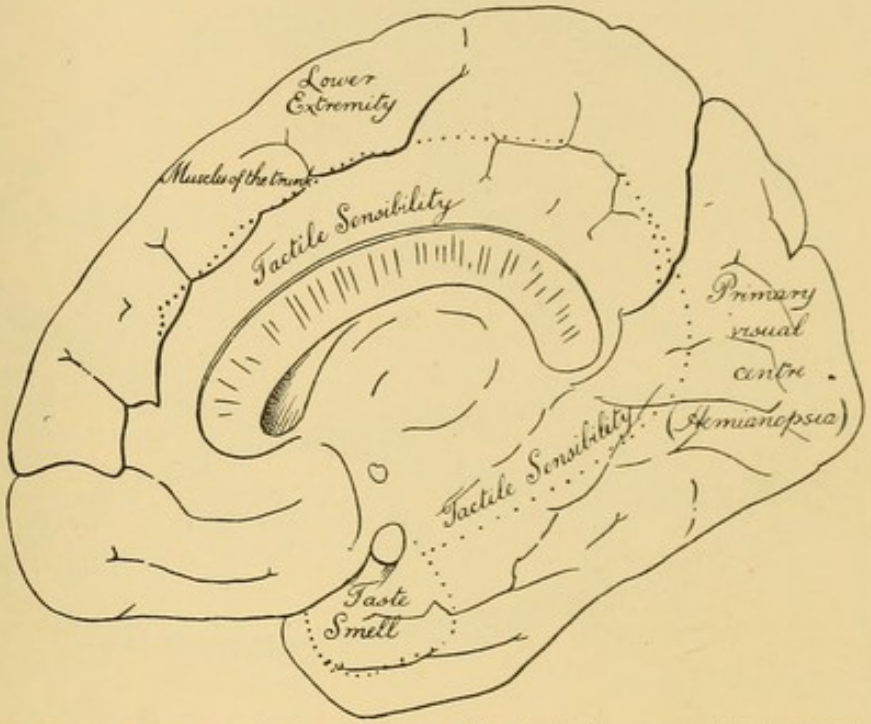


FIG. 24.—Centres upon the inner surface of the hemisphere, according to Horsley.

according to Beresowsky, they form the chief protection against adhesive inflammation of the cerebral cortex. The skin wound is closed by a continuous suture of silk, which should be drawn tightly, and must include the aponeurosis of the occipito-frontalis, in order to avoid reactionary bleeding from the edges of the wound.

Since aseptic trephining, as described, is an operation free from danger, some would have us believe that the development of cerebral localisation has been of assistance in making this circumscribed partial craniectomy a still more justifiable procedure. This is certainly not the case, although we are now in a position to recognise, at an early period, a number of strictly circumscribed focal diseases of the brain, and to lay bare the diseased focus by means of a limited trephining.

9. Cranio-Cerebral Topography. In order to reach a particular spot on the surface of the brain by trephining, we must be in a position to map it out upon the surface of the skull with some accuracy. Special functions cannot yet be assigned to the whole of the cortical area. Therefore it is most important to be able, in the first place, to map out exactly those areas in the neighbourhood of which the chief foci of known functions are grouped.

Hitherto it has been almost universally accepted that it is the recognition of the

Rolandic and Sylvian fissures which proves most useful for the topography of the cerebral surface. We regard this as in part erroneous. To demonstrate this we reproduce, mapped out in the figure of the left hemisphere (Fig. 23, page 60), 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 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

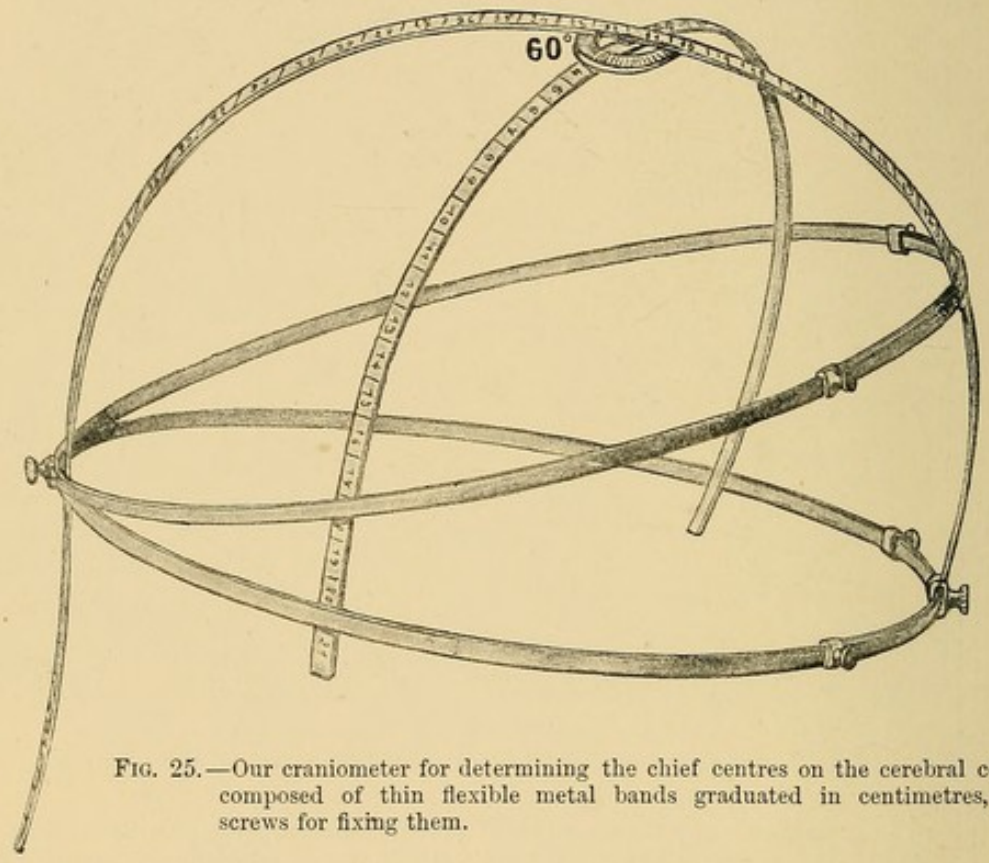


FIG. 25.—Our craniometer for determining the chief centres on the cerebral cortex, composed of thin flexible metal bands graduated in centimetres, with screws for fixing them.

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.

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 approximate 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. 24 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 improved craniometer, such as we now employ (Fig. 25). This consists of two nickel-plated

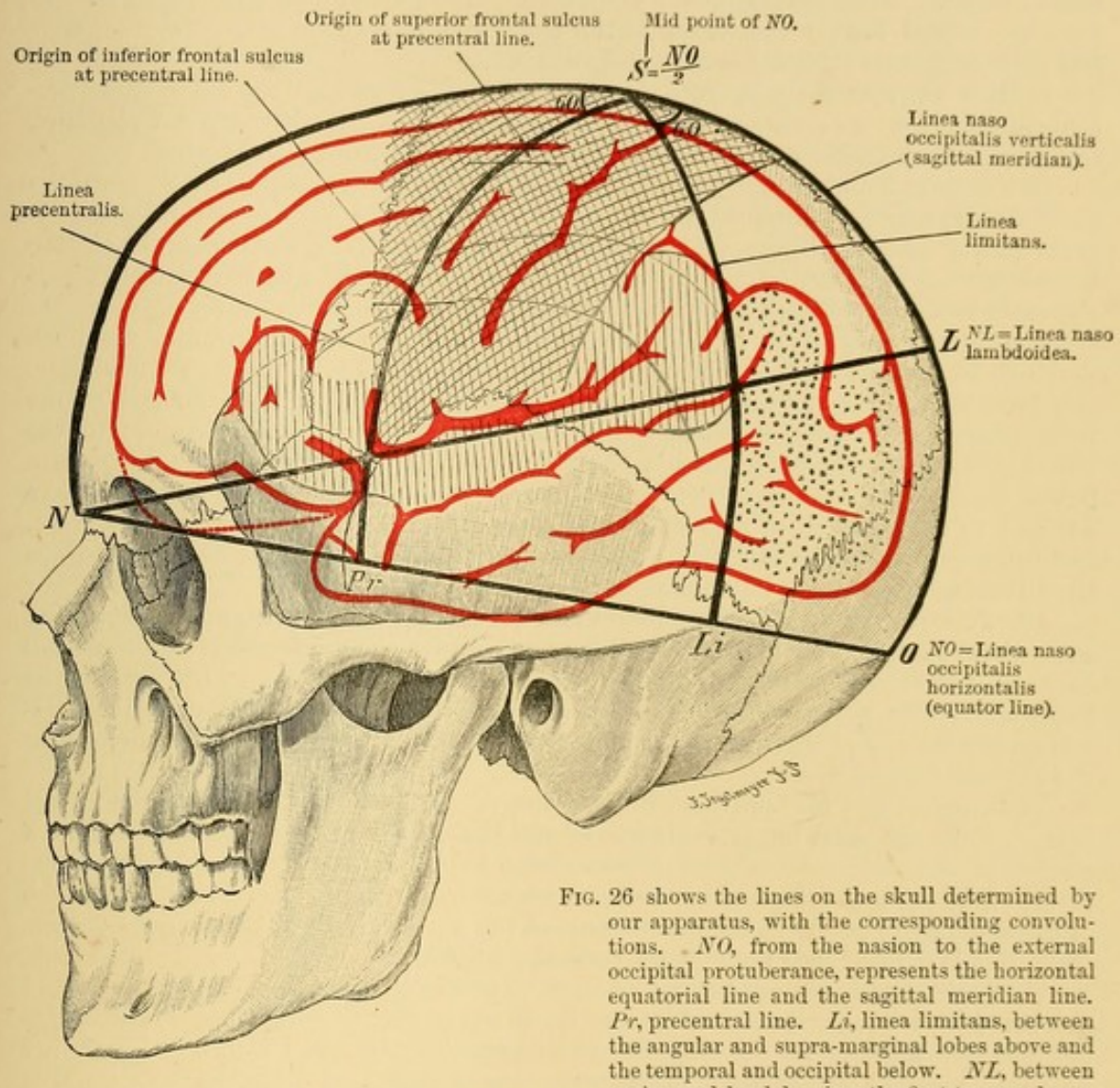


FIG. 26 shows the lines on the skull determined by our apparatus, with the corresponding convolutions. *NO*, from the nasion to the external occipital protuberance, represents the horizontal equatorial line and the sagittal meridian line. *Pr*, precentral line. *Li*, linea limitans, between the angular 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.

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. Lastly, a fourth band, movable on the sagittal band, encircles the cranium obliquely from the glabella to the lambda. This corresponds to

the Sylvian line of Poirier, which, however, does not quite correspond to 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.

In Fig. 26 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, the origins of the superior and inferior frontal sulci are very exactly defined.

In this way, as may be seen by comparing Figs. 23 and 26, the linea precentralis, 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.

If the band 3 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 gives 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 linea temporalis 1 corresponds, between the paracentral line and the linea limitans, to the first temporal convolution, and, where it crosses the paracentral line, it corresponds to the anterior end of the Sylvian fissure. The posterior end of the linea temporalis 1 corresponds to the parieto-occipital fissure, and therefore to the boundary between the occipital and parietal lobes. A glance at the figure gives 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.

10. Topography of the Cerebellum and of the Lateral Sinus, and Trephining over these Areas. The cerebellum is in contact with the inner surface of the skull only at its lower and back part, whereas the upper and posterior part lies against the tentorium. The portion of the skull within which the former division of the cerebellum lies is covered by the attachments of the occipital muscles, and is situated below the superior curved line.

The upper limit for applying the trephine is furnished by the line of the lateral sinus. This, the most important sinus of the skull, runs, in its horizontal part, in a line from the external occipital protuberance to the base of the mastoid process (Poirier), at the part which is marked posteriorly by a depression. The vertical limb of the sinus corresponds to the middle part of the outer surface of the mastoid process when this is divided into three equal vertical portions.

To trephine over the cerebellum an incision is made from the base of the mastoid process along the superior curved line, as far as the middle line, and thence downwards between the muscles at the nape of the neck. The occipital artery and vein are ligatured, and the attachments of the muscles are separated from the bone towards the foramen magnum. If it be certain beforehand that it is necessary to expose the cerebellum on both sides the median incision may be dispensed with, and an incision carried from the base of the one mastoid process to the other, over the external occipital protuberance.

If, after dividing the dura, more room is required, the dura and the lateral sinus are separated upwards from the bone with great care, and the occipital sinus is then separated downwards. The opening of the bone is now enlarged with cutting forceps, and, if it is necessary to divide the dura still further, the sinus must be ligatured. According to Horsley there need be no anxiety about ligaturing one sinus. The tentorium can then be divided laterally, so as to expose the upper surface of the cerebellum; the straight sinus must be avoided, as it receives, through the veins of Galen, the blood from the interior of the brain.

According to Cotterill the removal of the cerebellar fossæ of the occipital bone on both sides, to the extent which has been described, has no ill effect upon the brain.

The exposure and ligature of the vertical part of the lateral sinus, and of the longitudinal sinus, will be dealt with later on.

11. Extensive Resections of the Skull. The removal of large portions of the skull may, under certain circumstances, be attended with excessive hæmorrhage. As has already been mentioned, an exploratory perforation with the Kümmel-Sudeck burr enables one to decide if preparation must be made for severe hæmorrhage. However, it is our opinion that extensive resections of the skull should be much more restricted than is the present custom.

They should not, as much too often happens, be performed as exploratory operations when the diagnosis is imperfect, but should be employed only to meet definite indications.

The introduction of the osteoplastic methods of Wagner and Wolf induced many to perform extensive resections which were attended by severe hæmorrhage. We have already stated above that osteoplastic resections, for special purposes, are not usually attended with considerable hæmorrhage. Moreover, the chief reason for adopting the osteoplastic method, viz. the fear of large permanent deficiencies in the skull, is unwarranted. As the result of isolated observations, it has been stated that large bony defects in the skull are followed by disturbances of the cerebral function. Elsewhere we have fully shown (Nothnagel's *Spec. Pathologie und Therapie, Capitel über Hirnchirurgische Operationen*, 1901) that these cases allow of another explanation, and that, as demonstrated by the experimental and clinical investigations of Beresowsky and Fedoroff, very large defects in the skull can exist without the slightest ill effect. This view is also borne out by Horsley's observations. Lastly, we have shown, in the article above referred to, that the tendency of defects in the skull to heal is much greater than is generally believed, so long as the internal periosteum, *i.e.* the outer layer of the dura, is carefully preserved (Beresowsky).

The necessity for osteoplastic closure should, therefore, not deter us from the permanent removal of large pieces of bone, but all the same we should not be tempted to make unnecessarily large openings in the skull. Extensive craniotomy, even in its extremest form, viz. hemi-craniotomy, is only to be performed in special circumstances. Such do not exist where it is necessary to empty collections of fluid, to remove injured areas, to extract superficial foreign bodies (splinters), nor, as a rule, for the relief of increased intracranial tension. On the contrary, extensive openings of the skull are only required when large tumours are to be removed, or when an operation has to extend deeply into the brain, and in such a condition it then becomes a question as to which is the best method.

At the present day preference is given to the osteoplastic method for extensive resections of the skull. But this preference appears to find its explanation simply in the fact that one has far too often performed an extensive resection when a smaller one would have sufficed. But even when, for example, one operates for tumours, it is doubtful if the osteoplastic operation is better than, or even as good as, the permanent removal of bone, which is Horsley's invariable practice. If large portions are removed from the brain the gap must be replaced in some way. Provision must be made so that the soft parts can sink in and accommodate themselves to the defect, otherwise blood fills the deficiency and is subsequently replaced by fluid, and cysts, which are the main cause of the subsequent untoward results.

The simplest method of performing extensive resections is that employed by Horsley. A limited area of the skull is removed with a trephine, and as much bone is chipped away with cutting forceps (Horsley uses large, powerful, and somewhat pointed cutting forceps) as appears to be necessary for the exposure, in the first place, merely of a limited area of the surface of the brain. In this case, of course, all idea of an osteoplastic covering must be given up, which, as we have already remarked, is in many instances not to be regarded as a disadvantage.

12. Osteoplastic Resection of the Skull. The original method of Wagner

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 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.

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.

Both methods have recently been replaced by that of Sudeck. It consists in boring a hole down to the dura with one of Kümmel's suitable modified burrs (Fig. 27). Through this opening is introduced a steel rod, provided with a cutting screw-thread and a flat head, as shown in Fig. 28; by pressure on the piece of bone which is to be divided a flap of any size or shape is fashioned, or a piece of bone completely sawn out. Attention is to be directed to two points in an osteoplastic resection: firstly, it is desirable that the outer table of the flap be larger than the inner table, so that it may not subsequently sink too deeply towards the brain; secondly, it is well not to allow the incision in the dura to coincide with the skin incision, so that they may adhere to each other; for example, the dura flap, when it is small, should have its base directed upwards, while the bony flap, on the other hand, should have its base below.

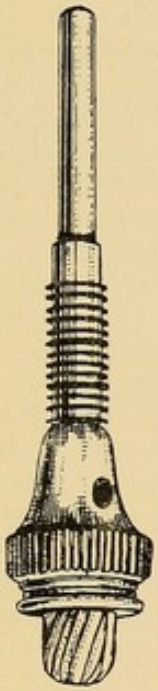


Fig. 27.

Fig. 28.

The bleeding with Sudeck's method is slight. The spiral burr must be driven with a powerful dental foot engine, or, what is much better, by an electric motor of similar power. This may be looked upon as a disadvantage of the method, otherwise Sudeck's burr is a distinct improvement. Should it happen that by this method the bleeding be serious, it can be diminished by frequently dipping the instruments into hot wax.

13. 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 hemi-craniotomy, 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 any shock, and have used merely a collodion dressing; but where there is any bleeding of importance it is better to apply pressure with a bandage.

14. Exploratory Trephining. It has for long been the practice to puncture the brain in various directions with needles and canulæ after it has been exposed and no alteration found on its surface, a deep lesion, in the shape of an abscess or collection of fluid, being expected. Souchon and Payr, relying on certain physiologists, have made small incisions into the soft parts and then drilled through the skull, with the object of making exploratory punctures, or of removing portions of tumours, or small pieces of the brain substance.

The simplest method is that described by Albert Kocher, in which a drill is pressed through the soft parts, without any external incision, down to the bone, which is then perforated. This can be done under cocaine with great ease; the operation is painless, as the injury to the dura is scarcely perceptible.

When collections of fluid, cysts, hematomata, or abscesses are suspected, this procedure is to be recommended. After the inner table has been penetrated (and the operator can always satisfy himself that this has been done if the instrument is withdrawn vertically so as not to displace the soft parts), the canula of Pravaz's syringe may be introduced through the dura into the brain and fluid withdrawn or injected.

The injection of tetanus serum by this method, for the Roux-Borrell treatment of tetanus, has been very successful in our hands. If the necessary spot be not indicated by an abnormal collection of fluid, we have always made the exploratory opening with the drill at a spot where the lateral ventricle can be most readily reached.

15. Puncture of the Lateral Ventricle. 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; it is difficult, therefore, 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, at 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 Fraser, 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 was 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. 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 it 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 may be prevented by a ring or flange on the surface of the skull.

16. Operations on the Brain. The evacuation of fluid, or the excision of scars and of tumours from the brain substance, is always preceded by trephining when we are not dealing with previous injuries. When merely collections of fluid, whether blood, serum, or pus, are to be removed, this can take place immediately after trephining. When, however, a serious operation is contemplated, as in the removal of certain vascular tumours of the brain, too much attention cannot be directed to the excellent practice of Horsley of operating in two stages. The operation in two stages, indeed in certain circumstances in three stages, has the advantage of avoiding the two-fold shock which may follow upon severe loss of blood and prolonged anæsthesia. This is all the more to be taken into account since in operations upon the brain chloroform is to be preferred, as it produces less excitement and hæmorrhage. Chloroform, however, entails the danger of more marked lowering of the blood pressure, and when this is combined with loss of blood it may readily lead to a fatal termination. In tumours the vessels are often dilated, and patients who have been unnecessarily lowered by prolonged antisyphilitic treatment have a special tendency to severe hæmorrhage. In this way, in consequence of intracranial pressure, marked venous engorgement may exist.

It is desirable that, in operating in two stages, a sufficient interval should elapse between the first and second operation, in order to allow the patient to recover completely; after fourteen days, a flap, resected by the osteoplastic method, may be readily opened up. If at the first operation one has been able to ligature the majority of the larger meningeal vessels, and especially the sinuses, the second operation becomes less serious.

As regards the method of procedure, it is to be borne in mind that all the vessels which give rise to dangerous hæmorrhage lie in the membranes of the brain. At first the arteries and veins of the dura have to be dealt with. The arteries present no difficulties; the veins, on the contrary, where they widen out into broad sinuses (spheno-parietal sinus of Brichet) or into the lateral lacunæ before entering the sinus, present great difficulties under certain circumstances, for example, when one is obliged to divide the dura in the immediate neighbourhood of a sinus—a procedure which is always to be avoided when possible. In the division of these large venous spaces as well as of the sinuses themselves, it must be the rule to carefully isolate them

first of all, or at least to make them so far accessible that they may be securely ligatured. The aseptic ligature of a sinus is without risk. Not only may the longitudinal sinus, but also the lateral sinus on one side, be ligatured, provided the other side is free.

Plugging must not be relied upon to permanently arrest the bleeding, although it is the best method of temporarily checking a profuse hæmorrhage. When a large venous sinus has been accidentally opened, forceps with sufficiently long blades are employed to enable the operator to grasp the dura along the whole breadth of the opening in such a manner that a continuous suture can be applied between them and the divided edges of the dura. In this case also such a continuous lateral suture is permissible as is now employed when any large vein is partly divided.

When one has finished with the dura, and, in stripping it off, has isolated and ligatured the large veins passing to the diploë, and those running from the surface of the brain to the dura (some ligatures are especially necessary in the neighbourhood of the longitudinal sinus), the next important step is the isolation and ligature of the vessels lying in the pia. As Horsley has shown, these are most easily reached by taking a fine pair of forceps or a hook and lifting up the pia from the surface of the brain and from out of the sulci over the part to be excised.

When the brain is finally exposed it may be incised without severe bleeding, and this, according to Horsley, is done in a vertical direction in the course of the fibres of the corona radiata. The bleeding which occurs during the removal of a tumour of the brain may be arrested by plugging. It is, however, desirable that the tampon be not left behind; but if the bleeding has been arrested and the parts aseptic (therefore not in abscesses) the wound should be completely closed. Horsley has drawn attention to the advantage of primary suture as compared with the tampon or packing with iodoform gauze so generally employed.

17. 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 obtaining 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, at Eiselberg'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 easily 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 from 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 heterogenous 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.

18. Exposure of the Superior Longitudinal Sinus. Trephining over the sinuses of the dura mater is performed only when rendered necessary by the position of the injury, or by a tumour of the brain, or when the sinus itself is to be exposed or opened. There need be no anxiety about the removal of bone immediately over a sinus, as the latter can be extensively separated from the bone without bleeding, but one must be careful not to injure the walls of the sinus or of the large veins entering it.

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 Poirer) and, including its lacunæ, measures as much as 3 cm., so that at a distance of 1½ 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 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.

Aseptic ligature in the region of the longitudinal sinus is without danger, at any rate at the vertex, because the large veins on the surface of the brain divide into several branches which enter it and afford a sufficient anastomosis.

19. Trephining over the Lateral Sinus (Figs. 29 and 30). 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

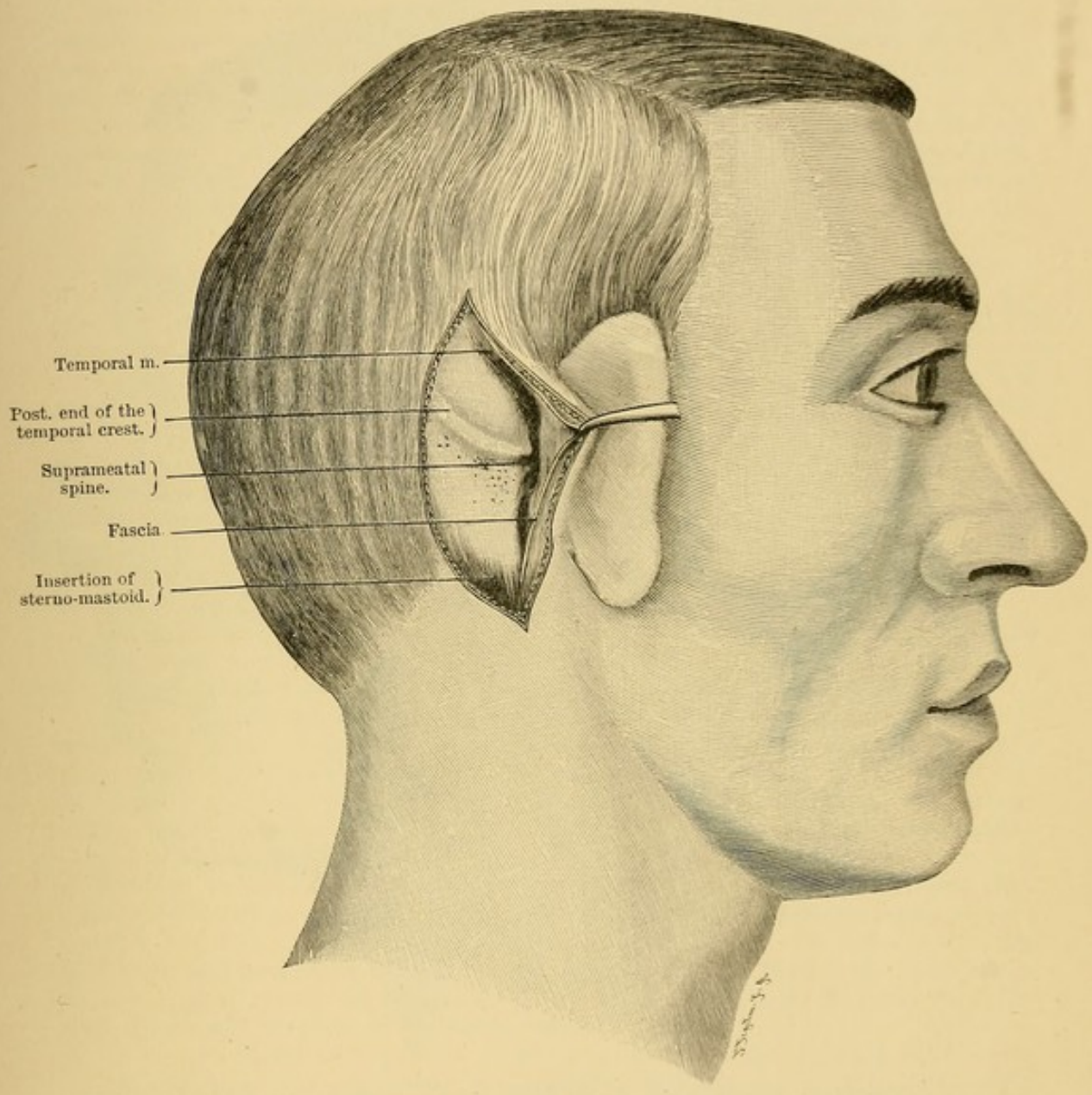


FIG. 29.—Post-auricular incision for opening the mastoid antrum, the lateral sinus, and the descending cornu of the lateral ventricle.

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. 29). 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. The posterior margin of the wound is

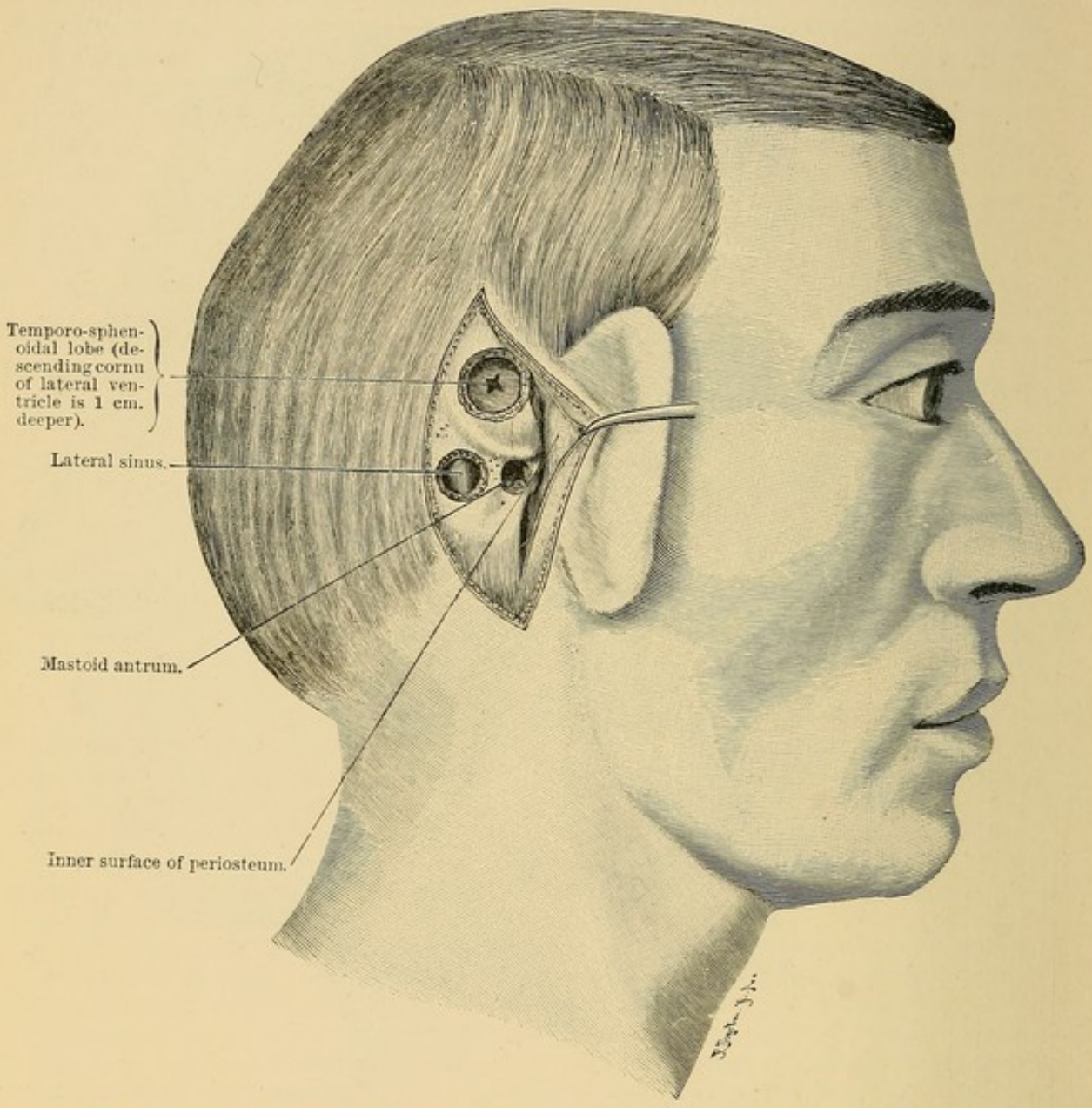


FIG. 30.—Opening the mastoid antrum and the lateral sinus. Exposure of the temporo-sphenoidal lobe and puncture of the descending horn of the lateral ventricle.

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.

The horizontal portion of the lateral sinus is indicated by that portion of the linea glabello-occipitalis which follows the superior curved line of the occipital bones (Poirier). The torcular herophili lies beneath the external occipital protuberance.

The horizontal part of the lateral sinus must occasionally be exposed to reach a cerebral tumour, and may be ligatured on one side without harm (Horsley; see trephining to expose the cerebellum, page 81).

20. Trephining for Intracranial Hæmorrhage. Trephining is not only indicated in meningeal hæmorrhage, especially from the middle meningeal artery, but more recently surgeons have gone a step further 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 $6\frac{1}{4}$ 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 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[2] 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, 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.

[1] *Inaug.-diss.* Breslau, 1897.

[2] *Arch. für klin. Chir.* 1886, Bd. xxxiv.

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.

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 Kohl 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*.

We agree entirely with Krönlein that the first object of the trephining 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.

21. Trephining to expose the Middle Meningeal Artery and its Hæmatomata (see Fig. 31). 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. 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, downwards and backwards, to the posterior extremity of the zygomatic arch, and from thence, upwards and backwards, to above the auricle. After having 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

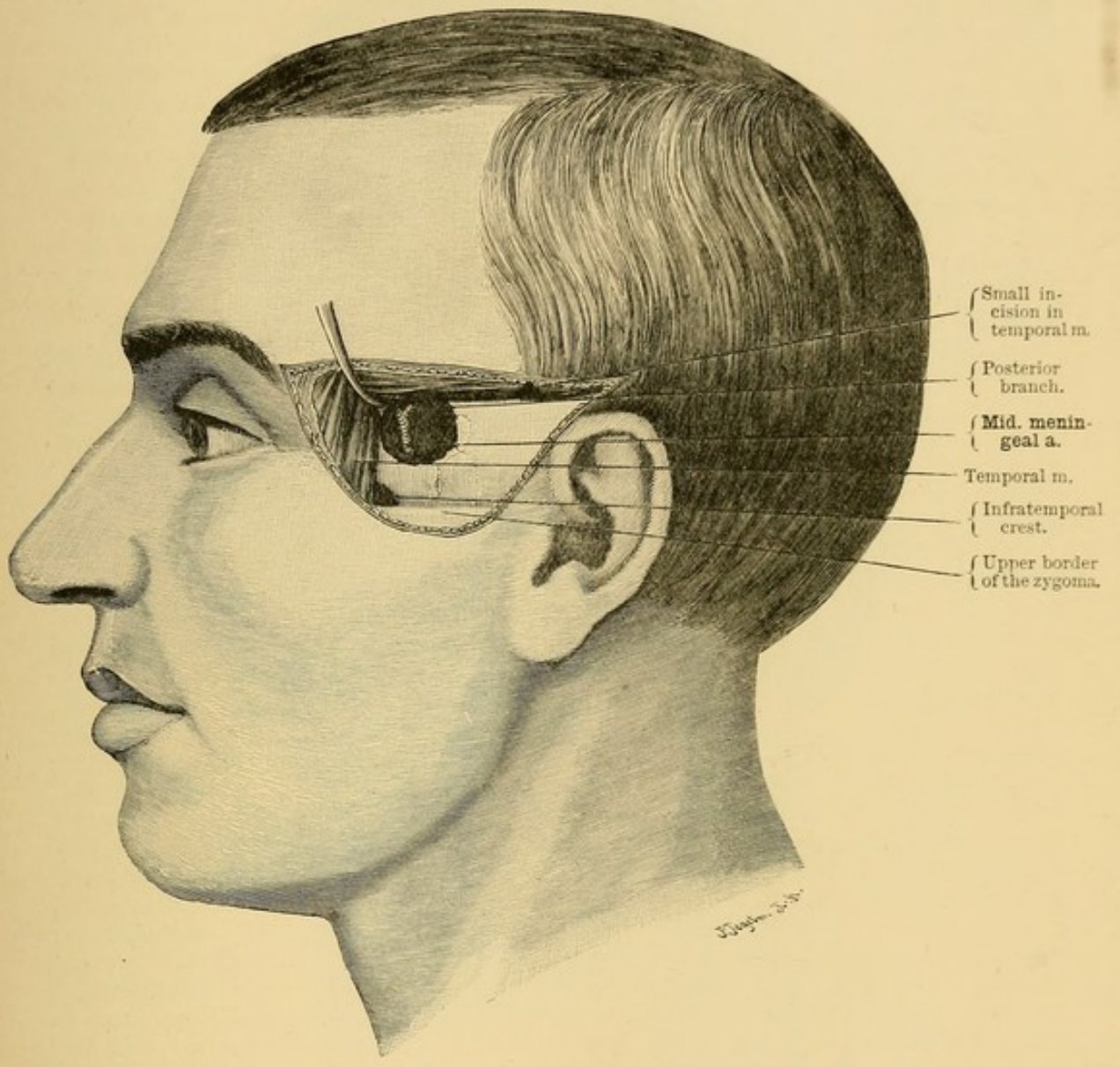


FIG. 31.—Ligature of the middle meningeal artery.

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.

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 are 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 extravasations (as he once observed), which reach almost as far as the foramen magnum, Krönlein gives a third point of trephining, viz. below the middle of the right or left half of the superior curved line of the occipital bone.

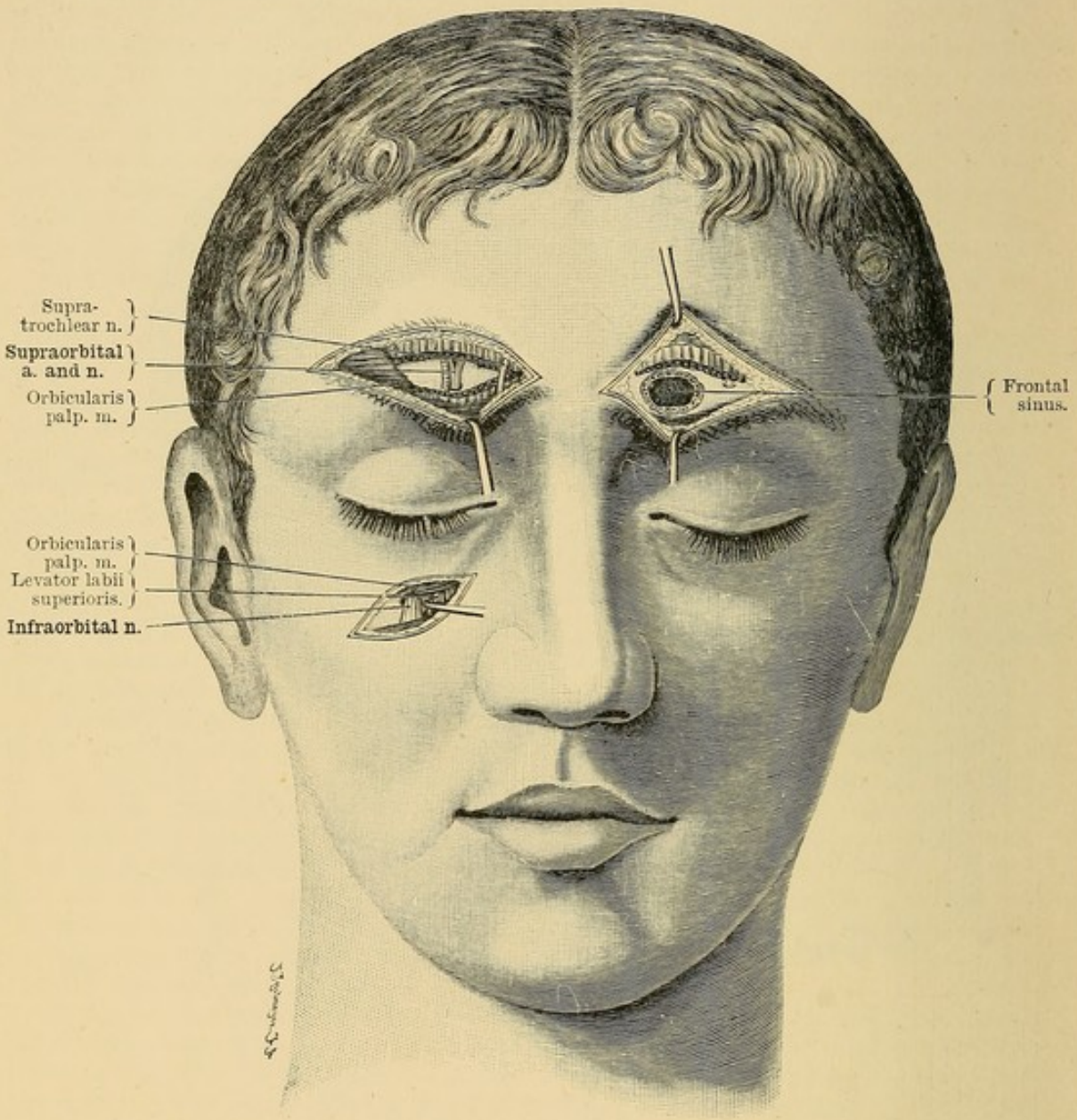


FIG. 32.—Ligature of the supraorbital artery. Exposure of the supraorbital nerve. Infraorbital nerve. Opening of the frontal sinus.

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.

There are still two areas of the skull which, as a rule, are to be avoided in trephining, but which may nevertheless require to be exposed. We refer to the region of the

frontal sinus, and of the mastoid antrum and its cells. Collections of pus in these cavities furnish the most important indication for the necessity of opening them.

22. Trephining the Frontal Sinus—(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 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 diploë, 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 thought of 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. 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 opposite the small opening first formed (see Fig. 32), so that the cavity may be thoroughly washed out.

The 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 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 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.

23. Exposure of the Middle Ear (Fig. 30). 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 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. The usual method of syringing out the ear is of little use in these cases. Should the discharge cease to escape the mastoid process must be trephined, and this ought to be done before the more serious consequences of continued suppuration set in. 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. From the external periosteum a "phlegmon" forms behind the auricle. The internal periosteum 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 a short time after the escape of the exudation, the tympanic cavity, along with all its recesses and neighbouring spaces, must be freely exposed. It is very 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 speak of 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 sufficiently early effected. For this purpose it suffices to open the antrum and mastoid cells, an operation in the execution and exact development of which Schwartze has done valuable service.

(a) **Trephining the Mastoid Processes.** Opening and exposure of the mastoid cells and antrum are 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 undertaken subsequently. 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. 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 osseous meatus will be found the more or less well-developed bony projection known as the supra-meatal spine of Bezold. By applying a small gouge in this position and removing the bone directly inwards parallel to the osseous auditory canal, the cavity of the antrum will 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 in a direction backwards from the above-mentioned area, so as to open the mastoid cells.

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 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 smooth and without projecting edges. 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 stuffed with xeroform gauze. Provisional sutures are passed through the edges of the wound, but 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, and when there is no longer a prospect of rapid healing. For the chronic cases of middle ear suppuration the radical operation is to be performed.

(b) The Radical Operation. By the radical operation (for the development of which, in its present form, we are indebted to Stacke) we understand the exposure not only of the mastoid cells and antrum, but of the entire tympanic cavity, including the attic (*recessus epitympanicus*). It is interesting to follow from Rheinhardt's minute description how this operation has been developed step by step to the attainment of a surgically correct procedure where there is retention of infectious exudate and necrotic material. What is done 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. Bergmann added the removal of the upper wall in order to enable the tympanic cavity and the ossicles to be thoroughly cleaned out. Zaufal made 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.

Stacke's operation, as performed by Schwartze and Körner, is as follows:—The above-mentioned auricular incision is made, and the retro-auricular flap is separated sub-periosteally as far as the bony meatus. With a periosteum detacher inserted between the osseous and cutaneous walls of the canal, the latter is separated and divided posteriorly and superiorly at the tympanic membrane and held forward with a blunt hook. The antrum is freely opened as above described, and then with a chisel the lower layer of the posterior wall of the osseous auditory canal is chiselled away, and the outer wall of the aditus and attic is removed to such an extent that no further bony projection can be felt as far as the tegmen tympani, and as far backwards as to completely open up the antrum. The tympanic cavity is then cleared out, the malleus and incus are removed with forceps, the posterior wall of the canal is removed, the canal for the facial nerve (aqueduct of Fallopius) and the horizontal semicircular canal being avoided.

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, definitely closed by secondary suturing.

(c) **The Operation in Intracranial Complications.** Körner and Macewen deserve the credit of having demonstrated the way in which extensions of suppuration towards the cranial cavity are to be most certainly reached. 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 under the headings (*a*) and (*b*), 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 damage possible. 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 now be scooped out from the sinus, which should be plugged by pressure from without, or, when it is more extensively opened, it 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. 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 is split up and the thrombus scraped out, with the object of preventing or curing the secondary bacteræmia.

Abscesses of the temporo-sphenoidal 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 trephining the skull.

(d) **Trephining for Cerebral Abscess.** Trephining for temporo-sphenoidal abscesses is performed by prolonging the auricular incision (Fig. 30) 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, the area of the squamous portion of the temporal bone above and behind the ear is exposed, this area leading most certainly to the floor of the middle fossa. 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, which becomes continuous with the root of the zygoma. After dividing 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 the vessels of the pia the abscess is opened with a knife, and the opening dilated with forceps. The opening must be large enough to allow the cavity to be cautiously and thoroughly washed out. It must be kept open for a few days and dusted with boracic acid and iodoform, or dressed with a xeroform tampon. The trephine-opening is stuffed with a xeroform tampon as a permanent dressing.

Trephining for an abscess of the cerebellum is performed after previously opening 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.

F. THE FACE, NOSE, MOUTH, AND PHARYNX

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*, 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: rather 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.

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 too severe 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 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 we 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 Schonborn.

Ligature of the external carotid is, as Lipps has shown, not a dangerous operation, 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. Ligature is simpler and more certain.

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 at page 23) 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 precautions, and have had such great 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 larynx, must keep this position for eight to fourteen days, or even longer.

24. Ligature of the Facial Artery (Fig. 33). This is the chief artery of the face. The place for ligaturing it 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, the artery is exposed, and 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.

25. Operations on the Nose and Nasal Cavities. Access to the nasal cavities through the anterior nares is not to be attempted in attacking nasal affections of a very serious nature, such, for example, as deeply invading inflammations and malignant growths. In such affections the interior of the nose must be made thoroughly accessible both to palpation and to inspection.

The simplest way of doing this is by *splitting the nasal septum*, a method recommended by us. 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.

If a good view of the interior of the nose is desired, freer access must be got. This is attained by *splitting the nose close to the middle line* (Fig. 10). The incision is not made exactly in the middle line, on account of the furrow which runs along the anterior edge of the septal cartilage of the nose. A cicatrix along this furrow would,

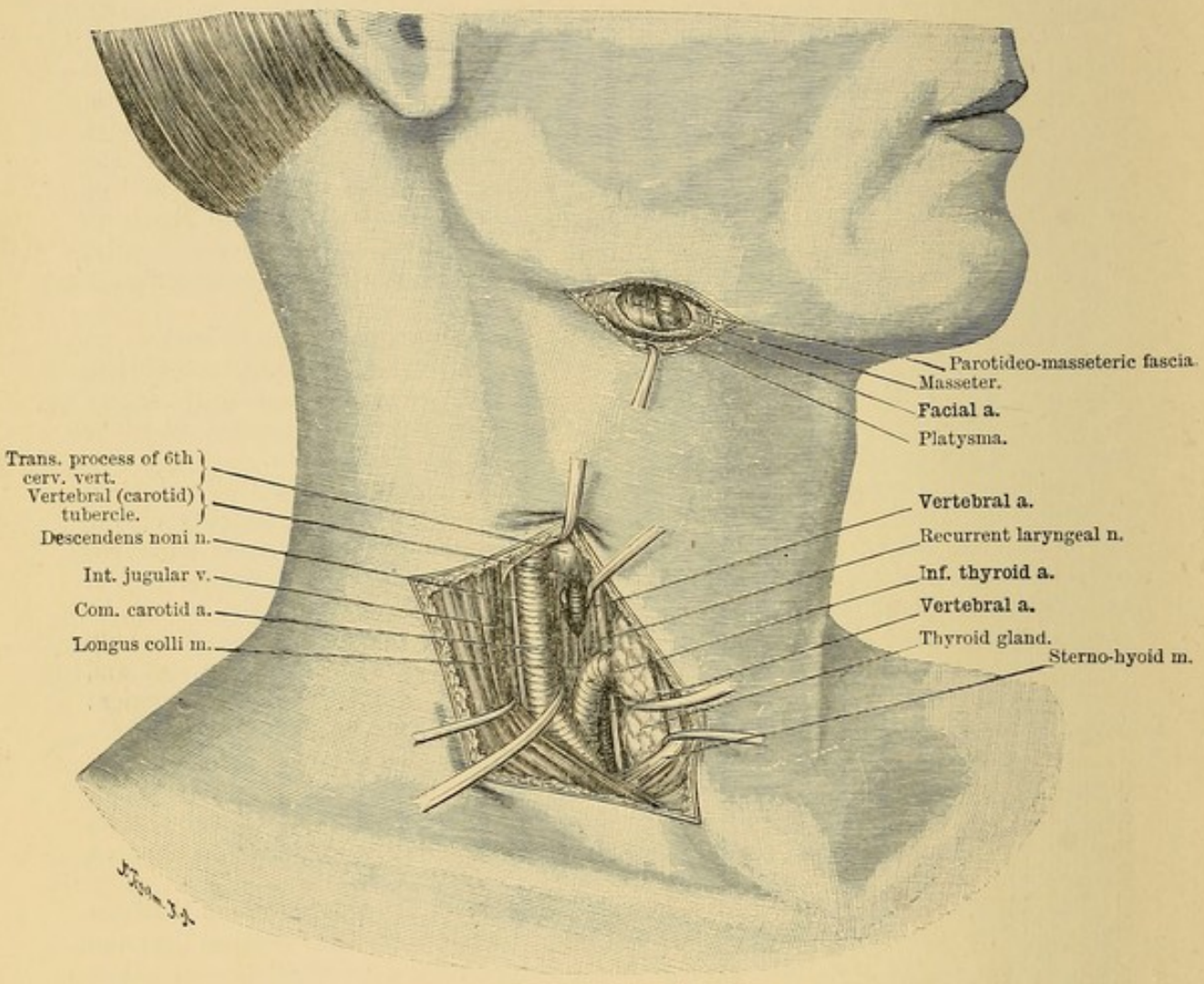


FIG. 33.—Ligature of the facial artery. Ligature of the inferior thyroid and vertebral arteries.

by contraction, render it visible, and so produce distinct disfigurement. By dividing 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. If, in addition to splitting the nasal bone, the nasal process of the superior maxilla be divided from below upwards, just in front of the lachrymal sac, and if the root of the nasal bone be chiselled across, then the corresponding side of the nose may be thrown upwards, and a good view of the entire vertical extent of the corresponding cavity is obtained. By adopting Barth's method of dividing the nasal bones and the nasal process of the frontal bones transversely, good access is got also to the upper ethmoidal cells, and the frontal sinus can be reached from below. Ollier has turned the nose downwards.

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* (Fig. 11). 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.

26. Exposure of the Base of the Skull or the Roof of the Nose. Another method of gaining free access to the back part of the nasal cavity is by *splitting the hard and the soft palates.* After making a mesial incision down to the bone, the muco-periosteal soft parts are separated and turned aside, and the hard palate, together with a portion of the vomer, is chiselled out (Nélaton and Gussenbauer). The posterior part of the nasal cavities and the naso-pharynx are thus exposed, so that tumours (fibromata and fibro-sarcomata) springing from the base of the skull can be removed under exact control. In a case we recently operated on for recurrent sarcoma of the base of the skull and back part of the roof of the nose, complete healing was obtained with a minimum of subsequent disfigurement by an osteoplastic resection of both upper jaws, namely, splitting of the upper lip up to the nostril, division of the mucous membrane on both sides along its line of reflection from the gums to the cheeks, and then chiselling across both upper jaws transversely outwards and backwards from the anterior nares. The wound having been plugged, the hard palate is next chiselled through along the middle line and the soft palate is split mesially. Both upper jaws (without the pterygoid processes) are now drawn well apart with sharp hooks, the mucous membrane of the floor of the nose divided, the vomer drawn aside, and the projecting turbinals excised. The tumour is thus completely exposed. Depage has obtained primary union by this method.

In such an extensive operation, in addition to prophylactic arrest of hæmorrhage by ligaturing both external carotids, we advise that the anæsthetic be not given with the head dependent, otherwise the venous hæmorrhage will be too free. A small dose (not more than $\frac{1}{6}$ grain) of morphia should be injected half an hour before the operation. The body is placed in such a position that the trachea is not too dependent. The head itself, however, is elevated, and the anæsthetic is administered by Arnd's apparatus, and exact doses of diluted ether mixture are given with Braun's apparatus.

Partsch has modified our method in such a way that he also separates the alveolar process from the upper jaw on both sides, but does not split it mesially; he turns

downwards the entire alveolar portion along with the hard palate, the hinge consisting of the soft parts in the region of the hammular process.

27. For *opening the sphenoidal sinuses* the above-mentioned plan of Gussenbauer appears to be the most suitable. These sinuses open into the nose opposite the posterior extremities of the superior turbinals. They can be opened by perforating the roof of the nose with a sharp spoon at the upper border of the posterior nares, between the posterior edge of the middle turbinal and the ala of the vomer.

28. Opening the *ethmoidal cells* in cases of malignant disease comes to be considered in epitheliomatous and sarcomatous polypi which have grown from the nose into the ethmoid, and possibly also into the orbit. The same operation may be performed when the disease springs from the ethmoid. Such cases are very frequently treated for a long time by specialists as nasal polypi, until recurrence, severe hæmorrhages, and the occurrence of amaurosis and exophthalmos prove definitely the situation and nature of the affection.

In a case (April 1898) where there was exophthalmos and complete blindness, and in which the eyeball was removed with the object of ensuring a permanent cure, we were greatly satisfied with the following procedure :—

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.

After opening the nasal cavity, access is got to the *nasal duct* under the anterior

end of the inferior turbinated bone 1½ cm. (⅝ in.) behind the edge of the osseous anterior nares. The *antrum of Highmore* is reached by passing outwards under the middle turbinal 2½ cm. (1 in.) behind the above bony edge; 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.

Lastly, the nasal cavities may be exposed without injury to the facial nerve *by an incision from the sublabial mucous aspect*. Without injury to the face, the mucous membrane is divided along its line of reflection from the gums to the upper lip, and the cartilaginous part of the nose is separated from its attachment to the osseous anterior nares so that the soft parts (nose and cheeks) can be turned upwards as far as the eyes (Rouge); if the septum be now divided, then the entire nasal cavities become accessible from the front. This operation has the advantage of leaving no disfigurement, but it is attended with considerable hæmorrhage.

In all extensive operations about the nose the desirability of a prophylactic ligature of the external carotid is to be considered.

29. To freely open the Antrum of Highmore. One method of gaining access to the antrum has already been referred to in dealing with the nasal cavity. Even when a large opening is necessary, one endeavours to avoid an external incision by entering from the mucous membrane either of the mouth or of the nose. The antrum is frequently the seat of suppuration following long-continued inflammation, so that we are often called upon to make a permanent opening into it. The *canine fossa* is the place from which it is most readily reached in order to allow of its being freely opened and thoroughly investigated. The upper lip having been everted, the mucous membrane and periosteum are divided along its line of reflection above the roots of the bicuspid and first molar teeth, and the periosteum is detached with an elevator upwards and outwards till just below the infraorbital foramen; the thin bony wall is then chiselled through with a gouge. The strong buttress on either side of the canine fossa, formed by the nasal process and the ridge of the malar bone, is left undisturbed. The operation can be performed painlessly under cocaine. The opening is kept patent and syringed out for months when the cause of suppuration cannot be removed.

A second method is to bore upwards with a perforator *through the alveolus* of an absent or extracted tooth, preferably the first or second molar. In this position a permanent silver tube can most readily be introduced.

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, is 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, as is the case when opened through the canine fossa.

30. Operations in the Region of the Orbit. We have referred above to a procedure for the removal of tumours which have invaded the orbit from the ethmoidal cells. Gussenbauer has described a method for the simultaneous exposure of the inner wall of both orbits, together with the ethmoidal, frontal, and sphenoidal sinuses; an incision is made in a curved direction from the eyebrow downwards close to the inner canthus as far as the nasal process of the superior maxilla, and a transverse incision is added above the root of the nose. Very good access is obtained with relatively slight disfigurement.

For tumours, abscesses, and foreign bodies, on the other hand, which lie behind the eyeball, we are indebted to Krönlein for the method which gives the best access. He resects osteoplastically the outer wall of the orbit, and divides the base of the external angular process of the frontal bone as far as the spheno-maxillary fissure, or, as stated by Domela, to a point 1 cm. behind the sutura zygomatico-sphenoidalis.

The base of the frontal process of the malar is then divided, and this portion of the bone is turned backwards.

The periosteum of the orbit is separated with a blunt instrument, and after it is retracted the severed bone is divided longitudinally. Czermak has made the resection more extensive by dividing the malar at its junction with the upper jaw, just as we have described and figured (Fig. 34) for the exposure of the superior maxillary division of the fifth nerve at the foramen rotundum. The extent of the affection must decide whether Krönlein's original method or Czermak's modification is to be employed.

Krönlein makes a curved incision with its convexity forwards through the soft parts at the outer margin of the orbit, the lower end of the incision reaching down to the middle of the zygomatic arch (Domela). We do not approve of this method,

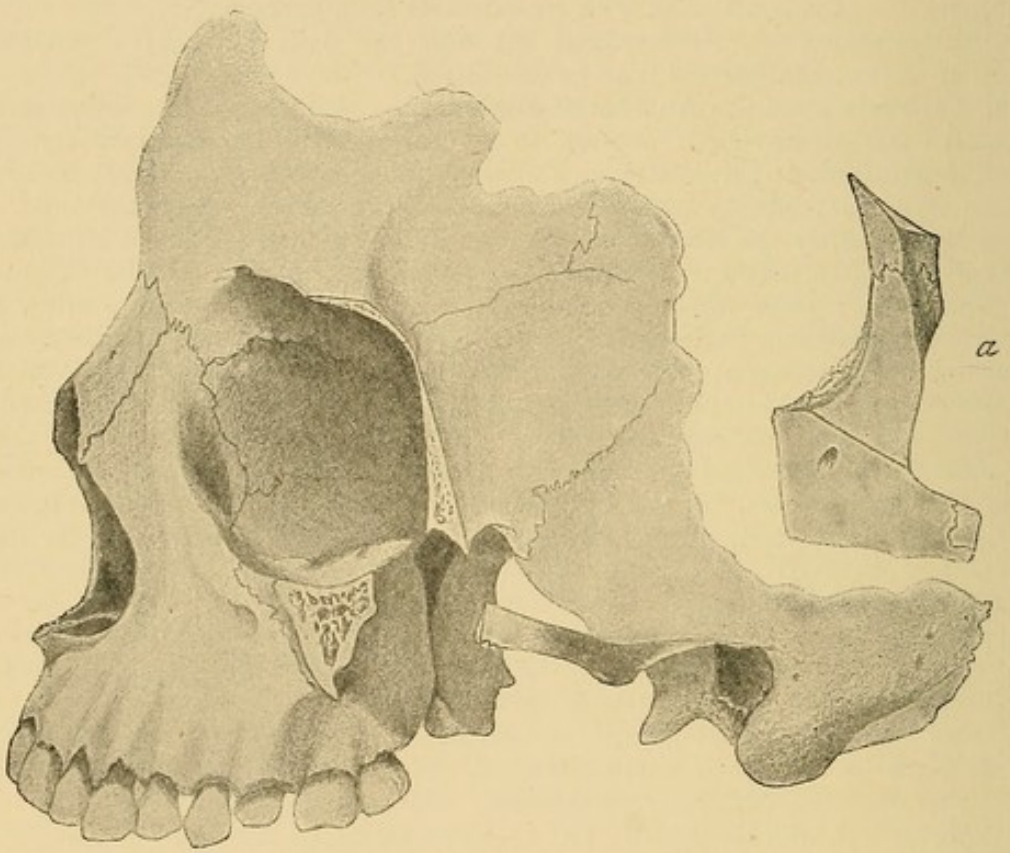


FIG. 34.—The figure, after Domela (Krönlein), shows Czermak's incisions, and on the right (*a*) is seen Krönlein's section of the bone.

as we discard all incisions which run from above downwards in the region of the facial nerve. We recommend, as in other cases, an oblique incision similar to that for resection of the malar bone, but situated somewhat higher (see Fig. 11) and extending into the outer commissure of the eyelid.

Operations on the Nerves of the Face

31. Facial Nerve (Fig. 35). In operations in the fossa behind the ramus of the jaw, such, for example, as the excision of lymphatic glands and parotid tumours, it may be necessary to expose the facial nerve with the object of preserving it. Again, the nerve is occasionally exposed and stretched for the purpose of arresting spasms of the facial muscles. We have repeatedly, and with excellent results, performed

stretching of the nerve for facial spasm (tic convulsif). The stretching must be carefully measured, and at first carried to the extent of producing a distinct paresis of the muscles affected by the spasm.

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.

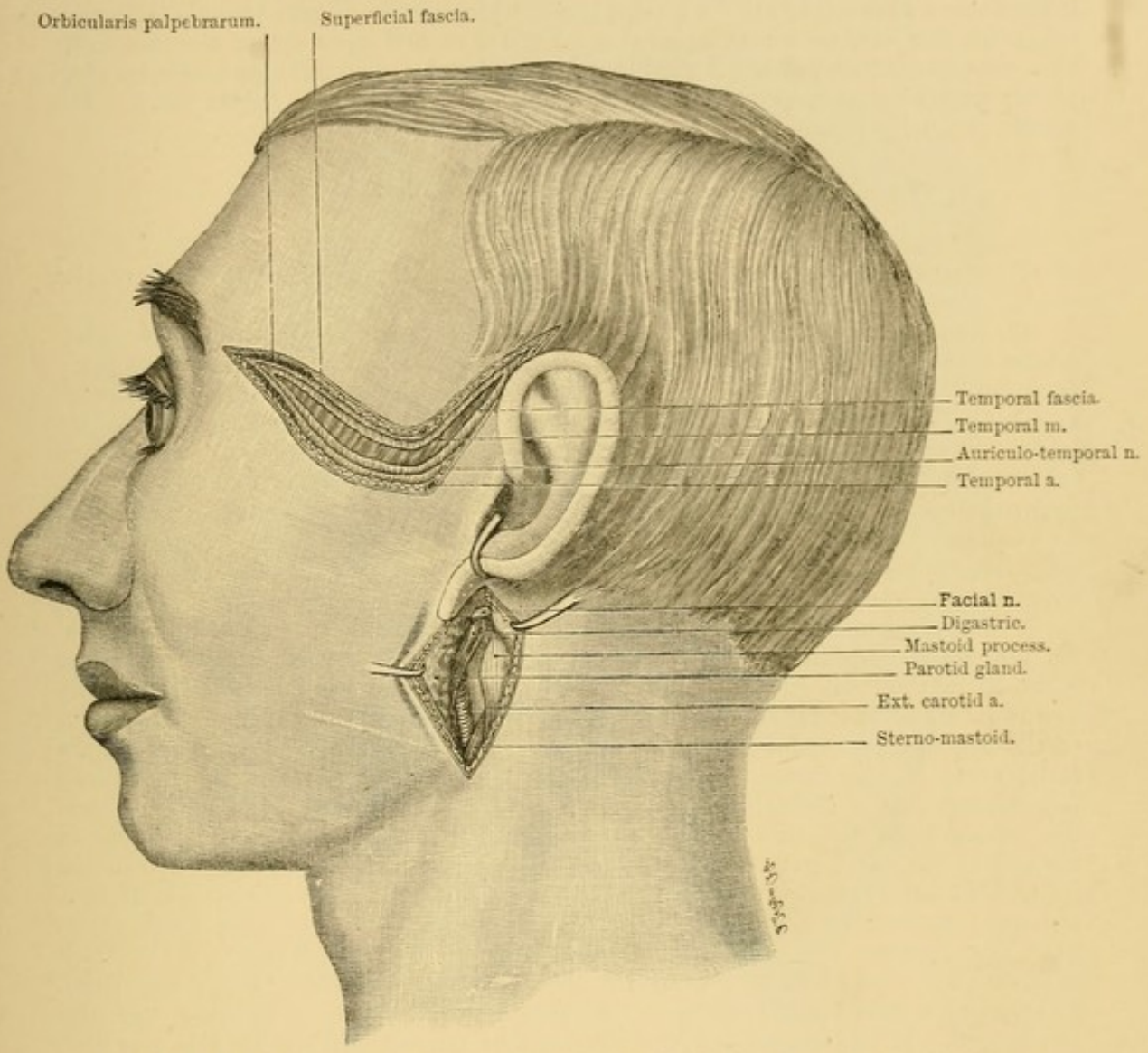


FIG. 35.—Incision for resecting the third (inferior maxillary) division of the trigeminal nerve at the foramen ovale. Exposure of the facial nerve.

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 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. 35 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 aneurism 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 passes off.

Trigeminal Nerve

Trigeminal neuralgias afford the chief indications for exposing the fifth cranial nerve. For the branches of the first division see Fig. 32.

32. Second Division of the Trigeminal Nerve (Figs. 36 and 37). The infra-orbital nerve is the branch which is most frequently the seat of neuralgia. This nerve may be stretched 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 may be stretched either with an aneurism needle or by drawing it forcibly forwards with the finger. Lastly, it can here be grasped with one of our artery forceps, with which it is twisted and wrenched away according to the method of Thiersch.

A very good method, but one requiring an external incision, is the following:— An incision is made in the line of our normal incision for the upper jaw, beginning ½ cm. below the inner end of the infraorbital margin and passing somewhat obliquely downwards and outwards as far as the lower angle of the malar bone. The origin of the zygomaticus major muscle is exposed and separated. 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 dividing 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 aneurism 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 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.

In order to obtain permanent benefit by operation for neuralgia of this nerve, it is necessary to resect the second division of the trigeminal at the foramen rotundum, because the infraorbital nerve gives off its orbital and posterior superior dental branches before it enters the orbit, and because the superior maxillary trunk, as it traverses the spheno-maxillary fossa, gives off not only the infraorbital nerve, but also the spheno-palatine branches to Meckel's ganglion, branches which cannot be isolated as is the case with the branches of the infraorbital.

The method of neurexeresis recommended by Thiersch has been recently employed by Angerer and Helfrich, with the special object of obtaining a permanent result. If the nerve be grasped as near the middle as possible and drawn out *in toto* with its

branches, and if, as Angerer advises, the branches of the trigeminus which are still healthy are removed in the same way, there is certainly a better prospect of a radical cure than if the nerve is only cut through.

33. Resection of the 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 the nerve is torn across at its entrance into the foramen at the orbital surface of the malar bone.

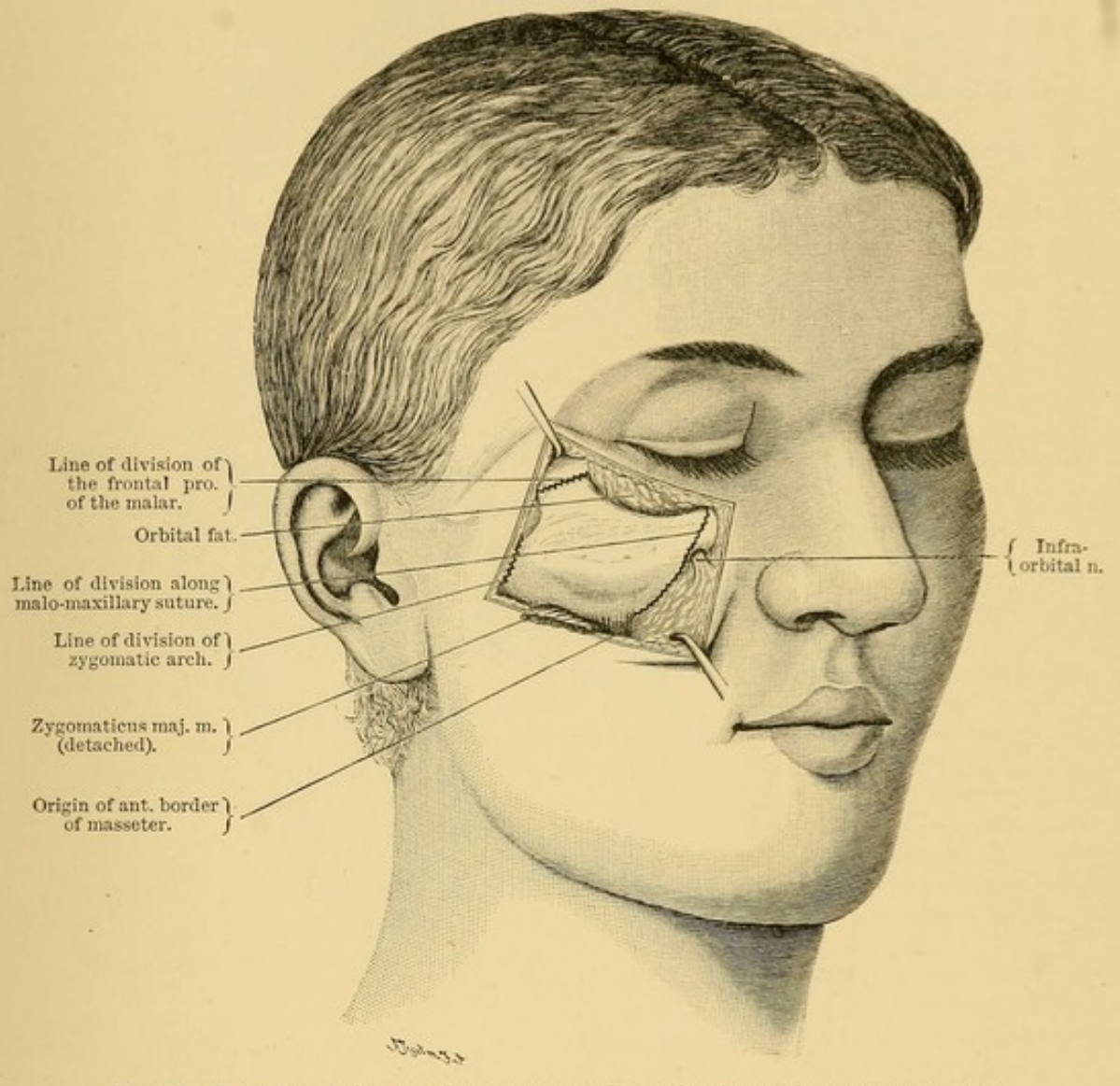


FIG. 36.—Resection of the second (superior maxillary) division of the trigeminal nerve.

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.

34. The more operations for neuralgia are limited to division of the peripheral branches the smaller is the prospect of a permanent cure. By exposing the **superior maxillary nerve at the foramen rotundum** (Figs. 30 and 31), the only branch which escapes is the recurrent branch to the dura mater. This proximal operation, however,

has the disadvantage of paralysing the vidian, and therefore also the motor branches from the facial which accompany the palatine nerves to the muscles of the palate.

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-

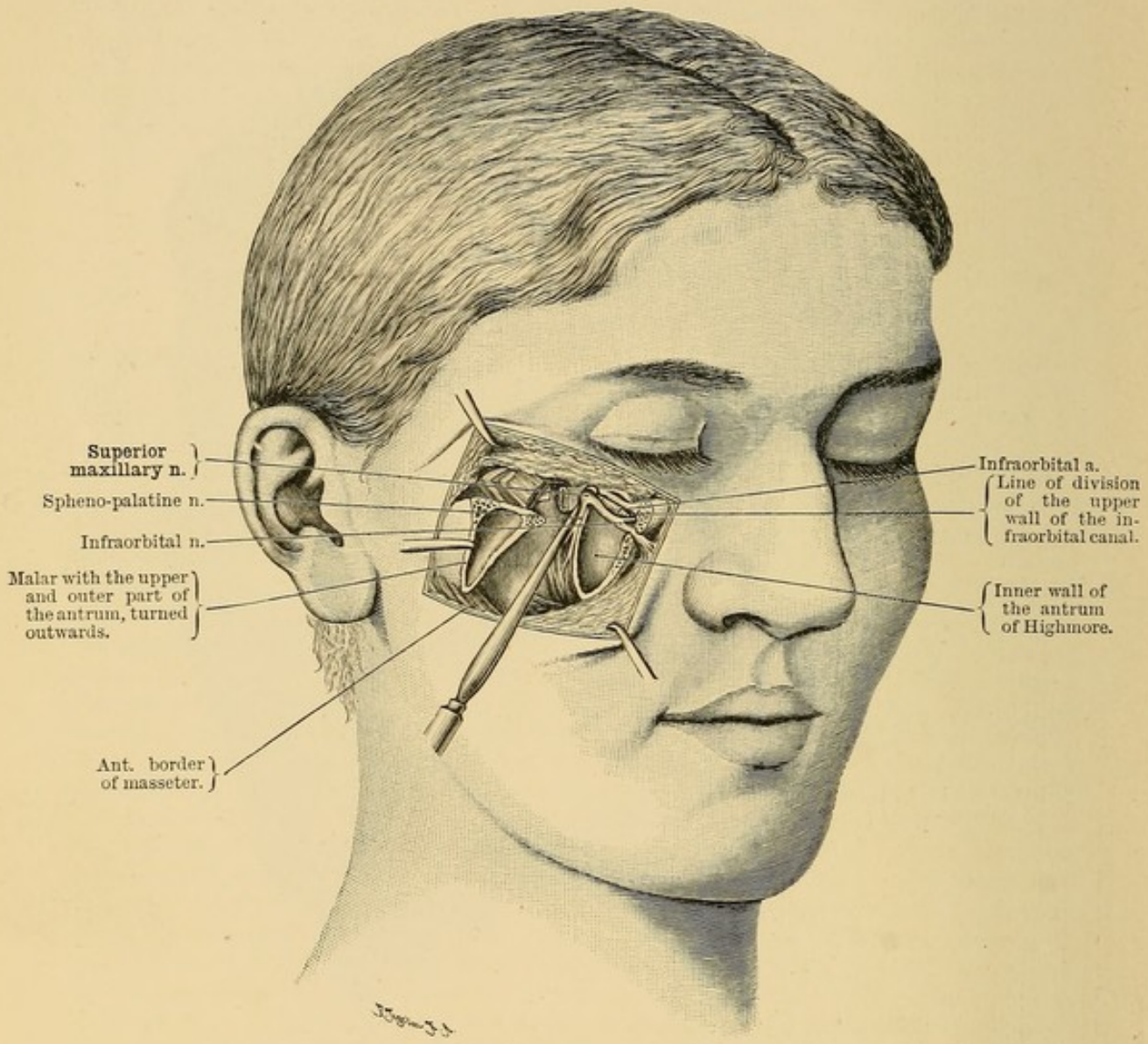


FIG. 37.—Exposure of the second (superior maxillary) division of the trigeminal nerve at the foramen ovale.

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 Bruns, and according to Lucke's procedure in the modification 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. 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 (Fig. 34) in combination with the method 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 (see Figs. 10 and 36), but longer, *i.e.* beginning 1 cm. internal to the infraorbital foramen and ½ cm. below the inner end of the infraorbital margin, and this is carried horizontally outwards with a slight downward inclination 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 lies 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 downwards subperiosteally, so 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, which are separated 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. 36), 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. 36), 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. 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 either cut across or wrenched out (Thiersch). The infraorbital artery, which accompanies the infraorbital nerve, is either avoided or ligatured. 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 fascial 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.

35. The Third Division of the Fifth Nerve.—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 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 range of its lateral movements. 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.

The lingual and inferior dental nerves are frequently the seat of neuralgias, especially the latter during its course through the inferior dental canal. Neuralgias occasionally occur also in the auriculo-temporal and long buccal nerves, the latter supplying the region of the angle of the mouth.

The inferior dental nerve may be exposed in various situations.

36. Its terminal portion, 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.

37. Inferior Dental Nerve (Fig. 38). (*a*) By trephining the ascending ramus through an incision along the angle of the jaw. Velpeau and Linhardt advocate a 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.

38. The Lingual Nerve may also be exposed by Paravicini's intrabuccal method. 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.

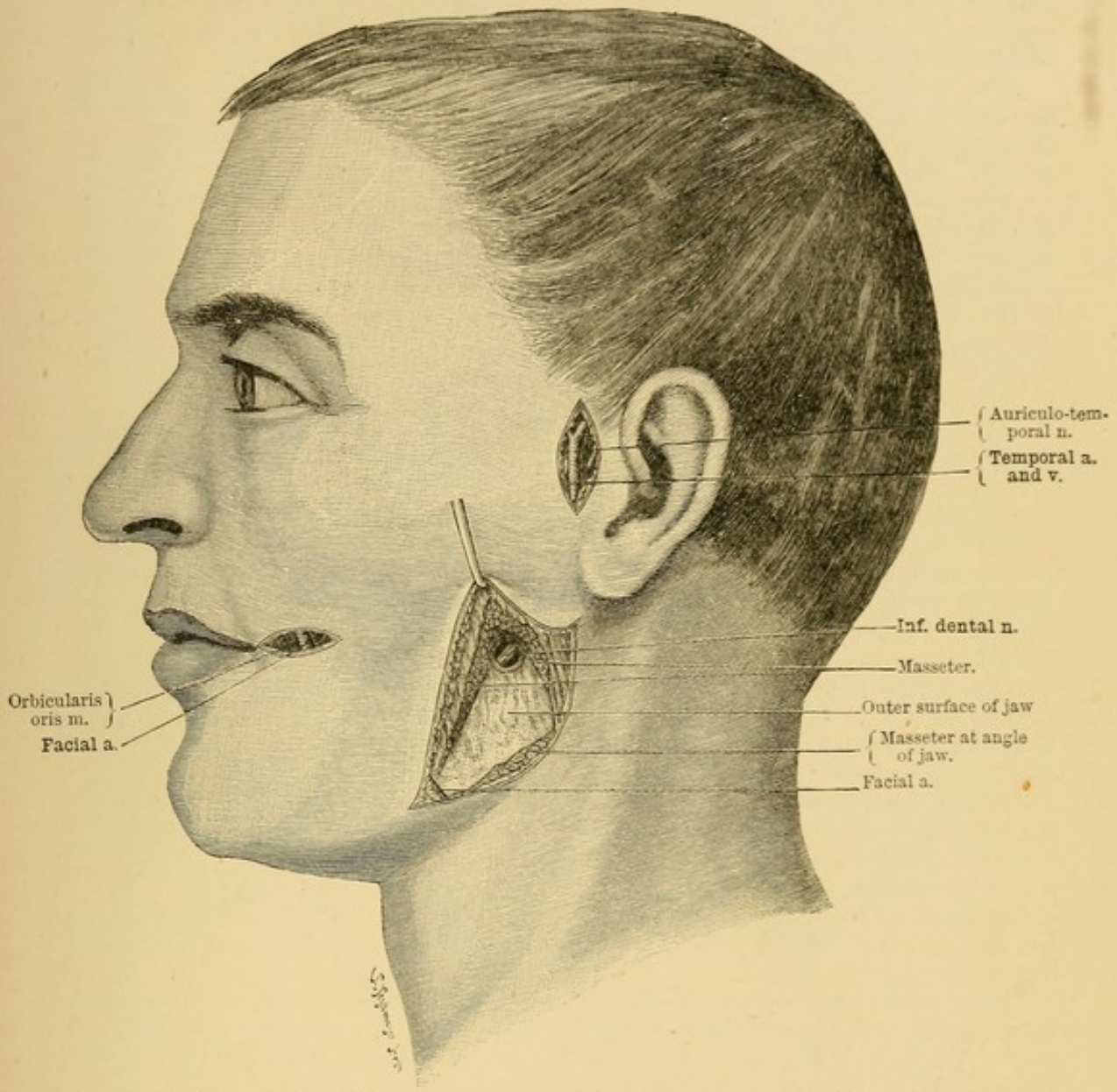


FIG. 38.—Ligature of the facial artery. Ligature of the temporal artery. Trephining the ascending ramus of the jaw to expose the inferior dental nerve.

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 (see footnote, p. 77). 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. The operation is considerably more difficult than that previously mentioned, but it possesses the advantage that primary healing is obtained with certainty.

A third method is to secure the nerve by trephining the ramus of the lower jaw in the same way as for the inferior dental nerve.

39. The Auriculo-Temporal Nerve (Fig. 19) 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.

40. The Buccinator Nerve is the sensory nerve for the region of the angle of the mouth. It lies to the inner side of the coronoid process of the lower jaw, and 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. The nerve will be exposed passing transversely forwards upon the process.

The operation from without (Zuckerkandl) is by an incision below the zygoma and the malar bone, beginning at the anterior border of the masseter and extending horizontally forwards above Stenson's duct, avoiding the transverse facial artery. The fatty cushion of the cheek, which is met with anterior to the masseter, is pushed aside or removed in order to expose the anterior edge of the coronoid process, upon the inner aspect of which the nerve is found passing forwards upon the muscular fibres of the buccinator. This method from without has the disadvantage that the branches of the facial nerve are liable to be injured.

41. Inferior Maxillary Nerve. 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 (Figs. 29 and 33). 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.

The incision (Fig. 39) begins just 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 temporal vessels being ligatured. The incision divides the skin, some fibres of the orbicularis, the superficial fascia, and the strong temporal fascia, all of which are drawn downwards along with the branches of the facial nerve which go to the orbicularis and to the frontal muscles. The malar is now exposed 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 drawn down with a strong 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.

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 be now 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

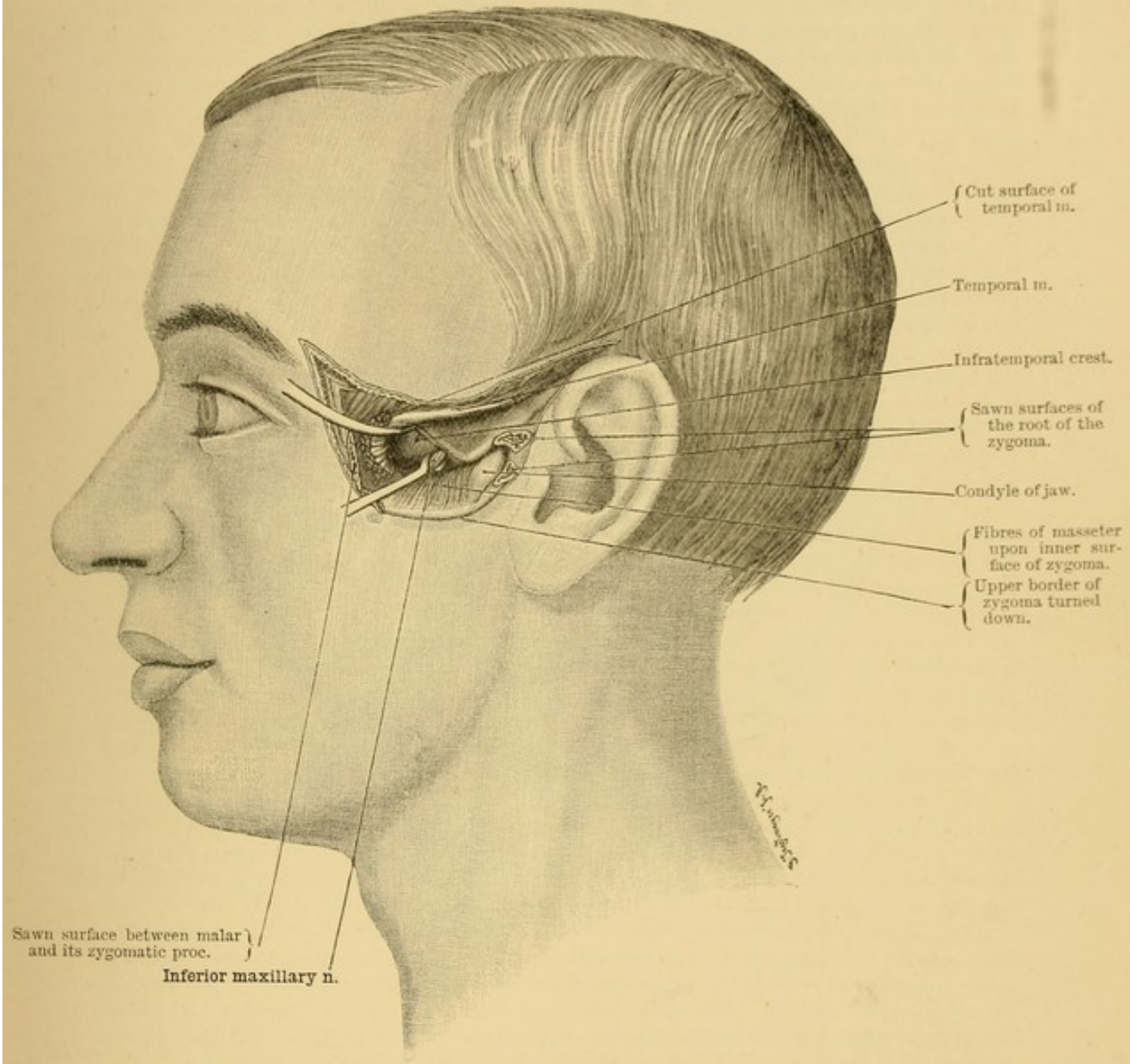


FIG. 39.—Exposure of the third (inferior maxillary) division of the trigeminal nerve at the foramen ovale.

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.

It is unnecessary to resect the malar either at its orbital plate or at its junction with the upper jaw, as no more room is thereby provided for isolating the nerve. 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 fascial 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.

42. Removal of the Gasserian Ganglion. From the successful operations of a large number of surgeons, especially Krause and Keen, it has been shown that removal of the Gasserian ganglion gives permanent relief in obstinate trigeminal neuralgias. Further, it has been proved that the results of this operation are not of a kind that entails on the patient any permanent harm. Neuroparalytic keratitis, with destruction of the eyes, does not occur, as a rule, after removal of the ganglion, *i.e.* it can be avoided by protecting the eye. The paralysis of the muscles of mastication on the one side does not impair chewing to any serious extent, and the anæsthetic area of the face gradually diminishes and gives no further trouble. The injurious effects of the operation, in so far as they affect the brain and the nerves to the muscles of the eye (especially the sixth, the pupillary branches of the sympathetic, and the third), gradually disappear.

There remains the danger from hæmorrhage, and it is for this reason that even the most experienced surgeons advise that the operation should only be undertaken in those cases where neurotomy, neurectomy, and avulsion of the individual branches of the fifth have proved insufficient. The bleeding comes from two sources: (1) The middle meningeal artery and the small branches to the ganglion; (2) The veins passing from the dura and the skull (in the form of the emissary veins or veins of the diploë to the pterygoid plexus. The clearer the view that is obtained of the course of the middle meningeal artery on the surface of the dura down to the foramen spinosum, and the less the dura is stripped, the less will be the hæmorrhage from both sources, and consequently smaller risk will attend the operation. Tiffany gives the mortality as 22 per cent out of 108 cases.

Two methods have been recommended for exposing the Gasserian ganglion, the sphenoidal and the temporal. The *sphenoidal route* (first employed by W. Rose) gives direct but limited access. It has therefore undergone many modifications, especially in the form of the temporo-sphenoidal method of Poirier and Doyen, and of the temporary resection of the zygomatic arch by Jacob, Quénu, and Sébileau. Tichonowitsch gives preference to the procedure of the latter authors.

The *temporal method*, recommended and perfected by Hartley and Krause, gives a much freer, though less direct access. Krause asserts that the results obtained by it up to the present are far better than those obtained by the sphenoidal method. The great drawbacks to the latter are got rid of, as Krause considers ligature of the middle meningeal necessary, while Friedrich recommends preliminary ligature of the external carotid, or the placing of a ligature beneath the vessel and tying it if the bleeding be severe. The dangers of a somewhat extensive stripping of the dura from the lateral aspect and base of the skull, and the venous bleeding attending it, are not got rid of by this method. We therefore prefer Harvey Cushing's method, which he terms *the Direct Infra-Arterial Method*, a procedure which is to be included among the temporal methods. He has carefully worked out the details of the operations in thirty cadavers, and has performed the operation successfully on four patients. We have had the opportunity of observing the accuracy and skill of this author's experimental work, and we cannot therefore refrain from reproducing his admirable illustration.[1] The procedure is very like that of Coelho, who also proposed to resect the zygoma in the Hartley-Krause method, in this respect resembling the methods of Quénu, Sébileau, and Jacob. Lexer has also made use of this very advantageous step.

[1] "A Method of Total Extirpation of the Gasserian Ganglion," etc., read before a meeting of the College of Physicians, Philadelphia, April 1900.

The idea of performing almost all operations on the brain by an osteoplastic method, the objections to which we have already referred to in our chapter on trephining, has induced surgeons to operate on the Gasserian ganglion. It is the osteoplastic method which makes it impossible to place the opening in the bone in such a position as to give the best access, *i.e.* as far down as, and even below the infratemporal crest. Cushing has avoided this error. He reflects, just as in the Hartley-Krause method a flap of scalp in the temporal region; the flap, the base of which corresponds to the whole length of the zygomatic arch, extends upwards only a little above the level of the auricle, and therefore not so high as in Krause's method. The zygomatic arch is divided at its extremities without injuring the insertion of the masseter. After the vessels in the incision have been clamped or ligatured, we can

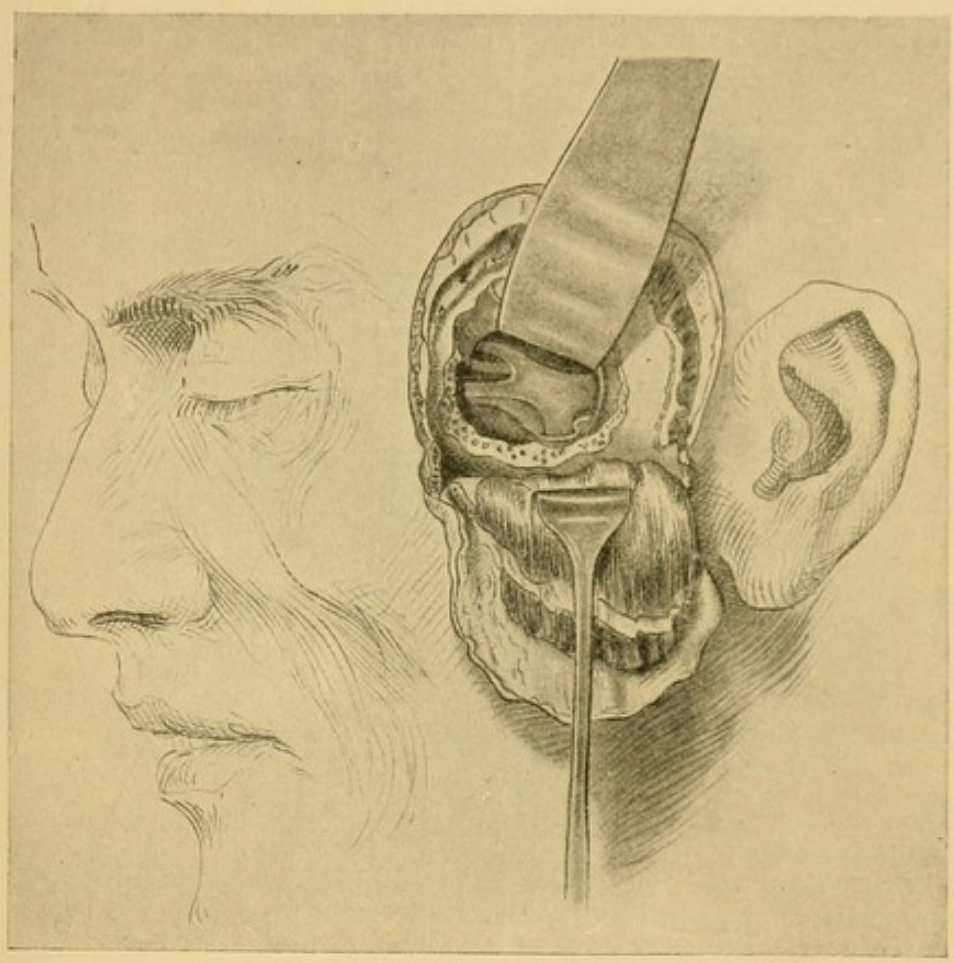


FIG. 40.—Cushing's flap for exposure of the Gasserian ganglion, with temporary resection of the zygoma.

avoid all further lesions in the deeper parts by detaching the temporal muscle and periosteum downwards, so that the infratemporal crest is fully exposed. The flap, together with the zygoma, is then retracted downwards (Fig. 40).

An opening is now made in the temporal bone with a burr, and enlarged to 3 cm. with skull forceps, so as to include the infratemporal crest. In Figs. 40 to 42 (and Fig. 31) it will be evident that an area is exposed where the middle meningeal artery is certain to be seen on the dura under the anterior inferior angle of the parietal, where it is often enclosed in a canal in the bone. By thus raising up the dura the artery can, from the very first, be controlled as far as the foramen spinosum, and this is a great advantage. When the dura has been separated as far as the foramen ovale it will be found to be firmly attached around its margin, as well as at the foramen

rotundum. A blunt dissector (*e.g.* "Kropfsonde") is then inserted between the two foramina, and the dura is stripped off the three divisions, the ganglion, and its roots, but at first only from the upper surface, as severe bleeding occurs if it is stripped from the under surface. The under surface of the dura is then separated from before backwards along the second division until the ganglion is raised up. Lastly, the dura is separated internally where it is adjacent to the sixth nerve and cavernous sinus, the separation being done from behind forwards towards the first division. The second and third divisions are now raised up on blunt hooks and cut across; the root of the ganglion is then seized with forceps and torn out along with the stump of the second and third divisions, and the first division.

Bleeding from the small arteries and veins below the ganglion, as well as from the cavernous sinus (should this occur), is easily arrested by packing. Cushing rightly refrains from drainage and packing, and has always obtained primary union by suturing the flap. It is unnecessary to suture the zygoma, as it is better that it should sink in as the muscles of mastication atrophy.

The advantages of Cushing's method consist in the resection of the zygoma, the avoidance of an unnecessary and severe osteoplastic measure, and the intentional exposure of the middle meningeal artery in its whole length; but notwithstanding

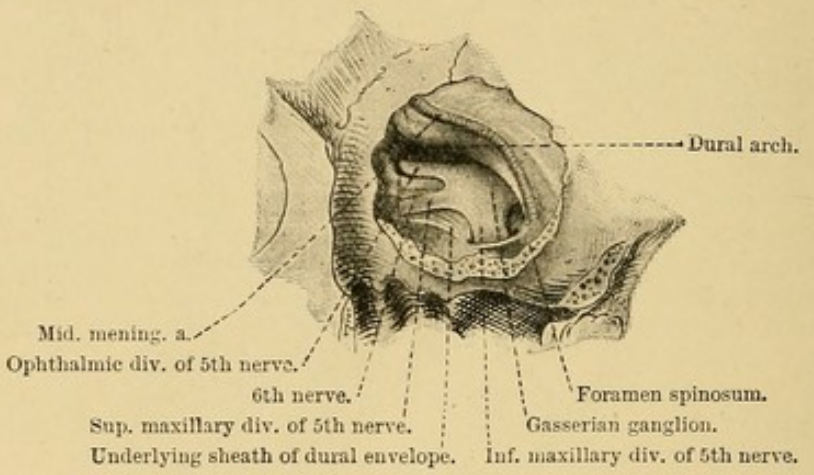


FIG. 41.—From Cushing: shows the relation of the middle meningeal artery to the trephine opening after raising up the dura. The opening should extend downwards so as to include the infra-temporal crest.

this we do not doubt that it may be necessary now and again to ligature the middle meningeal artery (Krause) or the external carotid (Friedrich).

43. Resection of the Upper Jaw (Figs. 10 and 11). 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" (page 114). The opportunity should at the same time be taken to ligature the external carotid. This preliminary procedure greatly diminishes the bleeding and allows the operator to see exactly what he is doing.

The incision is made 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 nasal bone with

the upper jaw, and finally upwards as far as the inner angle of the orbit. In this way the levator alæ nasi muscle alone is divided, which is of no importance as regards the expression of the features. Fig. 34 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 Nélaton, 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

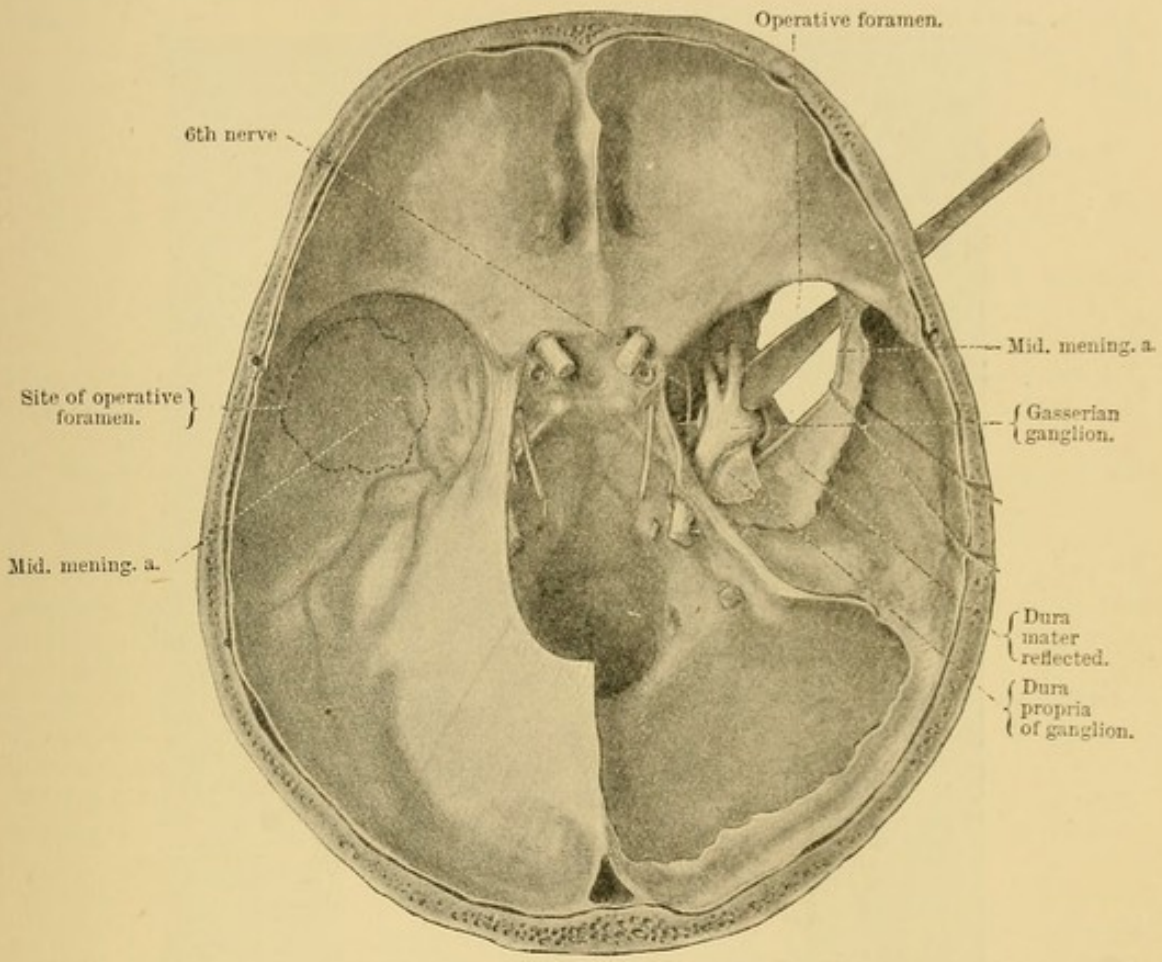


FIG. 42.—From Cushing, showing that the base of the ganglion has a fibrous capsule of its own besides the dura which is reflected in the figure. This capsule surrounds it above and below. (The upper layer is also reflected in the figure.)

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 needed 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, Fig. 10). This incision is similar to that described by O. Weber, except that it is directed obliquely

[1] As the anterior part of this incision injures the highest branches of the facial nerve, we would suggest that perhaps our incision for the inferior maxillary nerve would be more suitable, the temporal muscle being detached forwards.

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, except that 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. 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. For this reason, and on account of the loss of blood to the system generally, a

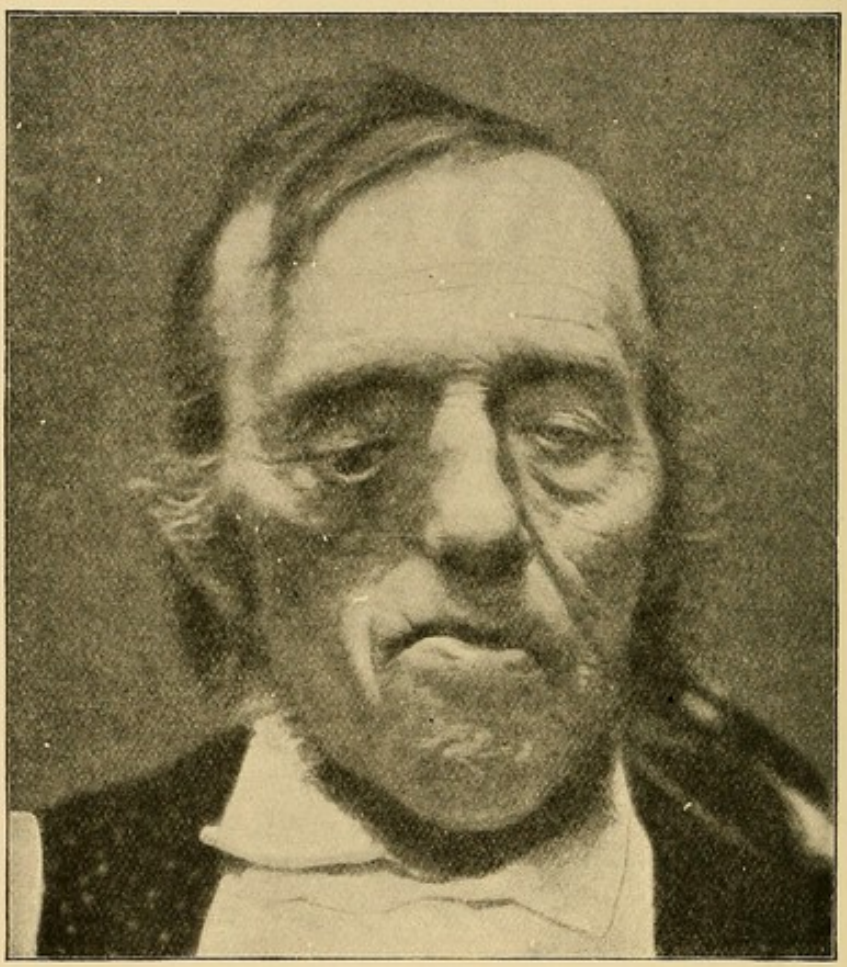


FIG. 43 shows the result after complete excision of the upper jaw (for a malignant tumour) by the angular incision.

preliminary ligature of the external carotid is very desirable, and makes the operation much cleaner and easier.

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 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 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.

Lastly, the connection with the pterygoid process is to be dealt with. 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 without. When the pterygoid is not to be removed the upper jaw is separated from it by forcibly wrenching it downwards; this should be done 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) are 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 there is still bleeding the cavity should be packed with xeroform gauze, and not changed until it becomes loose.

For quite localised tumours, as well as for the removal of sequestra, an incision through the upper lip into the nose will suffice. We have recently performed a complete resection of both jaws for phosphorous 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 had 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. We refer especially to what we have said on page 23 in connection with this subject.

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 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, 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 the 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.

44. A less extensive operation is the **Osteoplastic Total Resection of the Upper Jaw,** whereby the jaw is turned aside and afterwards brought back into position again. This procedure is indicated in tumours of the base of the skull (basi-occiput and its neighbourhood); and when sufficient space is not obtained by Gussenbauer's method of dividing the soft palate and chiselling out the hard palate, especially in retromaxillary tumours. The difference between this and the previous operation is, that after making the skin incision the soft parts are not separated from the bones, but the bony connections of the upper jaw having been severed, the latter is turned aside with the soft parts still connected with it. Division of the frontal process of the malar bone must be made through a small oblique incision in the same way as has been described in resecting the superior maxillary nerve at the foramen rotundum.

To expose the spheno-maxillary fossa, the malar bone is resected in the same way as has already been described in dividing the second division of the trigeminal nerve.

If it be desired *to expose the nasal cavities either alone or together with the antrum of Highmore*, it is sufficient to perform a *partial osteoplastic resection of the upper jaw* in the following manner:—

The skin incisions are the same as for resection of the upper jaw, except that the upper lip is not divided (Fig. 10), that is to say, the incision begins at the nasal orifice, and after passing round the ala nasi extends upwards to near the inner angle of the orbit, and from thence transversely outwards below the infraorbital margin to the malar bone; to this a second incision may be added extending from the ala nasi outwards and downwards in the fold between the upper lip and the cheek.

From the upper end of the osseous anterior nares the structures are divided in the following manner and order: first along the junction of the two nasal bones, then outwards, separating the connections of the nasal bone, the nasal process of the superior maxilla, and the lachrymal bone from the frontal; and, secondly, the bone pliers or a small chisel are carried obliquely downwards and backwards through the orbital plate of the ethmoid as far as the spheno-maxillary fissure. From the lowest part of the osseous anterior nares the inner and anterior walls of the antrum are divided with a chisel as far as the infraorbital canal, and the orbital plate of the upper jaw is then divided backwards along this canal from the horizontal skin incision. The bones, together with the soft parts, can now be drawn outwards, and the nasal cavity and *antrum of Highmore*, which have been transformed into a single cavity, are exposed.

In describing the operations on the nose, it has already been pointed out how both halves of the upper jaw can be separated from each other, and the base of the skull made accessible, merely by dividing the upper lip and splitting the hard and the soft palate mesially. We may here refer the reader to what has been already described under exposure of the nasal cavity and the base of the skull. There we called attention to the famous case of Depage, where a sarcoma was successfully removed from the base of the skull and the upper vertebræ. Preliminary ligature of both internal carotid arteries was performed.

45. 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-maxillary branches of the facial nerve.

On account of the simplicity and comparatively little mark it leaves, we employ a mesial incision (Fig. 10), which divides the under lip and extends downwards as far as the centre of the hyoid. By this incision we can get 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 jar 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 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-hyoglossus; 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.

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.

46. Osteoplastic Resection of the Lower Jaw is an important preliminary operation for exposing the floor of the mouth, the root of the tongue, the fauces, and the deep pharyngeal structures. For the structures in front of the fauces *mesial division of the lip and lower jaw* gives excellent access. It has the great advantage that after introducing a wire suture the movements of the lower jaw suffer no noteworthy temporary impairment, and union in good position is readily obtained.

For cases in which the disease affects the fauces and the pharyngeal structures posterior to them (as well as for carcinoma at the root of the tongue and invading the palate), division of the lower jaw becomes necessary, and it should be done

in front of the ascending ramus of the jaw (Langenbeck's method), in the same way as Mikulicz has lately employed (see above) for neurectomy of the fifth nerve; but we prefer instead of Langenbeck's perpendicular incision from the angle of the mouth downwards, the same incision as for resection of the jaw, viz. in a line from the mastoid process towards the hyoid bone, in greater or less extent according to circumstances. After ligaturing the facial artery the jaw is exposed at the anterior border of the masseter, the periosteum is separated forwards and backwards, and then, after the mucous membrane has been perforated with a periosteum detacher, the jaw is divided with a keyhole saw behind the molar teeth.

Before using the saw it is desirable to drill one or two holes for the passage of the steel wires which are afterwards used for accurately suturing the jaw. The sawing is to be done obliquely, in such a way that the line of section is farther forward upon the outer and lower aspect than upon the inner and upper, because the sawn extremity of the posterior fragment of the jaw has a tendency to pass inwards and upwards. The ascending ramus is now pulled upwards with a sharp hook, whilst the body of the jaw is drawn forward.

47. Resection of the Temporo-Maxillary Articulation. 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. An incision is made through the skin only, commencing in front of the lower end of the tragus and extending obliquely upward and forward. The fascia is then divided, carefully avoiding the superficial temporal artery and vein, which may be preserved, or ligatured if they are in the way (especially the vein). An incision is then made down on to the zygoma and the fascia carefully stripped off it subperiosteally. In the course of this removal the capsule is separated below from the condyle and the joint is opened into, the fascia of the temporal muscle is being divided and retracted upwards. 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. To ensure mobility, Helferich interposes part of the temporal muscle, while Kusnagow places a piece of the masseter between the glenoid fossa and the mandible.

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 and obtained an excellent result.

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 a very good 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. A similar operation has been performed by Le Dentu.

48. Free Exposure of the Cavity of the Mouth. *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 incision through the cheek* (Fig. 45), 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. 44), because the play of the features is in no

way diminished, as the branches of the facial 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

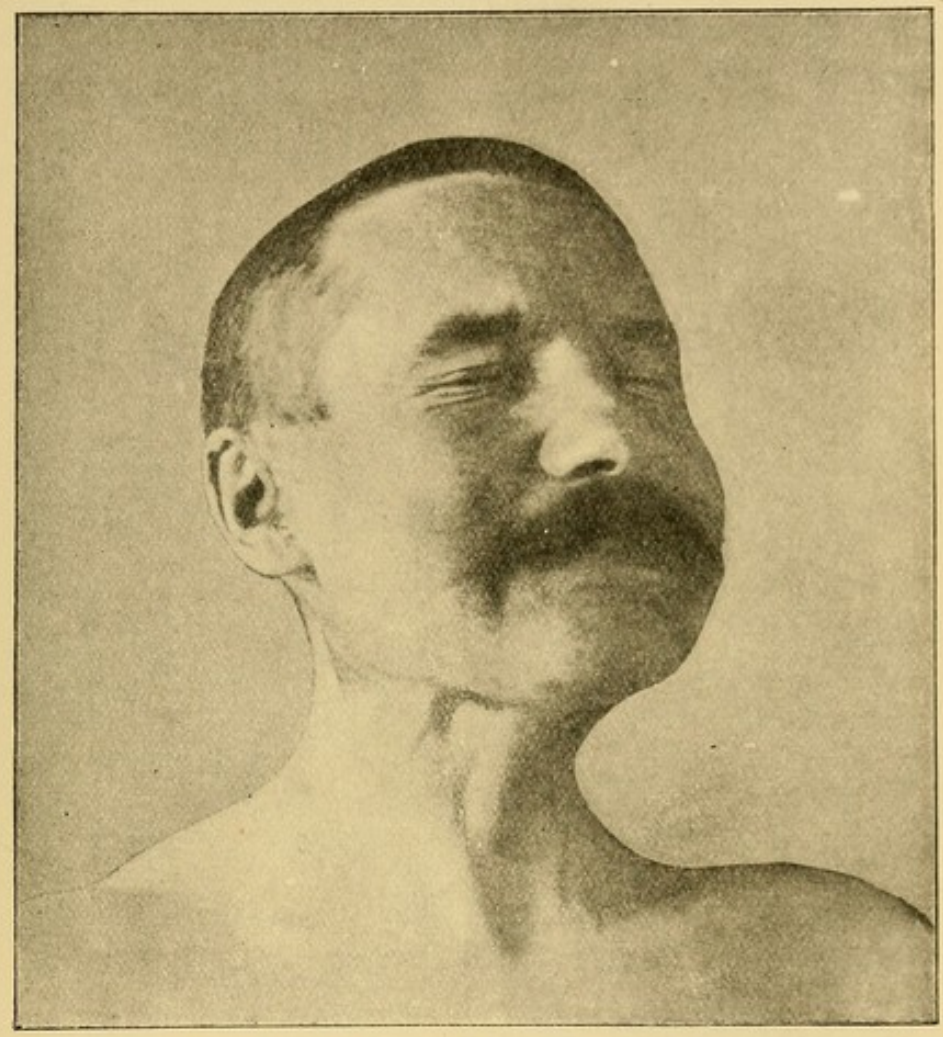


FIG. 44 shows the action of the facial muscles after the wound for splitting the cheek transversely has healed.

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 a gag of our own. Subsequently the jaw must be firmly united with wire sutures, so that movement may be begun early. A periosteal suture is unnecessary.

If occasionally healing is delayed by slight necrosis, the function of the jaw is during this time not interfered with.

49. 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 (White's), 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

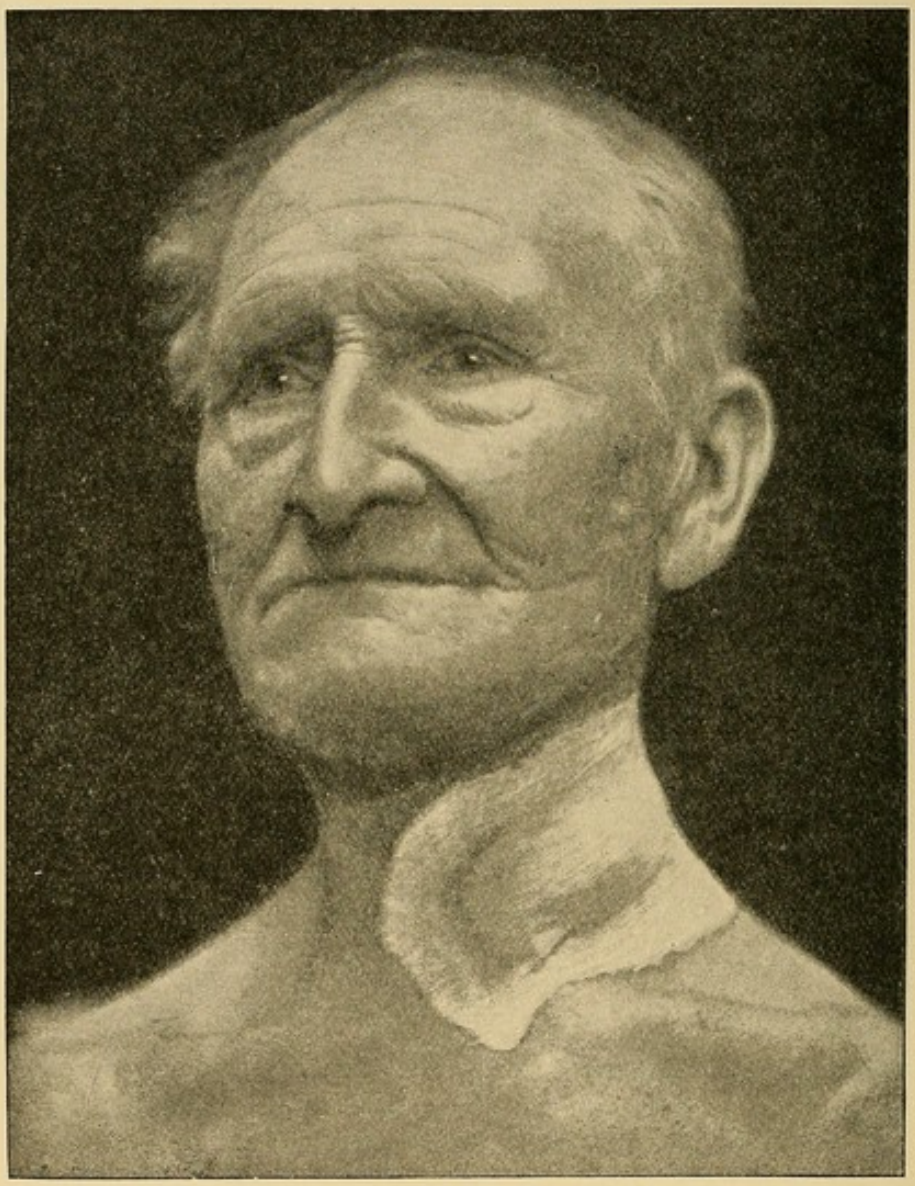


FIG. 45.—Patient after excision of the tongue by splitting the cheek.

vessels and nerves. 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. 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.

50. Excision of the Tongue. Since the publication of the third edition of this manual we have modified this operation very considerably, and have introduced a normal procedure which makes the operation much more simple and easy to perform, and the recovery more certain and rapid. We adhere, however, to all we have said regarding the preliminary antiseptic precautions.

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 drawing all bad teeth, and by cauterising all ulcerating patches. An anæsthetic is often required to do 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 carefully slitting up their cavities.

We would lay more stress than we did in our third edition 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 given 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 like to use the thermo-cautery to divide the muscles, in order to limit the primary infection of the freshly cut surface. A great improvement in our new method is that we no longer perform a preliminary tracheotomy and pack the trachea so as to prevent blood passing down into the lungs; and, moreover, we make no important difference in the form of operation to be employed according to the seat of the disease. It is only when there is a small new growth at the tip or at the side of the tongue that we do not split the jaw.

The disease in the glands is the only point which is not considered in our new procedure. The glands must be reserved for a second operation, or removed first of all. We are now convinced that this is the best treatment. If, at one operation, the anterior triangles on both sides are cleared out along with the glands underneath the sterno-mastoid and those lying along the large vessels, the wound becomes too large and gaping, and no matter what care be taken it is almost impossible to prevent it becoming infected.

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 Sédillot's method. It can be done with almost no 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 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, 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 getting 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

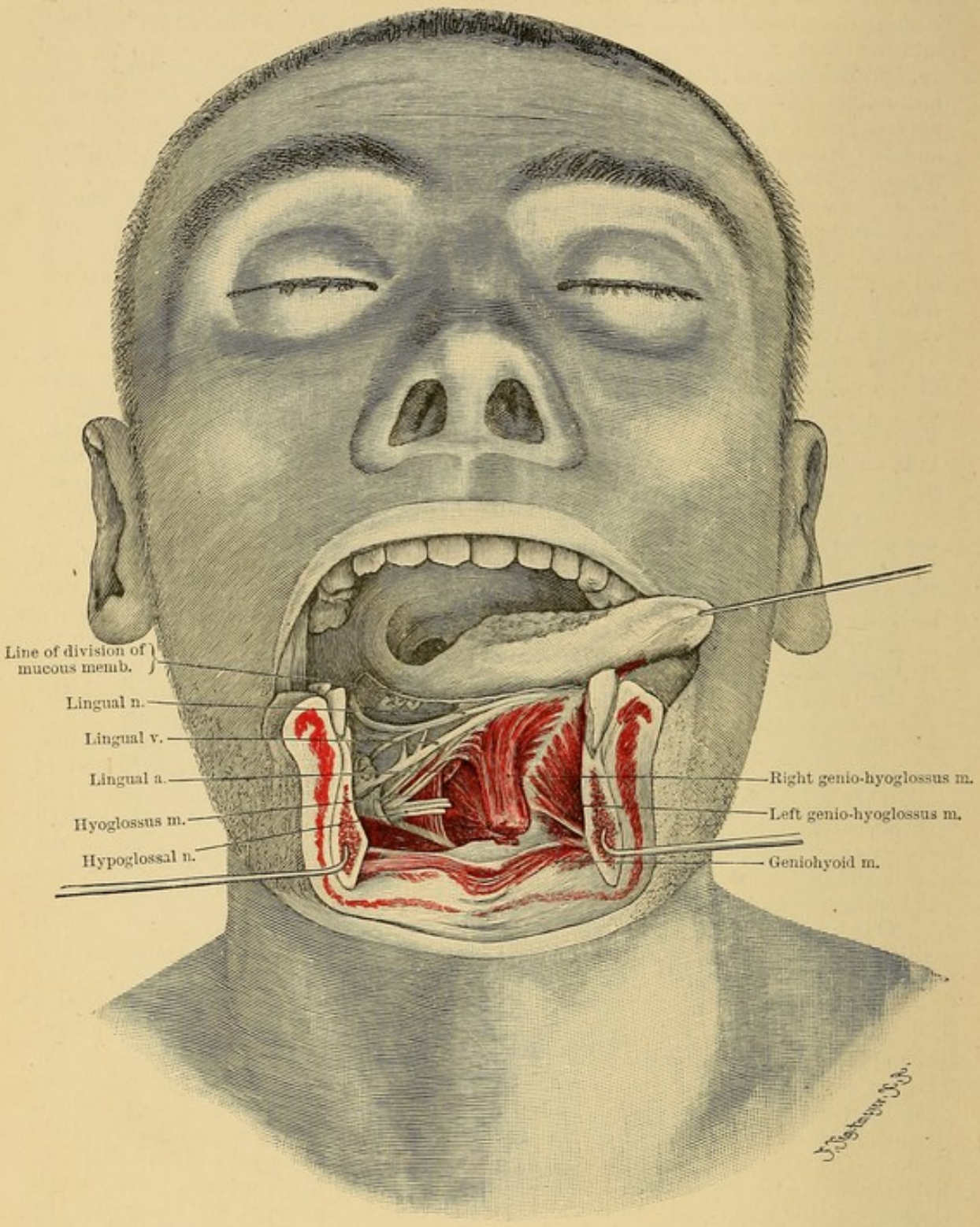


FIG. 46.—Normal procedure for excision of the tongue. The lip and lower jaw are divided in the middle line down to the hyoid bone, and forcibly separated. In the figure (the right is the diseased side) the right genio-hyo-glossus is detached from the jaw and pulled over to the left, so as to show the deeper structures better, but in the operation it is left attached to the jaw. The mucous membrane is divided along the floor of the mouth as far as the soft palate, and the tongue is forcibly pulled to the left. The lingual nerve is seen above, the lingual vein slightly lower; the hypoglossal nerve is lowest, lying on the hyoglossus muscle, with the lingual artery underneath the latter.

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, forceps being applied to the divided vessels in the lip. The jaw is then sawn through in the middle line.[1] Sharp hooks are introduced into the sawn surface and the genio-hyoids and genio-hyo-glossi separated in the middle line if they are involved on one side. The two halves of the jaw are widely separated (Fig. 46), and the tongue drawn out of the mouth and towards the healthy side by means of a loop of silk passed through it. 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 hyoglossus 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 later. The hyo-glossus is divided and, as in all muscular 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 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; the stylo-glossus muscle, which is visible, and the glosso-pharyngeal nerve lying alongside it are both divided.

By dividing 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 cut through 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 this 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. Fig. 46 illustrates a case in which very wide separation of the jaw is necessary for extensive unilateral disease of the tongue. We may either pass in between the genio-hyo-glossi in the

[1] In some cases it is advisable to saw obliquely backward toward the affected side in order to keep the insertions of the genio-hyo-glossus and genio-hyoid on both sides in the healthy part of the jaw, and to facilitate suture. It is a good plan to bore two symmetrical holes with the drill before sawing. The boring is to be done without reflecting the periosteum.

middle line, or, in case this does not give enough room, we may saw through the jaw obliquely, so that the genio-hyoids and genio-hyo-glossi on both sides may be preserved and pulled to the healthy side. The genio-hyo-glossus is only detached from the jaw (as represented in the figure) if it is adherent on the diseased side and prevents the halves of the jaw from being fully separated. The mylo-hyoid would also be overstretched. The figure illustrates how ample access is got, and shows how, by using the mesial incision, a clear view is obtained as far back as the isthmus of the fauces.

51. Excision of the Tongue where there is Simultaneous 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 preferable, (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, (3) because it admits of preliminary ligature of the lingual or external carotid arteries, (4) and 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 who remained free from recurrence some 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 ligaturing the subcutaneous veins, 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 ligaturing the vessels going to them. Even when one wishes to do nothing else than to remove secondary infected glands after excision of the tongue this is the best method to employ.

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, and now 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.

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 should be administered a quarter to half an hour before the anæsthetic, $\frac{1}{3}$ 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 is applied over the wound. The patient is 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.

52. Excision of Carcinoma of the Base of 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. The patient is anæsthetised, and a low tracheotomy is 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. 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 are to be treated similarly. 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. In this way 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 seen as they were divided.

The oblique position of the body with the head dependent must be maintained after as well as during the operation, and the wound must be left open and packed with xeroform and sterile gauze. The patient referred to above was allowed up the day after the operation, and made an uninterrupted and excellent recovery. During the night he resumed the sloping position.

53. 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.

54. Excision of Tumours of the Tonsils. We have lately had occasion to operate on two cases of carcinoma of the tonsil; both made an uneventful recovery, and 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 was preserved.

The wound healed by first intention, and fourteen days afterwards 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 great 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 therefore divided the jaw in the middle line, 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, thus preventing pneumonia.

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 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.

G. THE SUPERIOR LATERAL TRIANGLE OF THE NECK[1]

Normal Incision. 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-breadth below and behind the angle of the jaw, where it crosses the anterior border of the sterno-mastoid

[1] For practical reasons we regard it as bounded by the lower border of the jaw above, by the middle line as far down as the upper border of the thyroid cartilage internally, and by the anterior edge of the sterno-mastoid posteriorly.

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; 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. From 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 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 its action is not interfered with. Quervain's musculo-cutaneous flap for exposing the posterior triangle is shown in Fig. 69.

55. External and Internal Carotid Arteries (Fig. 48). When ligature of the external carotid is sufficient for the arrest of hæmorrhage, the common carotid must never be ligatured instead, as it 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. Recently Lipps has demonstrated the same fact from an analysis of 130 cases of ligature of the common carotid. 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.

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

The point of 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 much 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-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 pass 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 dividing 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, the external and internal carotid arteries come into view, the latter lying posteriorly. The internal carotid gives off no

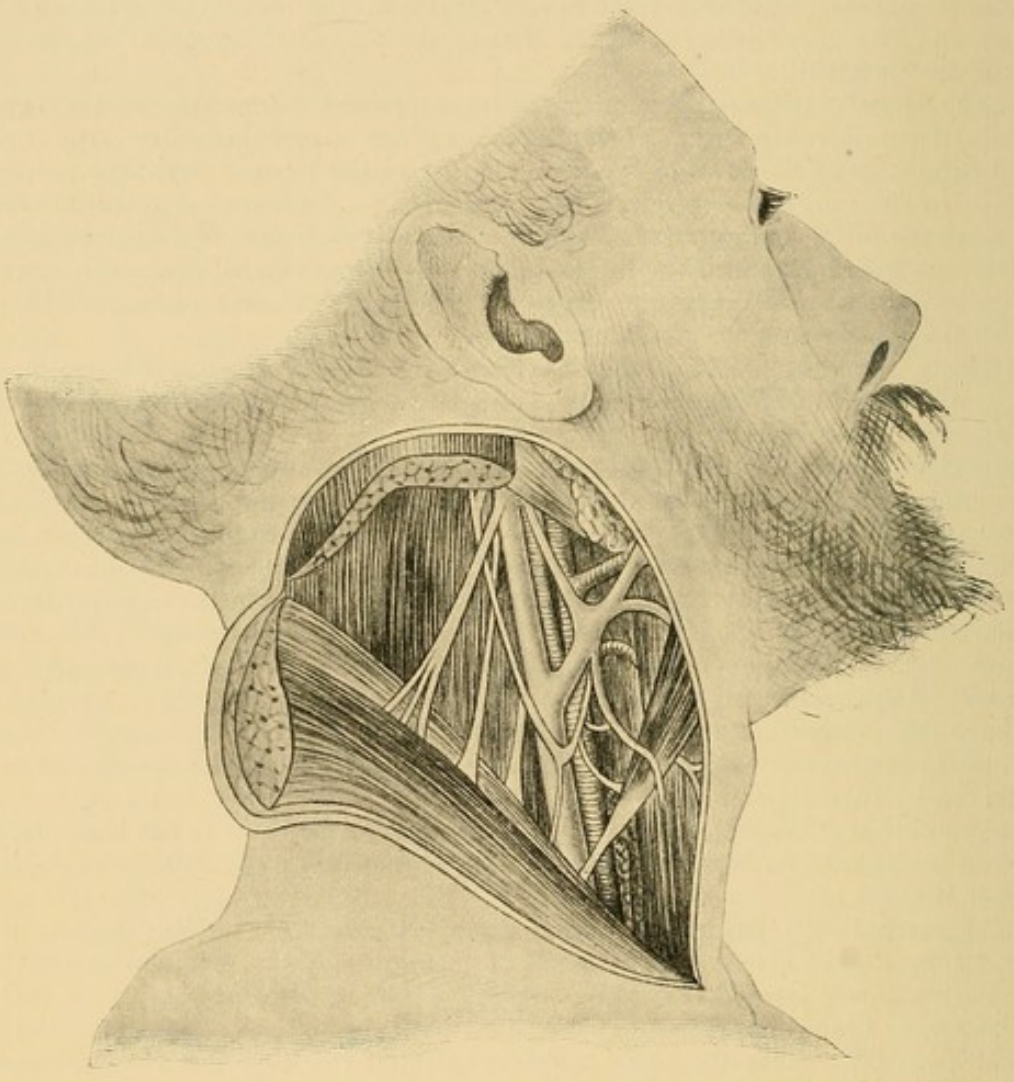


FIG. 47.—Küttner's muscle flap for exposure of the deep structures in the upper part of the anterior triangle.

branches, whilst the external carotid is identified by giving off the superior thyroid close to its origin. The *hypoglossal nerve* winds across the external carotid from behind forwards opposite the origin of the facial artery, whilst bending downwards and backwards over the nerve is the small sterno-mastoid artery. 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. The descendens noni nerve, which supplies the depressors of the larynx, must be avoided. It is still more important, however, 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 chosen which are more readily accessible and less dangerous.

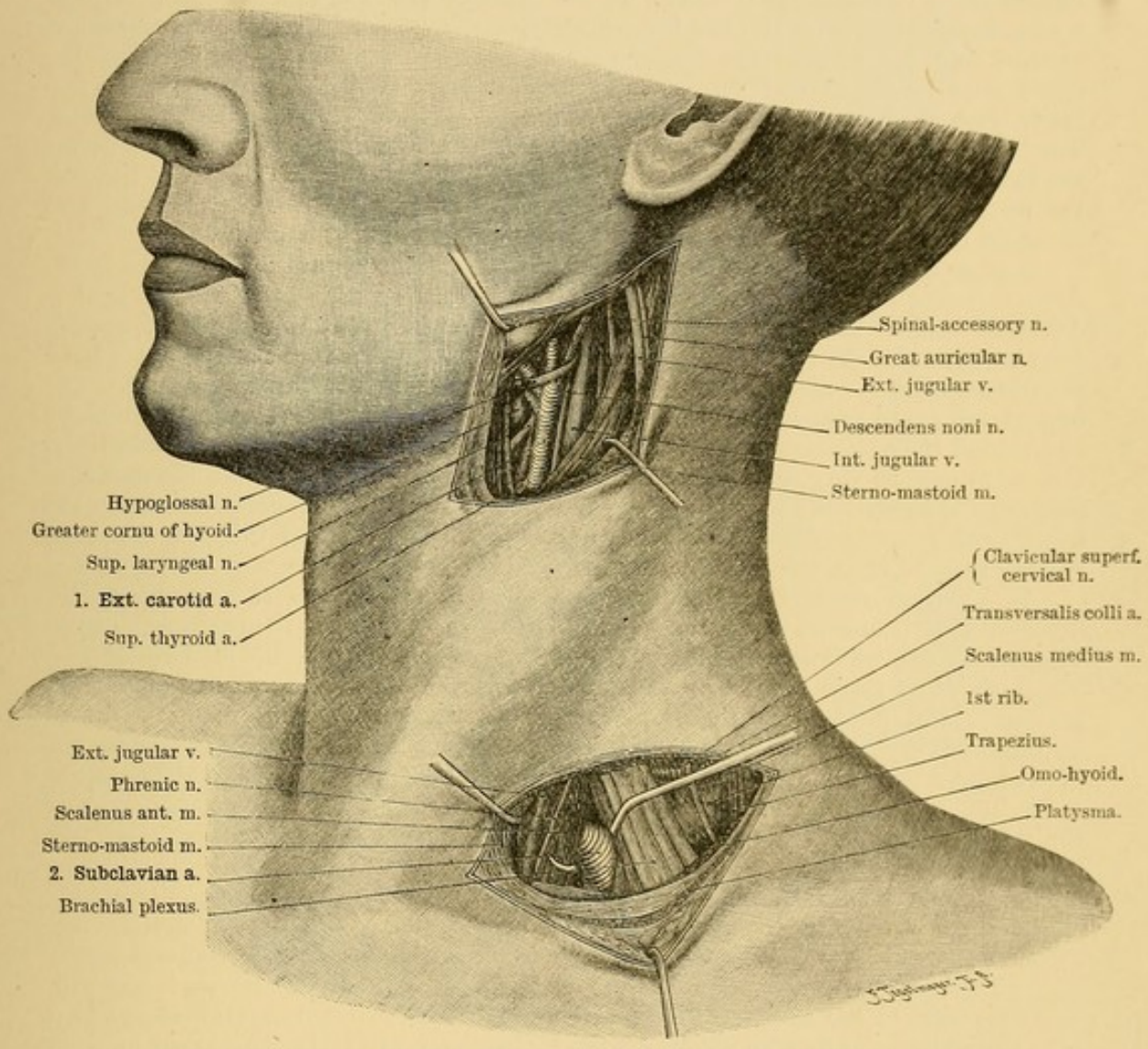


FIG. 48.—Ligature of the external carotid with the origins of the lingual, facial, and occipital arteries. Ligature of the subclavian artery.

56. Superior Thyroid Artery (Fig. 48). The superior thyroid artery is ligatured at the apex of the lateral lobe of the thyroid gland. The incision corresponds to that part of our *normal incision* which extends from the anterior border of the sterno-mastoid muscle to the body of the hyoid bone, the lower edge of the wound being well drawn down. In cases in which the gland does not reach so high up, it is better to make the incision 3 cm. ($1\frac{1}{4}$ in.) lower down, so as to correspond to the upper border of the thyroid cartilage. The anterior branch of the artery, in enlargement of the thyroid gland (the only case where the ligature in question is necessary), is always

to be felt descending upon the anterior and inner aspect of the upper horn of the gland close to the larynx. By following this branch upwards over the apex of the upper horn, the trunk of the artery will be found with certainty.

57. Lingual Artery (Fig. 49). Ligature of the lingual artery is important because it supplies a deeply-situated organ, the direct arrest of hæmorrhage from which is not always easy. It is often desirable, therefore, 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 greater cornu. It is most conveniently ligatured at this situation, because in most people the extremity of the greater 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 greater cornu of the hyoid bone as far as its body. The incision extends through skin, platysma, and fascia, just as if one wished merely to expose the greater 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.

It is well to press forwards the hyoid bone from the opposite side of the neck. After exposing the greater cornu in this way, it is seized with a hook and the bone is drawn forwards. This 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. One 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 greater cornu of the hyoid bone, immediately above which the artery lies. 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. This is described by Winiwarter as due to Pirogoff-Hueter, while Röser Malgaigne and Béclard incised underneath the digastric. The incision is made parallel to the greater 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.

58. Ligature of the Internal Carotid. In intracranial hæmorrhages (with the exception of those due to the middle meningeal artery), ligature of the internal carotid (Fig. 48) 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 the same as that for ligature of the external carotid, except that intervening between the two vessels are 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, occasionally also in tonsillotomies, it is important to be clear 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 feared, because opposite the tonsil the artery is separated from the pharyngeal wall by the stylo-glossus and stylo-pharyngeus muscles. On the other hand, an injury to the pharyngeal and ascending palatine arteries and to their tonsillar branches is possible (ZUCKERKANDL).

59. Exposure of the Hypoglossal Nerve (Fig. 49) falls to be considered along

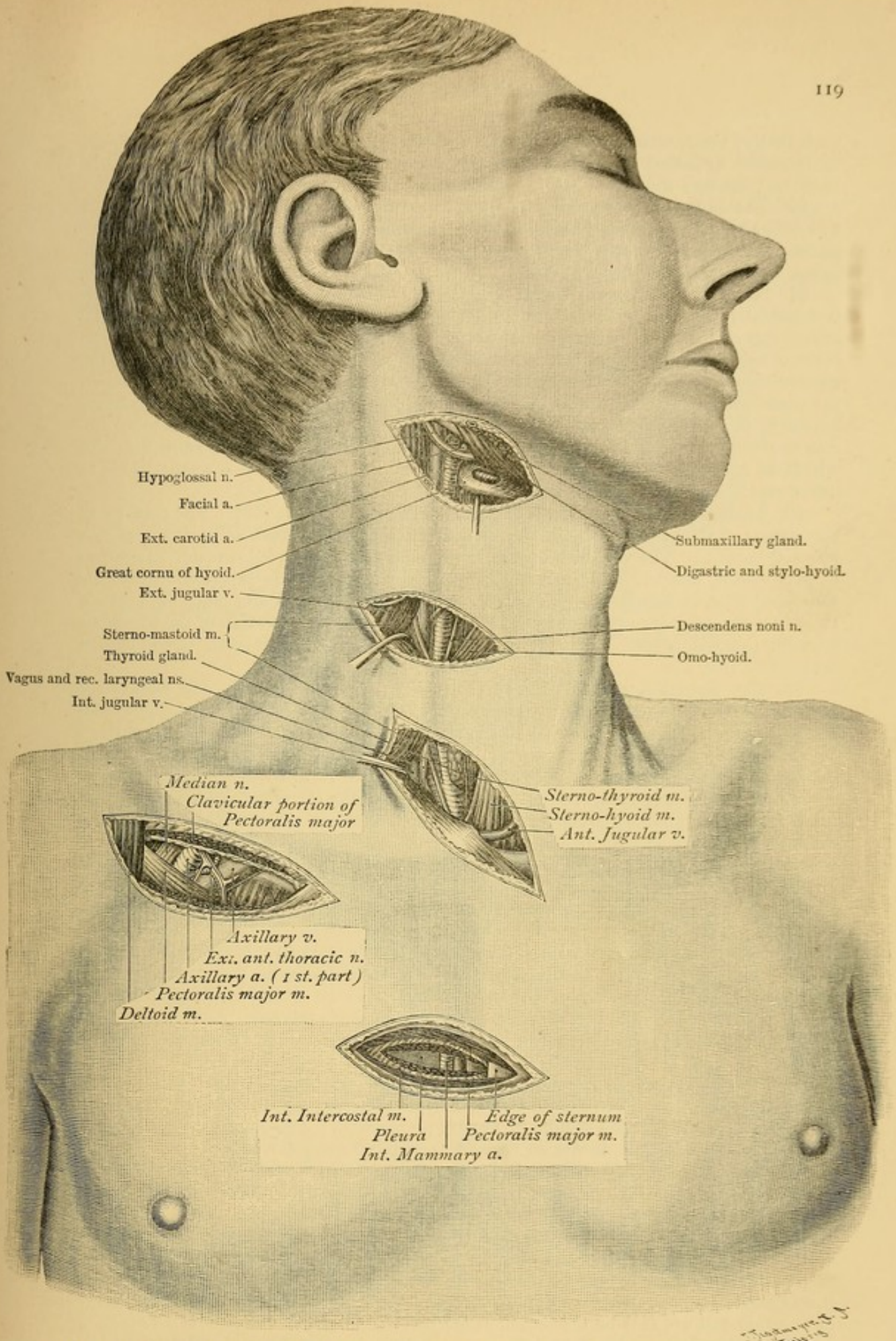


FIG. 49.—Ligature of the lingual artery above the greater cornu of the hyoid. Ligature of the common carotid at the level of the cricoid cartilage. Ligature of the innominate artery. Ligature of the first part of the axillary artery. Ligature of the internal mammary artery.

with that of the external carotid artery round which it winds, and in the anterior part of its course with that of the lingual artery. The nerve, however, lies upon the outer surface of the hyo-glossus muscle, the artery upon its inner surface.

60. The Lingual Nerve may be exposed by turning aside the submaxillary gland and by nicking the posterior fibres of the mylo-hyoid at the outer surface of the hyo-glossus muscle and towards the mucous membrane of the floor of the mouth. The nerve, however, is very deeply placed.

61. Superior Laryngeal Nerve (Fig. 48). 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 greater 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*).

62. Ligature of the Internal Jugular Vein (Figs. 48 and 49). The method of performing this operation should be considered along with that of ligature of the internal carotid. The vein lies on the outer side of the internal carotid. Ligature of this vein is, apart from hæmorrhages, especially important in infective thrombosis connected with its tributaries. When, for example, otitis media and mastoidea invade the bones thrombosis may occur in the lateral sinus; by disintegration of the thrombus embolic, pyæmia occurs. The internal jugular vein is ligatured with the object of preventing this.

63. The Spinal-Accessory Nerve (Fig. 48) 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 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. 50 shows the transverse incision made through skin and platysma, rather below the middle of the sterno-mastoid. The external jugular vein, which descends across it, is drawn forward and the superficial cervical nerve, which crosses the sterno-mastoid muscle, is not interfered with. After dividing 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.

64. The Small Occipital, Great Auricular, and Superficial Cervical Nerves. These three divisions of the third cervical nerve can be exposed at the posterior border of the sterno-mastoid by an oblique incision above the middle of the sterno-mastoid; the edges of the wound are well retracted, and the trunk of the third cervical nerve can be followed up, if it be the seat of neuralgia.

For occipital neuralgia Krause has suggested an incision, beginning in the middle

line of the neck 3 cm. below the external occipital protuberance, passing outwards to 2 cm. below the tip of the mastoid process, and then turning downwards for 7 cm. along the posterior border of the sterno-mastoid. Through this incision he then divides the splenius and complexus, and looks for the great occipital nerve (second cervical) and the third occipital (third cervical) lying on the posterior surface of the rectus capitis posticus major and obliquus capitis inferior, and then excises the second intervertebral ganglion lying below the lateral part of the arch of the atlas.

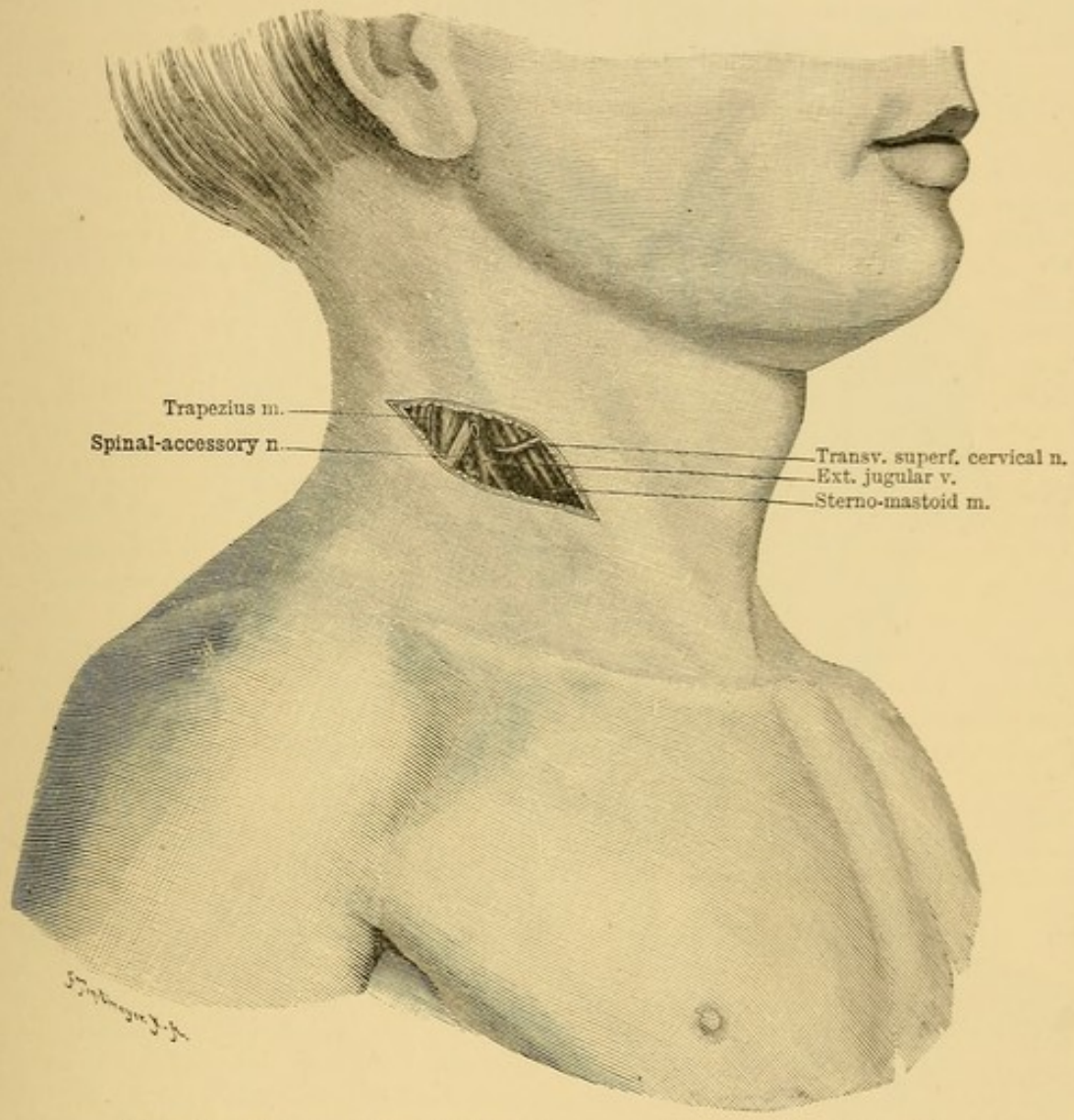


FIG. 50.—Exposure of the spinal-accessory nerve in the middle of the neck.

As described above, he finds the trunk of the third cervical nerve by following up its superficial branches at the posterior border of the sterno-mastoid.

Opening the Pharynx

The results of opening the pharynx for the removal of tumours, especially carcinomata, would be far better if the patients reached the surgeon when the disease was in an early stage.

65. Exposure of the Entrance of the Larynx—Subhyoid Pharyngotomy (Fig. 51).

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, ary-

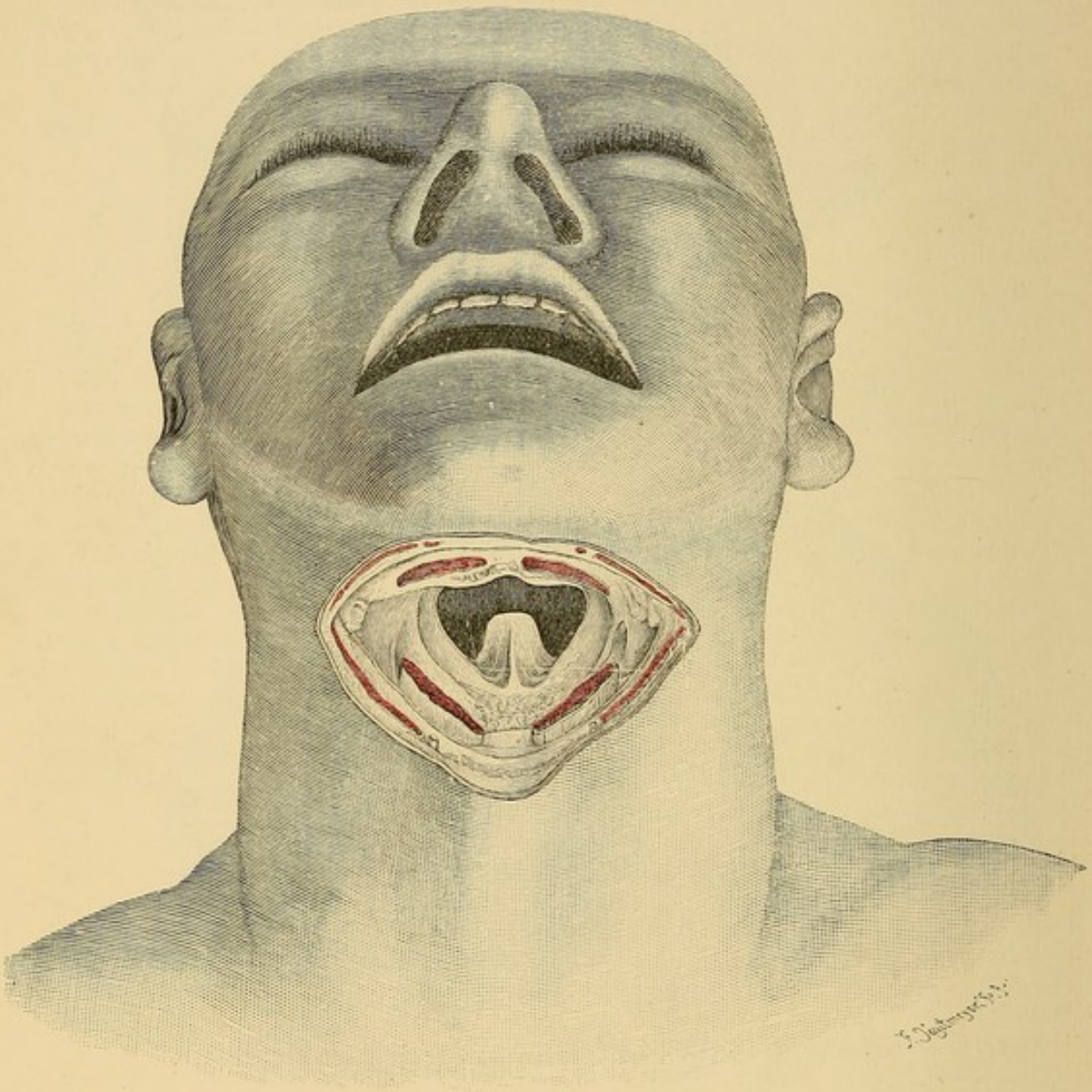


FIG. 51.—Subhyoid pharyngotomy. The platysma, fascia, infra-hyoid muscles (sterno-hyoids and thyro-hyoids), thyro-hyoid membrane, and mucous membrane are divided, and the anterior surface of the epiglottis exposed.

tenoid 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; 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, and instead a 1 per cent solution of cocaine 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 are 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. It is important, if possible, to retain some of the fibres of these muscles, but this can only be done in circumscribed tumours.

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 transversely divided 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. 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 cocaine solution, 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 well under certain circumstances to perform tracheotomy to avoid the danger from œdema glottidis, which often develops in an extremely insidious way, and may cause danger from asphyxia. The main wound is dressed with iodoform gauze and collodion. We used formerly to stuff the wound, but we have now abandoned the practice. As we always cut round new growths with the fine blade of a thermo-cautery and carefully stop all bleeding, we have found it sufficient to insist that 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 avoid, wherever it is possible, performing secondary tracheotomy. It is only when the sensitiveness of the larynx has been destroyed by injury to the superior laryngeal nerve that one cannot trust to the cough reflex to prevent secretion from flowing down.

66. Median Pharyngotomy. 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 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, but extending farther outwards on the diseased side, and only about 1½ inch across the middle line on the healthy side. From this another incision is carried 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 are ligatured as in median laryngotomy.

On the diseased side the sterno-hyoid, thyro-hyoid, and omo-hyoid are divided parallel to the hyoid, and the subjacent thyro-hyoid membrane is cut across as described in subhyoid pharyngotomy; the tip of the epiglottis is then seized with a small sharp hook and dragged forwards and towards the healthy side.

The extent of the new growth anteriorly is now defined, and the epiglottis is divided ½ cm. in front of the disease along its lateral border down to its base. 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 then split in the middle line and the muscles attached to the wing of the thyroid cartilage are separated, along with the perichondrium, from the diseased side. With a sharp hook the wing of the thyroid on the diseased side can be sufficiently drawn outwards and downwards to enable the tumour to be detached from below and then from behind, and the mucous membrane to be divided in healthy tissue in the region of the arytenoid cartilage (it is often necessary to divide it between the arytenoids). The new growth is now grasped by the fingers, and the limits of the hardness examined with sufficient exactness to decide where the soft parts (the muscular attachments of the pharynx) are to be divided from the outside. The limits of the mucous membrane towards the pharynx are clearly exposed, and the removal of half or so of the larynx along with part of the pharynx can be carried out, the bleeding being easily controlled and the diseased tissues completely removed.

In this operation, just as in simple subhyoid pharyngotomy, we dispense with a preliminary tracheotomy by operating with the patient in the sloping position, and we use cocaine in preference to chloroform.

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 thyroid cartilage. 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.

We repeat that lateral pharyngotomy, like lateral incisions to reach the tongue, should be employed only in those cases where adhesions with the external tissues have already occurred—that is to say, if one still desires to operate on such cases. The disease in the external parts frequently results from swelling, softening, and inflammation of glands which become adherent to the pharynx and to the soft tissues covering it.

67. Lateral Pharyngotomy. 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, 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 thrown 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 (page 105), 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.

We would warn our readers specially against attempting to operate from the mouth in those common cases of carcinoma situated at and behind the isthmus of the fauces, and spreading on to the epiglottis, and involving the soft palate and lateral wall of the pharynx, because, in cutting wide of the diseased tissues, one cannot avoid doing a serious injury to adjacent parts and dividing large arteries. If the carotid is wounded in adherent indurated tissue, there is a great risk of not being able to arrest the hæmorrhage quickly enough, whereas from outside one can control the large vessels with much greater certainty.

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 may have to be divided), the incision reaching from the larynx upwards as far as the origin of the descendens noni from the hypoglossal at the anterior aspect of the carotid. 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 also extensively diseased, 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.

H. Anterior Triangle of the Neck [1]

In passing deeply between the organs in the neck and the sterno-mastoid muscle, transverse incisions corresponding to the direction of cleavage of the skin are not always sufficient. It is often necessary to make a longitudinal incision, either mesially, or laterally along the sterno-mastoid.

68. Common Carotid Artery (Fig. 52). The common carotid artery passes vertically upwards in the shortest direction from the chest to the head. 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 is 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 artery 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 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 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; the sympathetic nerve is behind it.

If the incision be prolonged somewhat backwards so as to expose the posterior border of the sterno-mastoid, the *spinal-accessory nerve* will be seen emerging from beneath it and the external jugular vein, and passing downwards and somewhat backwards towards the trapezius muscle.

69. In the conditions above mentioned it may be necessary to **remove a portion of the Vagus Nerve** (Fig. 52). Unilateral division of this nerve does not endanger life, and indeed may not give rise to any unfavourable symptoms whatever. It is quite common to have to resect it on account of adhesions with the sheath of the vessels.

70. Ligature of the Inferior Thyroid and Vertebral Arteries (Fig. 52). Ligature of these two large branches of the subclavian artery is performed by means

[1] We regard this triangle as bounded above by the upper border of the thyroid cartilage, internally by the middle line of the neck, posteriorly by the anterior border of the sterno-mastoid from the level of the upper border of the thyroid cartilage to the sternum.

of an oblique incision which, beginning above the suprasternal notch, arches obliquely upwards and outwards over the sterno-mastoid. Recently we have often performed ligature of the *inferior thyroid artery* (recommended by Wölfler for goitres generally) for vascular goitres (*struma vasculosa*). A definite situation for exposing it is where it turns inwards behind the common carotid towards the posterior surface of the thyroid gland. It lies here horizontally upon the longus colli muscle covering the vertebral column, and to the inner side of the common carotid. To expose the artery, cut down as if about to expose the common carotid. The skin and platysma being divided, the anterior edge of the sterno-mastoid is exposed and drawn well outwards.

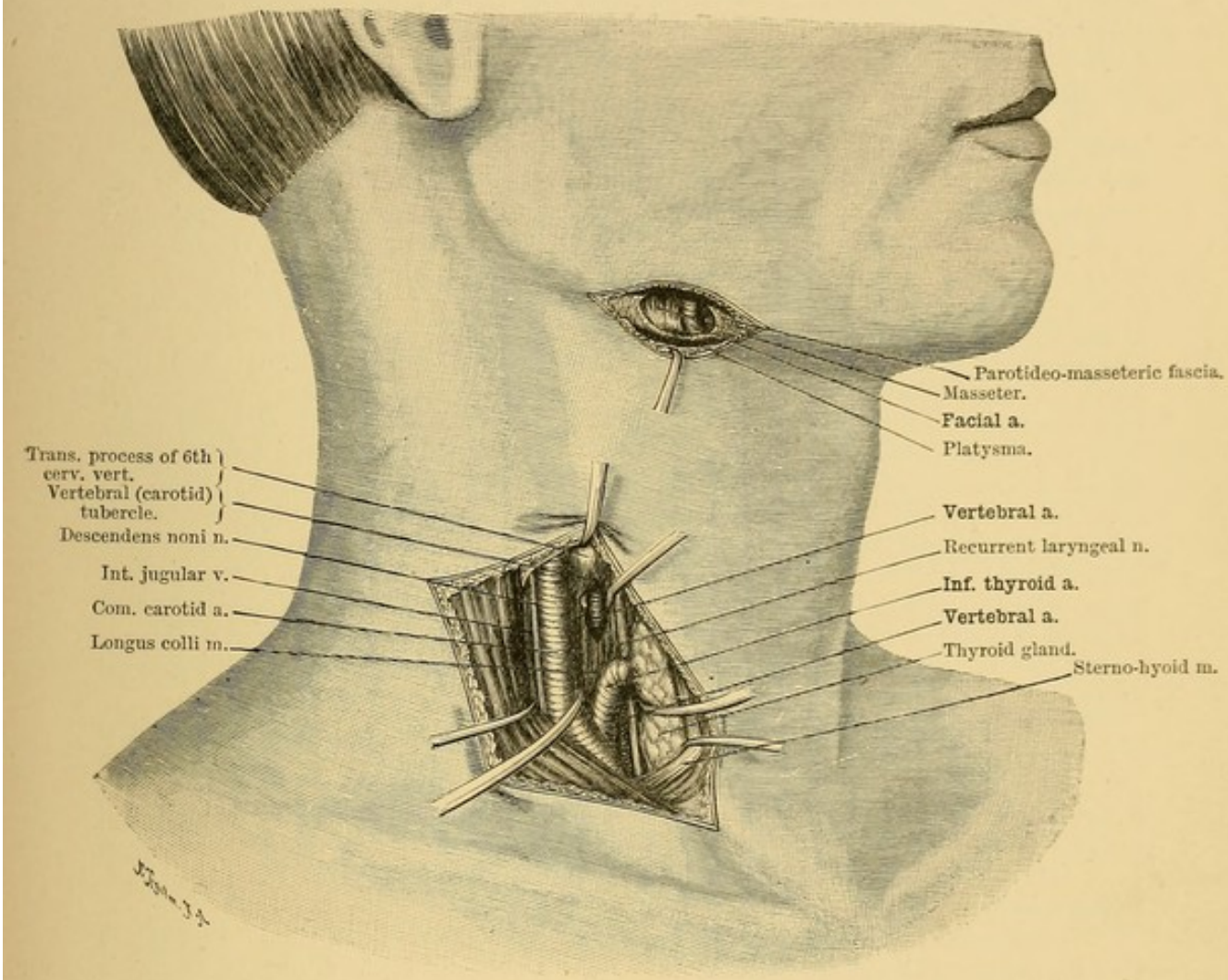


FIG. 52.—Ligature of the facial artery. Ligature of the inferior thyroid and vertebral arteries.

The subjacent omo-hyoid, which now appears, is drawn downwards and inwards, as also is the sterno-hyoid, which lies to its inner side. The carotid artery, the internal jugular vein, and the vagus are all drawn outwards after freeing the inner aspect of the sheath. The dissection is now continued towards the vertebral column between the inner aspect of the carotid sheath and the border of the thyroid gland, covered by the sterno-thyroid muscle. The pulsation of the vessel can here be felt. The thyroid gland must be raised and drawn inwards. The artery is characterised by being arched with the convexity upwards, a course which is produced by the passage of the artery towards the middle line, to reach the place of attachment of the thyroid gland to the trachea. The *recurrent laryngeal nerve* passes upwards alongside the

trachea, behind the gland and the inferior thyroid artery. The ascending cervical artery is given off at the point where the inferior thyroid turns inwards behind the carotid. All hæmorrhage must be carefully arrested during the operation, in order that a good 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 whence 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 sympathetics, 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 doing this the inferior accessory thyroid vein is divided between two ligatures.

71. Vertebral Artery (Fig. 52). The operation for ligaturing the vertebral artery is similar to that for the inferior thyroid, but is more difficult, as the artery lies still deeper. It lies behind the prevertebral fascia, and is 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 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, the prevertebral fascia is divided 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 lie 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.

72. Œsophagotomy and Œsophagectomy (Czerny's operation). 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 tumour or a foreign body, the incision is the same as for ligature of the common carotid and inferior thyroid arteries, only longer. Langenbeck (according to whom Goursand in 1738 first performed the operation) employs Guattani's incision at the edge of the sterno-mastoid.

We recommend a curved incision in the line of cleavage of the skin. Frequently also an incision is made through the skin and platysma from the middle of the inner border of the left sterno-mastoid vertically downwards to the clavicle. 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 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, closing it with a suture may be tried, in which case the main wound must be left completely open. Gussenbauer has incised deeply situated fibrous strictures of the œsophagus through an œsophagotomy wound in the neck.

In 1873 Czerny first performed *œsophagectomy for carcinoma* with success. Since that date a great many 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. We have performed the operation several times. When the œsophagus has to be divided very low down, it must occasionally be held up and fixed for a few days with a pair of catch artery forceps. Sutures tear the œsophagus. It is therefore a question whether a specially devised rubber tube, like a catheter (such as is used in the continuous treatment of strictures of the œsophagus), would not meet the difficulty best. It could be drawn upwards after the wound had cicatrised. It is always safer to leave the external wound open.

73. Opening of the Retropharyngeal Space. Retropharyngeal abscesses, which form a definite projection into the pharynx, and which are not palpable from the outside, or appear to be difficult to get at, are to be opened by an incision as near as possible to the middle line of the posterior wall of the pharynx, provided that a tampon can be inserted below it to prevent the pus from entering the larynx and producing asphyxia or leading to aspiration pneumonia. On the other hand, when collections of pus in the retropharyngeal and retroœsophageal spaces have spread laterally and can be palpated from the neck, it is far better to open them from the outside, as this not only excludes the immediate danger of asphyxia, but also the risk of secondary infection of the wound, which is so difficult to prevent when the opening is made from the pharynx.

For fluctuating tumours in the upper division of the anterior triangle Buckhardt recommends making the incision along the anterior border of the sterno-mastoid, and then passing inwards close to the larynx. But it is better to adopt Chiene's plan 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 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. 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. Evacuation from without has the advantage over evacuation from within, of allowing the wound to heal by first intention.

Laryngotomy and Tracheotomy

Cutting down mesially in the anterior triangle of the neck is the most frequent operation which one is called upon to perform for the purpose of opening the larynx and the trachea.

74. High Tracheotomy (Crico-tracheotomy) (Fig. 53). 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 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

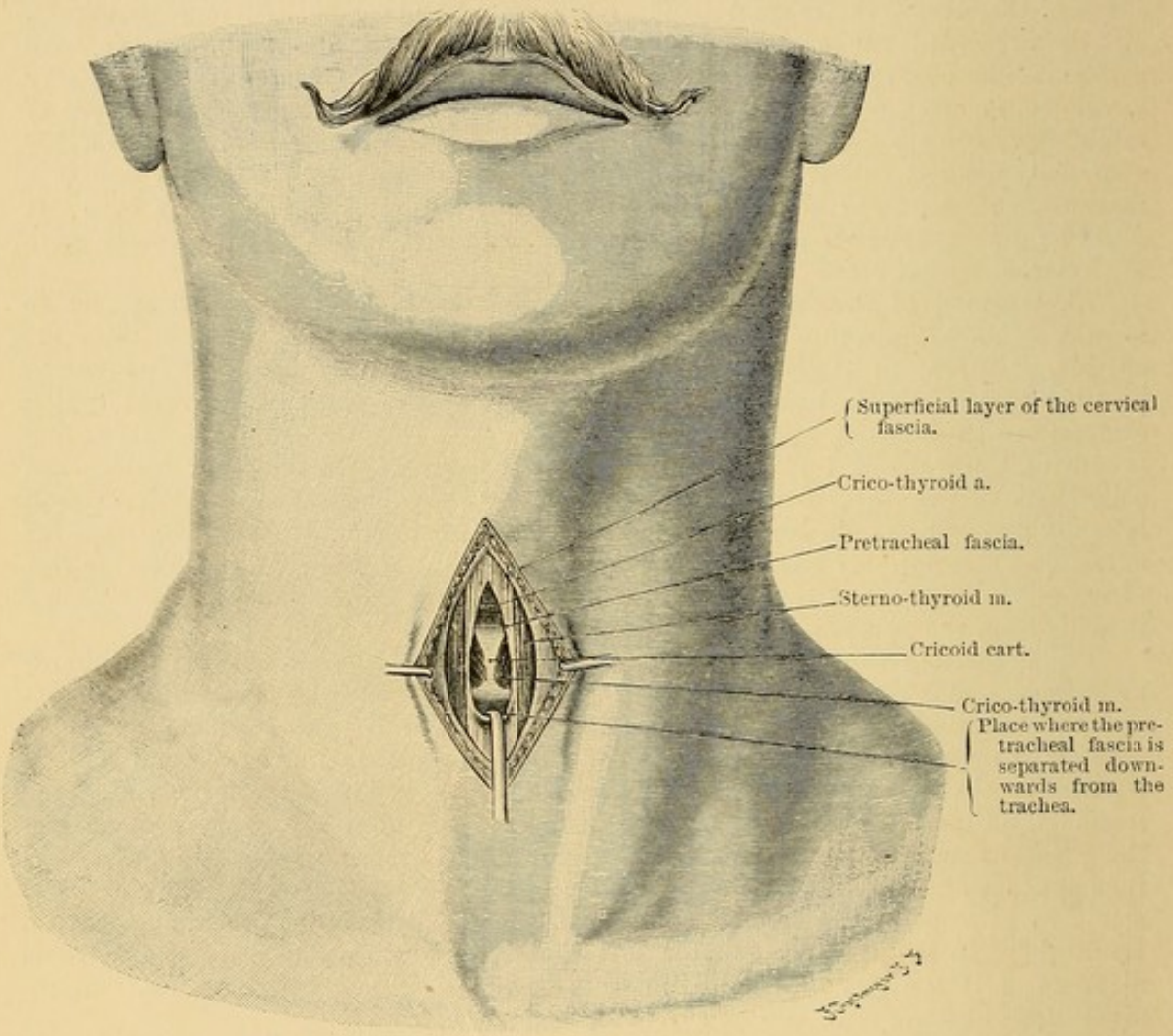


FIG. 53.—High tracheotomy.

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 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 is 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 (Kropfs.), 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.

75. Low Tracheotomy. 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 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 aneurism 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.

In tracheotomy performed preliminary to pharyngotomy, laryngotomy, and laryngectomy, the low operation is preferable, as it leaves a clear field for the second operation. When possible, 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, because the trachea is then much deeper, and there is no palpable guide to it to take the place of the cricoid cartilage.

76. Median Laryngotomy and Partial Laryngectomy. Opening into the larynx is definitely indicated in intralaryngeal malignant growths; it may be necessary also 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 trachea is divided with scissors upwards exactly in the middle line. Before dividing the thyroid cartilage a grooved dissector 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 cocaine should be repeatedly painted on the surface of the mucous membrane. For this purpose we formerly used a 10 per cent solution of cocaine, but we now prefer to use the solution composed of 5 per cent cocaine, 5 per cent antipyrin, and 1 per cent carbolic acid (introduced by Professor Stein, of Moscow).

If the edges of the tumour are distinctly visible 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 (thyroidotomy) without using a general anæsthetic, a local application of cocaine (1 per cent solution for the skin incision) being used, which we consider much better. If the operation is performed with the lower part of the body elevated, the modified 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.

The after treatment of laryngotomy, with or without partial laryngectomy, has become very simple; formerly we introduced a canula into the opening in the trachea, rubbed the edges of the wound with iodoform powder, and stuffed the larynx with iodoform gauze, at the same time surrounding the canula with the same material. As soon as the edges of the wound had granulated we removed the gauze, no sutures being introduced. The wound usually closed in three or four weeks. Now, however, we seldom use a canula or stuff the larynx; we unite the halves of the thyroid cartilage with catgut sutures and allow the patient up on the second day, placing him in the inclined position at night. Needless to say, he is carefully watched, so that a tube may be introduced at once should œdema glottidis supervene. We refer the reader to the description of subhyoid pharyngotomy for cases of laryngeal disease in which merely the parts in relation to the aditus are affected.

77. Complete Laryngectomy (Watson and Czerny's operation). If the whole larynx is diseased, so that one is satisfied from the first that complete excision is required—which is usually difficult to decide—a transverse incision along the lower border of the hyoid bone is added to the longitudinal one, thus combining median laryngotomy with a modified subhyoid laryngotomy. This median-subhyoid laryngotomy is performed in the following manner:—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 silk ligatures. The trachea is then opened and the patient put in the hanging position recommended by Trendelenburg and Rose, 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 tracheotomy 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

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 as far as necessary through the fibres of the sterno-mastoid, the omo-hyoid, and the subjacent thyro-hyoid. The hyoid bone is 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 divided, and the mucous membrane beneath it is then cut through transversely, so that the tip of the epiglottis can 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 it is cut round beyond the diseased tissue. 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, as often happens, the new growth has spread upwards on to the pharynx, the division with the cautery is continued along the arytenoid cartilage and the posterior wall of the cricoid cartilage on to the pharyngeal wall.

The outer surface of the larynx is now for the first time exposed. The muscles which cover the lateral and anterior aspect (sterno-hyoid, thyro-hyoid, and crico-thyroid) are as far as possible preserved, but if diseased they must be removed. The cartilages are then cut through with strong scissors along the groove caused by the thermo-cautery and as much as is in contact with the disease removed. If the mucous membrane on the posterior wall of the cricoid and œsophagus is healthy and movable, it is retained. Out of twelve cases collected by Rutsch [1] one died as a result of the operation, and of the total number of cases (24) operated on by us two died (8·3 per cent), five had no recurrence, one recurred two and a half years after, another four and a half years after the operation.

The anterior wall of the pharynx and œsophagus is sutured as far as possible, in order to restore the septum between the respiratory and alimentary passages, as it is most important to retain the normal act of deglutition. For the after treatment the trachea is sutured to the lower end of the wound and a tracheotomy tube inserted. The patient is fed through an œsophageal tube. The patient can be allowed up the day after the operation, but when in bed must lie with the head and neck inclining downwards.

Dr. Lanz has tabulated our cases of laryngectomy up till 1890, and of these we only lost one out of eighteen cases. Dr. Rutsch has published fifteen cases from our clinic, twelve of which were subjected to radical treatment. It was found that we could usually do without the upper transverse incision in the later cases; and we would also draw attention to the fact, that by splitting the hyoid bone and epiglottis in the middle line (as we have also recommended in excising the root of the tongue by subhyoid pharyngotomy) free access is obtained and no lateral incision is needed. Keen operates at present in a similar manner, but our procedure is still simpler and more categorical.

78. Excision of the Thyroid Gland. Up to the present we have performed excision of the thyroid gland in 2160 cases of goitre; we are thus in a position to speak with authority regarding the best way of performing the operation. Our procedure, which is both definite and simple, guarantees excellent results, but it must, of course, be slightly modified in individual cases. The prognosis after excision of the ordinary forms of goitre we can now give from our own results. From our last series of rather over 1100 cases we have only had 3 deaths, *i.e.* not quite one in 350,

[1] We cannot understand how Keen can gather from Rutsch's papers that we regard cure as very doubtful after excision of the larynx. Our statistics show that a bad result is now quite exceptional.

and since these deaths can be attributed to accidental and avoidable causes, we can with perfect truth say that danger to life need no longer be anticipated.

Medicinal treatment, still so often employed by the physician, and persevered with to the patient's detriment, can have no effect, and is therefore unjustifiable. As soon as a goitre produces dangerous symptoms, viz. obstruction to respiration and a tendency to asphyxia, or when it undergoes inflammatory changes, or assumes the slightest suspicion of malignancy,[1] it should be removed by operation.

Unfortunately the majority of malignant goitres, which are not so uncommon in young persons as one imagines, but which one should always be suspicious of in old people with enlarging goitres, come under the surgeon's care too late to allow of radical cure.

Further, all deep goitres, *i.e.* goitres growing downwards towards the inlet of the thorax, whether they are movable or not, are to be considered dangerous, and should therefore be operated on.

All considerable enlargements of the thyroid due to the growth of large isolated colloid nodules can only be got rid of by operative treatment; medical treatment affects only the hyperplastic changes associated with the enlargement. If, as not infrequently happens, symptoms resembling those of Basedow's disease begin to be associated with the growth of the tumour, operation is the best means of preventing the development of this serious disease.

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 exists:—

1. When there has been marked tracheal stenosis of long duration, which, by causing imperfect oxygenation of the blood in the lungs, has interfered with the functions of other organs, especially the heart.

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.

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 markedly debilitated patients suffering from Basedow's disease, with extreme emaciation 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

[1] This suspicion is always present in the case of an elderly person, or indeed in that of any one above thirty in whom the thyroid begins to enlarge without obvious external reason.

the patient is deteriorating, in which cases we have had better results 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, the result of difficulties connected with the adhesions.

In those numerous cases where the above dangers (which are chiefly due to undue

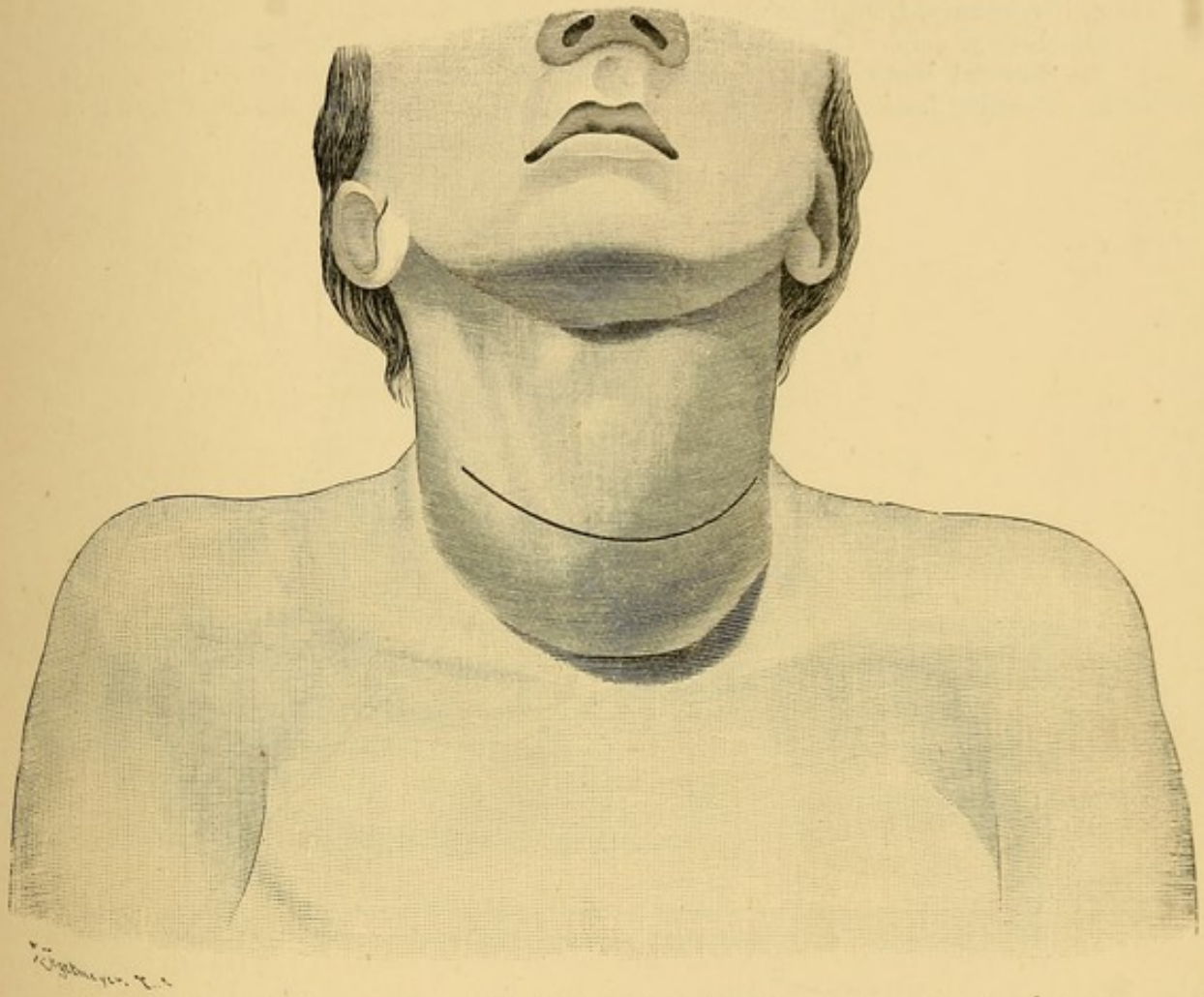


FIG. 54.—Symmetrical transverse curved incision (collar incision) for excision of the thyroid gland; the incision follows the line of cleavage of the skin of the neck, hence a fine cicatrix is obtained.

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.

2. By substituting cocaine 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.

3. By using a large incision properly placed. We recommend our symmetrical "collar incision" as shown in Fig. 54. This incision leaves a scar which is hardly perceptible; moreover, it gives plenty of room, and it 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 deeper-seated processes of the tumour.

4. By careful and timely ligature of the chief arteries and veins (superior and inferior thyroid artery and veins, thyroid ima vessels, and the accessory veins). It is by attending to this that we guard against injury to the recurrent laryngeal nerve, and against reactionary hæmorrhage.

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 pass in the middle line between the muscles and detach them, if necessary, from their upper insertions.

On these principles the following method of excision of the thyroid is founded :—

79. Normal Method of Excision. A symmetrical transverse curved incision is made, extending from the outer border of the one sterno-mastoid to the outer border of

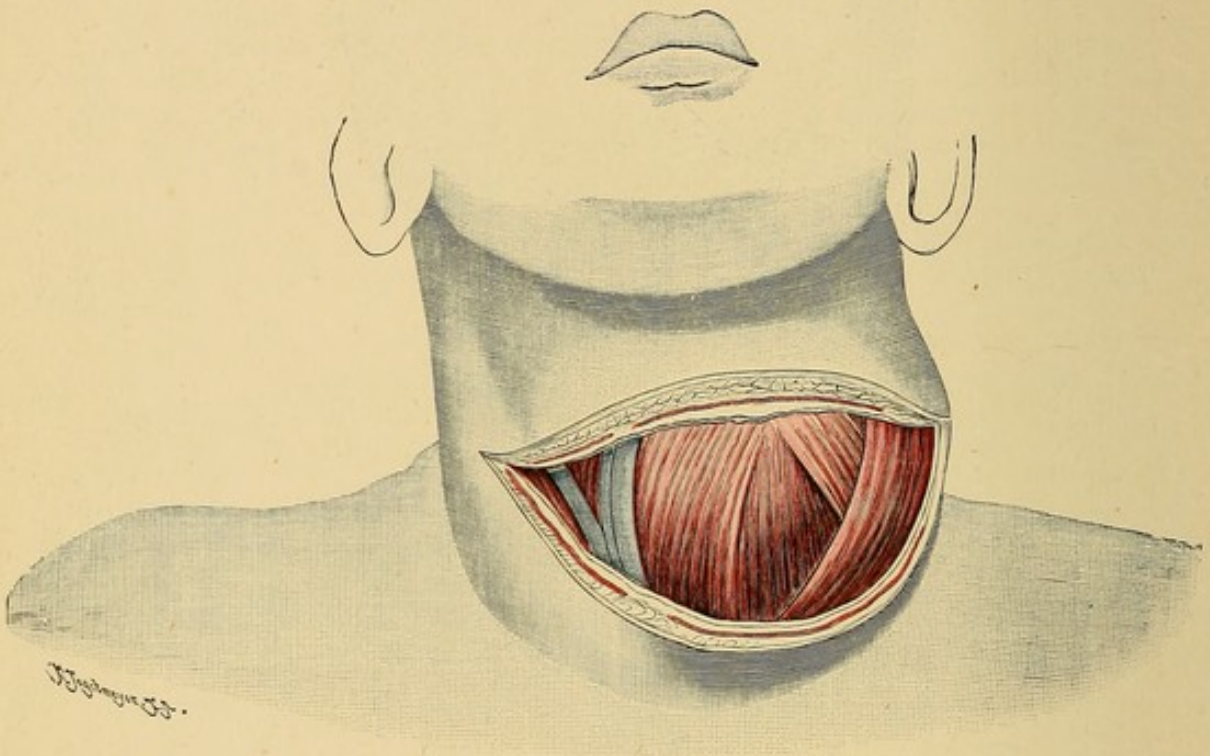
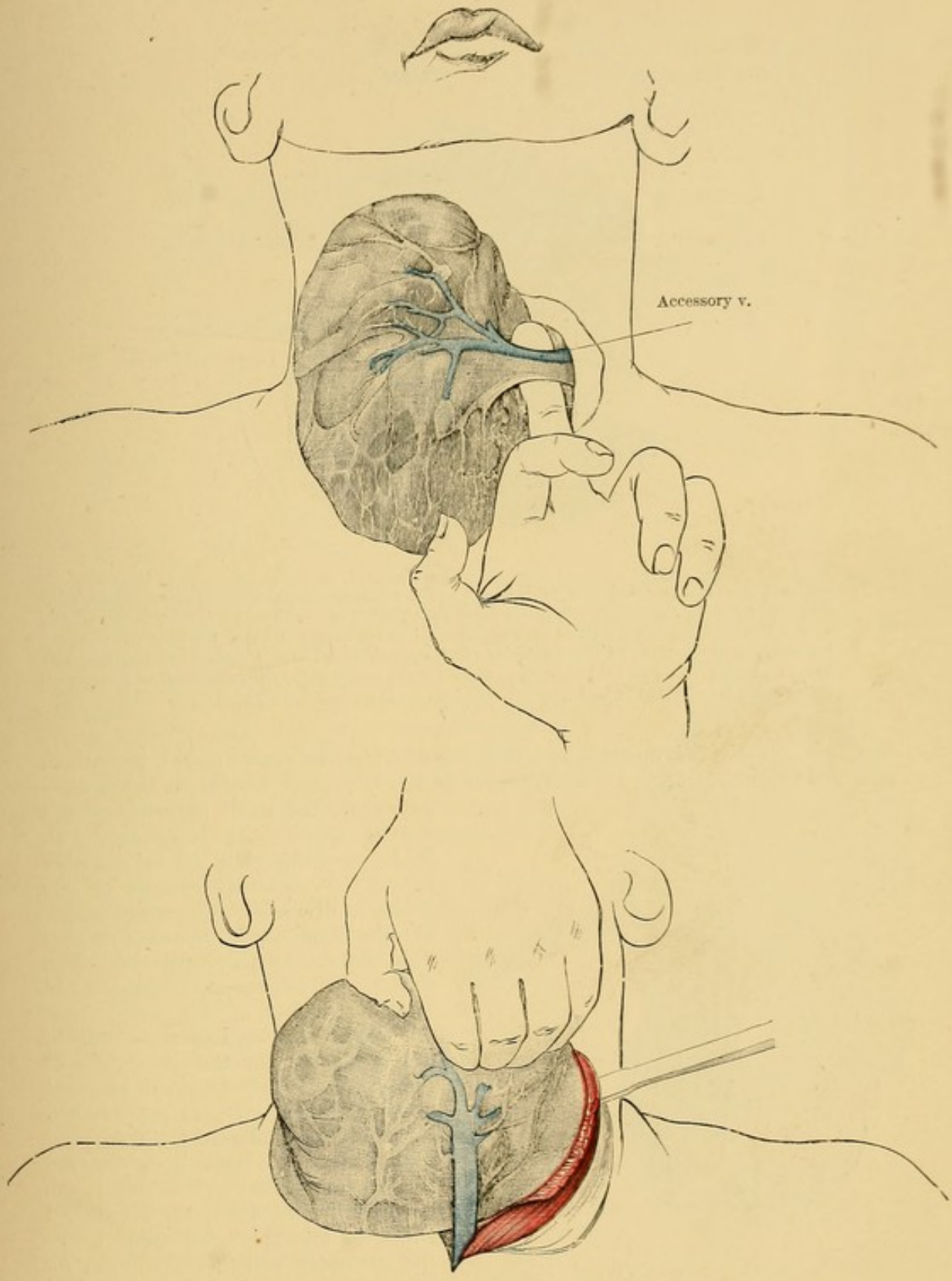


FIG. 55.—On the left of the figure are seen the anterior jugular veins, pushed well over to the right side of the neck. The sterno-hyoid and sterno-thyroid muscles are spread out over the tumour. On the right of the figure is the sterno-mastoid with the omo-hyoid seen running obliquely upwards towards the middle line.

the other. The incision is made at a higher or lower level according to the positions 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 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. 55), 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. 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 need to be divided a second time.



FIGS. 56 *a* and *b*.—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.

The sterno-laryngeal muscles are then separated in the middle line, and the sub-

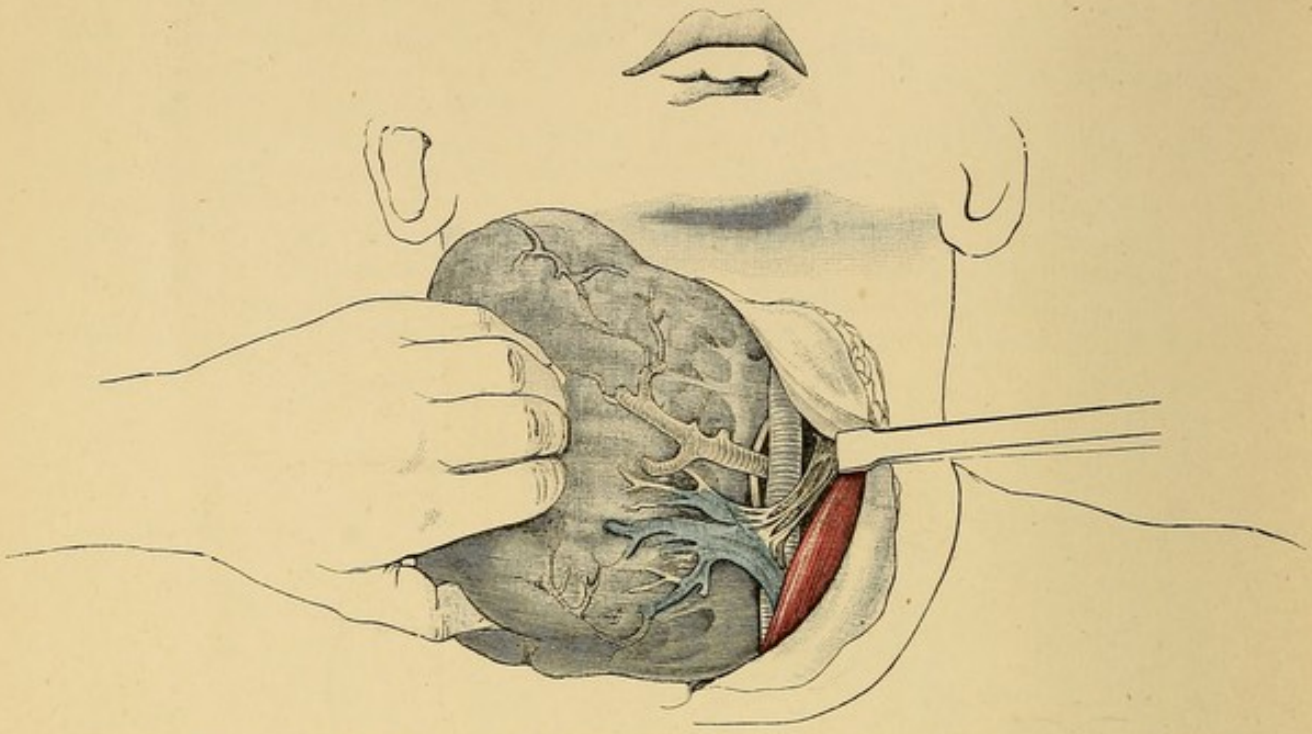


FIG. 56 c.—The goitre is dislocated and pulled over to the opposite side, the left sterno-mastoid being well retracted to the same side (more force than shown in the figure). The common carotid artery is seen lying deeply (it is here represented as too superficial and too near the trachea). Crossing in front of it, to the posterior and lateral aspects of the goitre, are the accessory veins; passing inwards behind it is the inferior thyroid artery, with the recurrent laryngeal nerve ascending behind it and dragged forwards by the traction on the goitre.

jacent 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. 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.

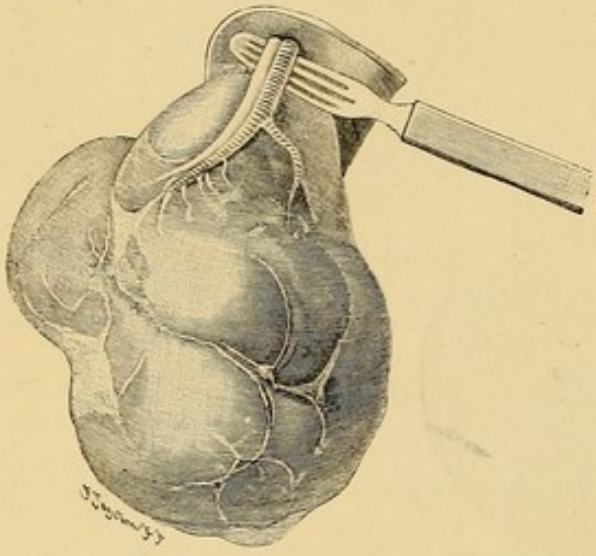


FIG. 57.—Isolation of superior thyroid vessels.

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 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 (Figs. 56, *a*, *b*). These veins are very well developed in large goitres. During the above procedure the muscles 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

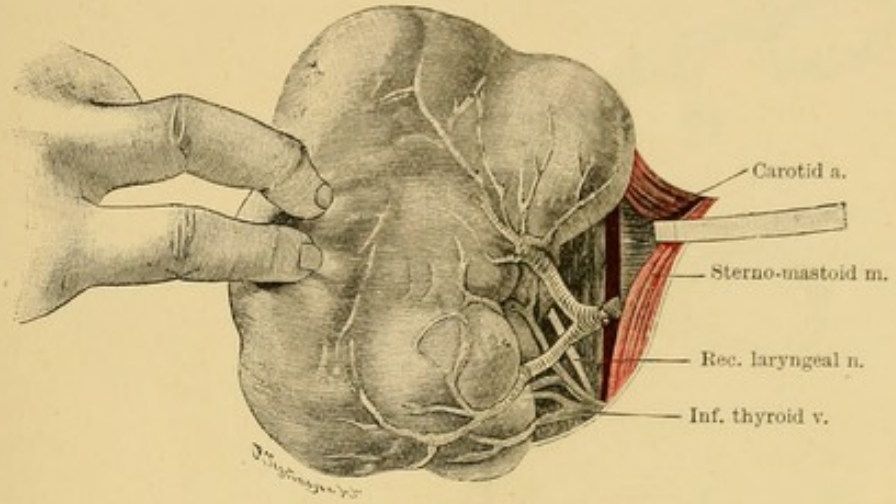


FIG. 58.—Ligature of the inferior thyroid artery.

artery and vein, which pass downwards and inwards. These main vessels are then divided between two carefully applied ligatures (Fig. 57).

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 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. 58).[1]

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. 59).

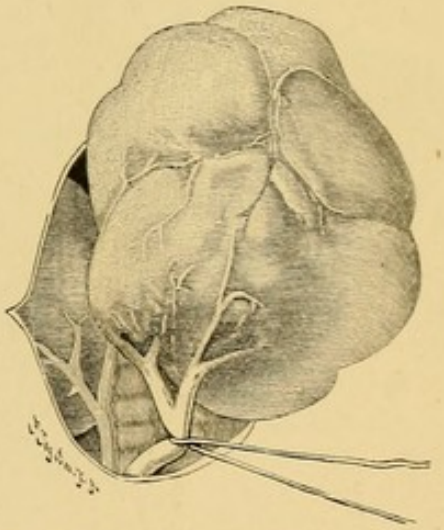
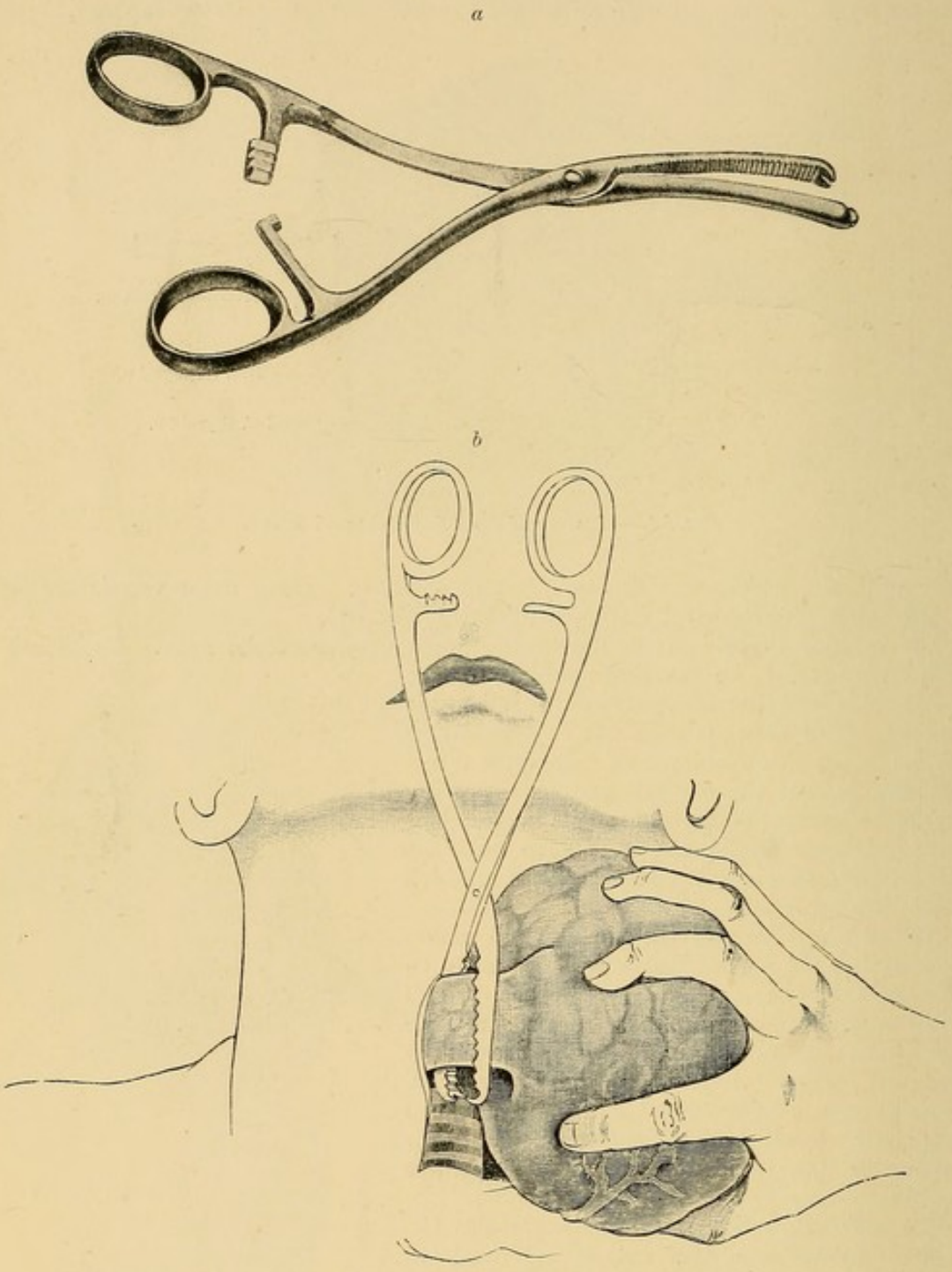


FIG. 59.—Isolation of thyroidea ima veins.

The isthmus, and in some instances also the processus pyramidalis, still remain to be isolated and divided. The latter is more easily freed; it is supplied by a special branch of the superior thyroid artery and vein. In isolating the isthmus it is, as a rule, well 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

[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.

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.



FIGS. 60 *a* and *b*.—*a*, Goitre crushing-forceps. *b*, Application of the crushing-forceps before ligaturing the isthmus.

Special forceps are then applied (Fig. 60, *b*), and the isthmus, which is frequently very thick, is so compressed that after taking off the forceps only the vessels and connective tissues are left. These are then firmly tied with a strong ligature.

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 from being cut through. One cannot be too careful to avoid injuring this nerve at the last moment, and it is well, therefore, to catch every bleeding point.

The wound is thoroughly washed out with warm sterilised salt solution, the surrounding parts and the hands being purified, and the numerous ligatures and sutures tied after putting on clean sterilised cotton gloves. If it has been necessary to completely cut across the upper attachments of the muscles, they should be sutured

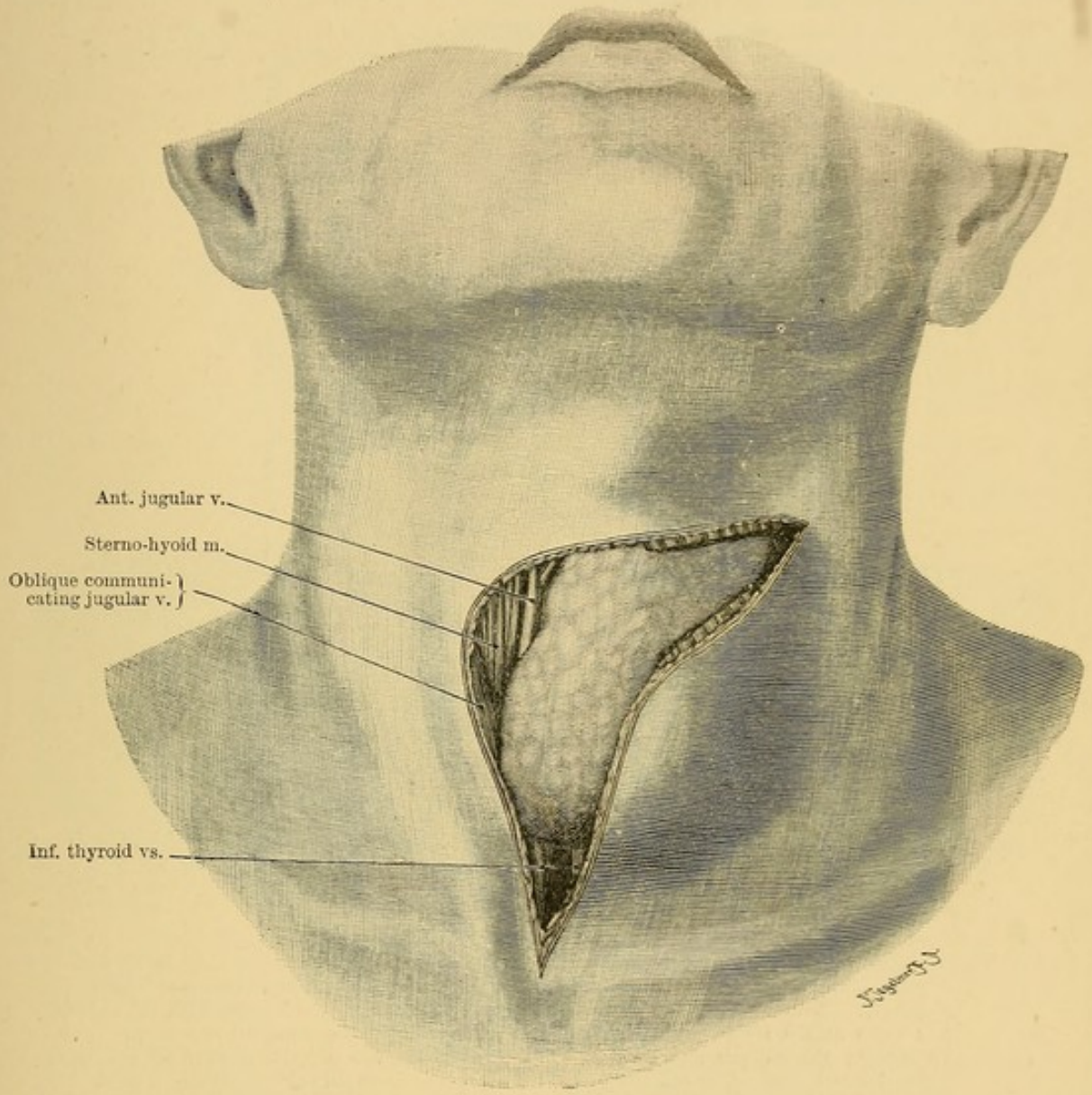


FIG. 61.—Excision of a left-sided goitre (difficult cases) by an angular incision.

in position again. The wound is then closed with a continuous suture and a small short glass drainage tube inserted, which may generally be left in for twenty-four hours.

The angular incision which we formerly recommended, and which is illustrated in Figs. 61 and 62, is still applicable to those goitres which extend as far upwards as the muscles of the jaw, and are at the same time immovable, as is frequently the case in very large diffuse colloid tumours, and in inflamed and malignant goitres.

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 elongated on to the manubrium sterni. The skin, and, in the transverse part of the incision, a distinct layer of platysma, are divided. In the middle line, the large anterior jugular vein, and, at the anterior border of the sterno-mastoid, the "oblique jugular" vein, are double ligatured and

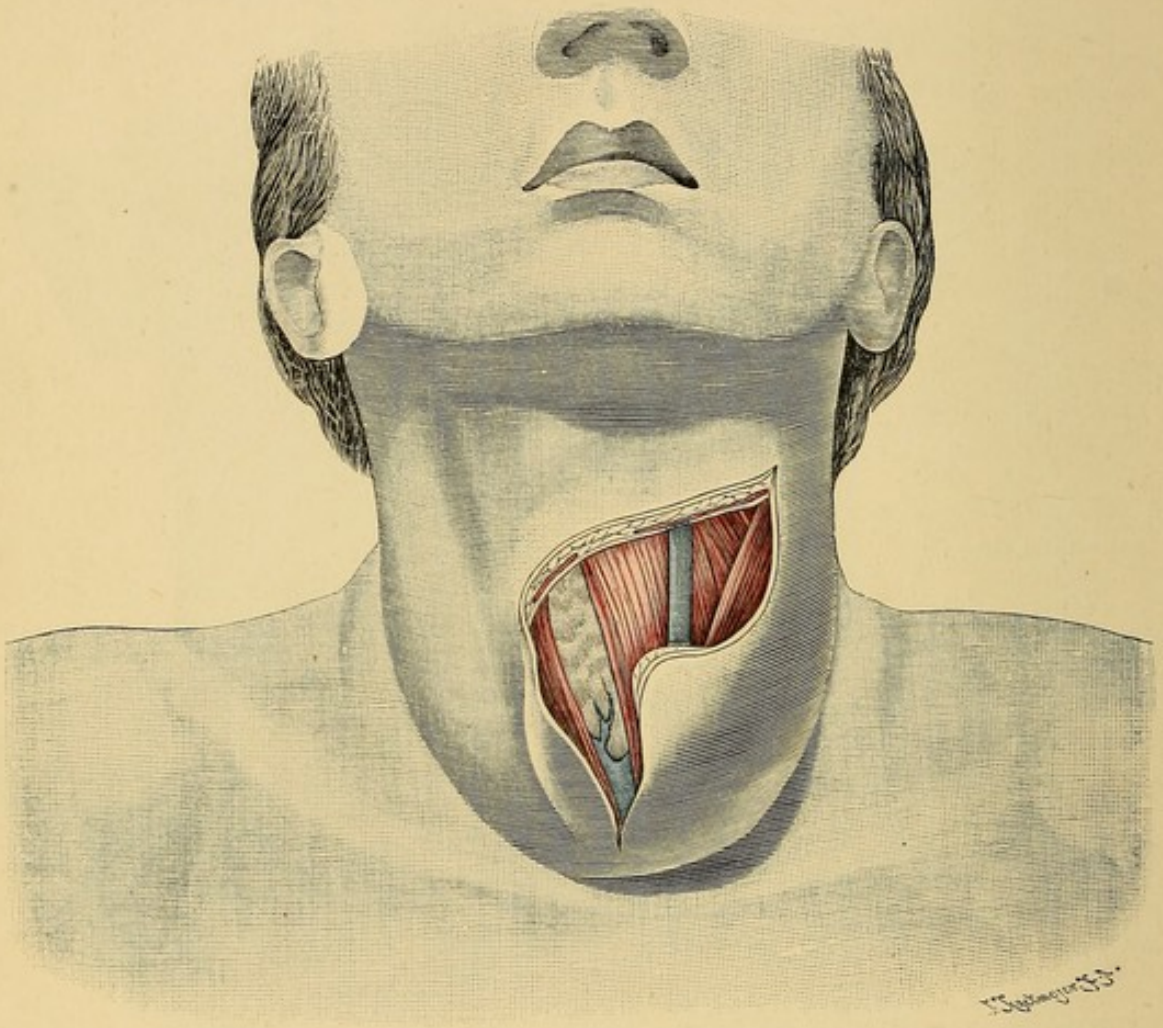


FIG. 62.—Angular incision in the case of a left-sided goitre which reaches both high up and low down. The larynx is much displaced; the inner borders of the sterno-hyoid muscles lie obliquely. Between them is seen part of the anterior surface of the goitre with the thyroidea ima veins at the lower end of the incision. One anterior jugular vein crosses the muscles vertically; the oblique jugular vein which runs along the anterior border of the sterno-mastoid is not seen. The omo-hyoid is seen ascending from behind the sterno-mastoid.

divided. The external jugular vein, which crosses the sterno-mastoid from above downwards, can be preserved.

After dividing 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 them.

The remaining steps of the operation are the same as when the "collar" incision is employed.

80. Enucleation of the Goitre. Enucleation, recommended by Porta, and brought into general use by Professor Socin, 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

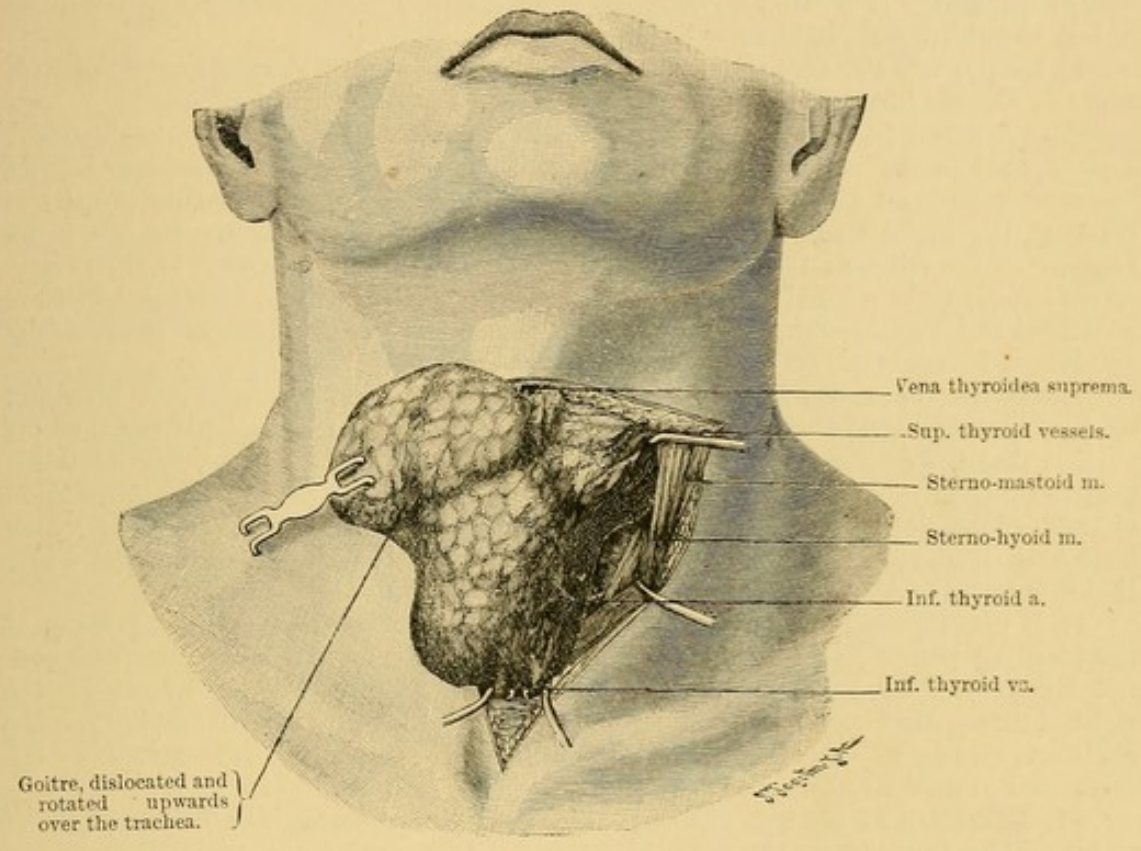


FIG. 63.—Excision of a left-sided goitre by the angular incision. Dislocation of the goitre over to the sound side, and ligature of the main vessels (inf. thyroid veins, inf. thyroid arteries, vena thyroidea suprema, and superior thyroid artery and vein).

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 Bruner, 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 only one or two small isolated nodules are to be felt in otherwise healthy gland tissue.

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 take 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 careful ligatures in the neighbourhood of less atrophied parts of the gland.

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).

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.

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 hæmatomas.

81. Resection of Goitre. Mikulicz has suggested resecting the diseased part of the thyroid gland, but we can only recommend it for exceptional cases. Hæmorrhage is generally less easily controlled than by 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). By means of the forceps which we have made (Fig. 60, *a*), 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.

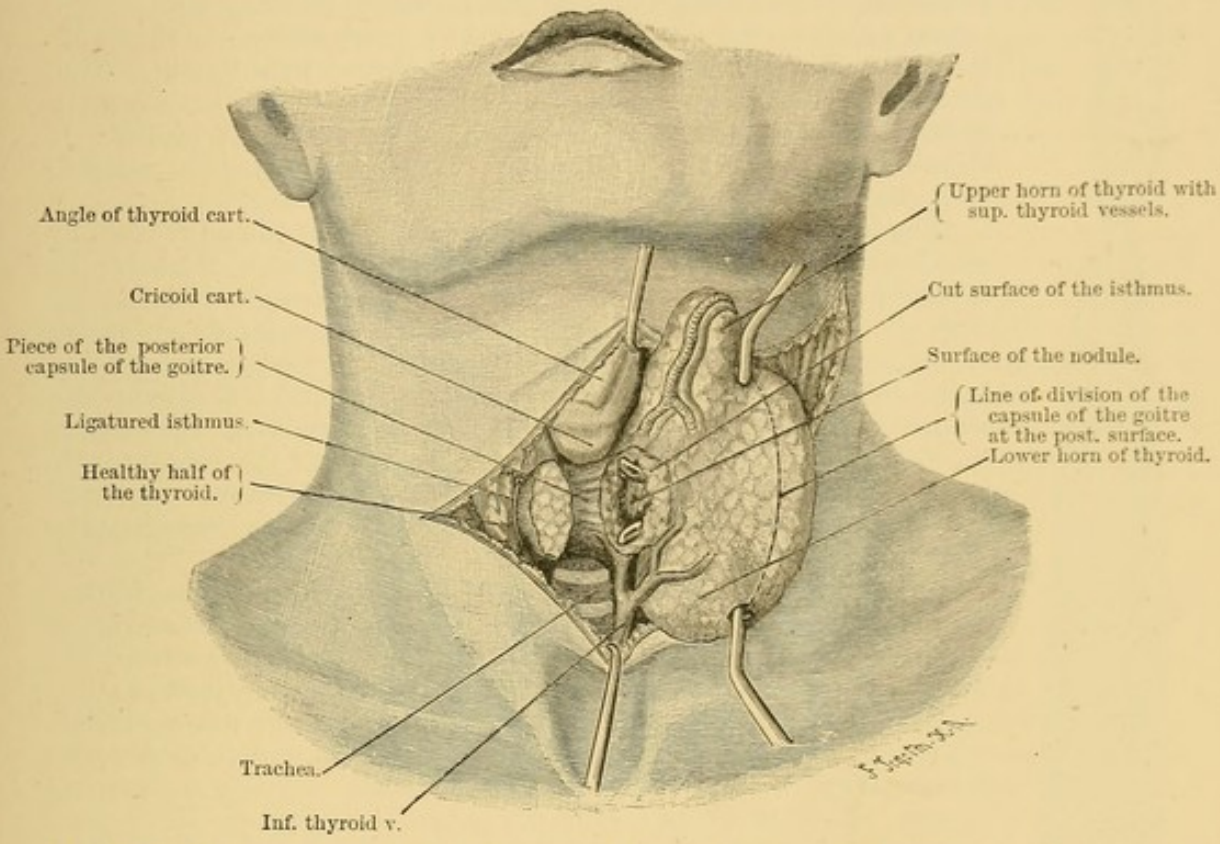


FIG. 64.—Enucleation-resection of a hypertrophied nodule from the left lobe of the thyroid. The left lobe of the thyroid has been brought out of the skin incision, the isthmus ligatured and cut across, the cut surfaces of the latter drawn apart so as to bring into view the surface of the colloid nodule. The line of division of the capsule of the goitre is indicated on the anterior surface by the two aneurism needles, on the posterior surface by the interrupted line (which has been placed too far forward).

82. 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 resection, and leaving behind the posterior part of the inner capsule of the gland, which is usually the thickest. Fig. 64 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. 64. Into this opening a finger or blunt dissector (Kropfsonde, Fig. 65) 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 aneurism needle is passed under them and a ligature applied.

Under some circumstances this linear separation must be repeated in the neighbourhood 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.

FIG. 65. Goitre dissector.

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. 64 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.

The method has the advantage of reducing considerably the bleeding which was so troublesome in enucleation and resection. Moreover, by leaving a well-nourished piece of gland tissue posteriorly, 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 large colloid or cystic masses, forming spherical tumours imbedded in relatively healthy gland tissue.

83. Evacuation (Exenteration) of the Contents of the Goitre. This operation, as its name implies, consists in dividing the capsule of the goitre and scraping out and expressing the colloid contents, the walls of the cyst being left behind. It is the simplest method of all.

It 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. The operation is rendered still easier by applying a clamp to the base of the nodule and ligaturing or suturing the pedicle to stop the hæmorrhage.

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. 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 we repeat 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 Ponta, an Italian surgeon, whose method is identical with our enucleation.

84. 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 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 was completely cured.

The operation is difficult, and requires both skill and experience. The incision, which must be placed low down, should, as a rule, be the angular rather than the collar incision. It is of the utmost importance to thoroughly free the upper pole of the swelling, and to carefully ligature the superior thyroid vessels, the accessory veins, and the superior communicating vein, and, when possible, to divide the isthmus of the thyroid.

The vessels (especially the veins) which enter and leave the surface of the tumour should be divided between two ligatures as low down as possible. If necessary, the sternal head of the sterno-mastoid and the muscles going from the sternum to the larynx must be divided on the diseased side. The critical moment then comes when the tumour must be seized with the forceps (Fig. 66) we have specially devised for the purpose and dragged forcibly upwards. All the vessels entering the surface of the goitre should be divided between two ligatures, 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. 67), 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. In colloid tumours, on the other hand, one must make up one's mind to "exenteration," the size of the tumour being diminished by breaking up and removing the colloid material piecemeal, in much the same way as in "morcellement" of a large uterine fibroid.

The main difference is that in goitre 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. 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

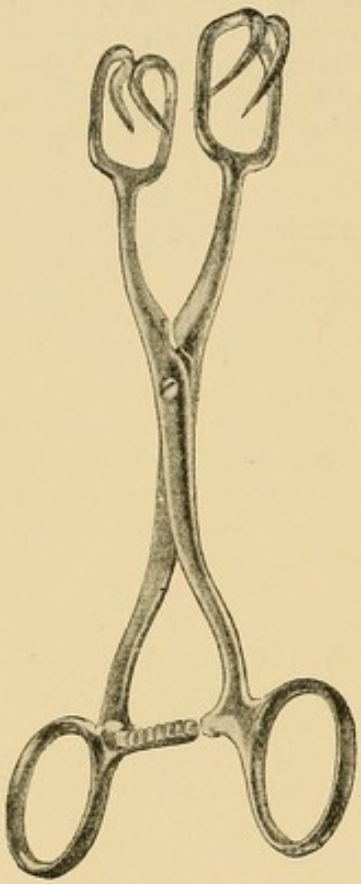


Fig. 66.—Goitre forceps. The ring-shaped blades cause no hæmorrhage, while the recurved hooks prevent them from slipping.

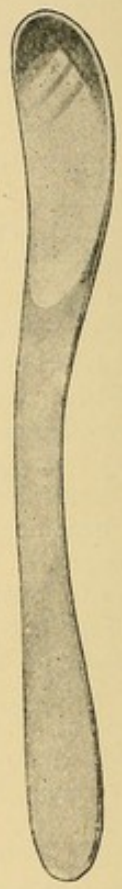


Fig. 67.—Goitre spoon for releasing intrathoracic goitres.

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.

85. 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 that the other lobe of the thyroid develops to such an extent as to cause trouble. It occurs most commonly in diffuse follicular colloid tumours. The reasons are obvious why recurrence should

occur more frequently after enucleation than after excision.[1] 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 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 freed all round so that it can be isolated in the usual fashion. If the upper pole appears relatively healthy, the arteries and veins going into it 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 (Fig. 60, *a*), the crushed part may be ligatured, and the remainder of the tumour excised in the usual way.

If the upper pole is entirely diseased, and if the dislocation cannot be done 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, the goitre raised (as far as possible without hæmorrhage) from the trachea, and the resection performed in the manner we have described for ordinary cases that are adherent to the trachea, *i.e.* 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 aspect under the muscles and dividing them transversely along with the soft parts, thus leaving the entire cicatrix attached to the goitre. An endeavour is then made to work the finger underneath the vessels passing into the gland from above downwards and inwards, so as to be able to ligature them, and to deal with the accessory veins and the superior thyroid vessels. The upper pole can then be turned downwards so as to reach the posterior surface, which can be separated comparatively easily. By drawing out the upper horn the inferior thyroid artery can be reached. It is easier to free difficult goitres, especially those which extend deeply, or are adherent below, if the tumour be drawn upwards so that its connections are put on the stretch. No time, therefore, should be wasted in separating cicatrical adhesions from its anterior surface.

86. Ligature of the Thyroid Arteries. As regards the manner in which this operation is to be carried out we have already said much. If one wishes to ligature two or more of the thyroid arteries at the same operation, but cannot decide until the operation is in progress which, or whether one will ligature vessels or excise the tumour, a similar incision is made as for excision of the goitre, and the thyroid is exposed in the same way. Ligature of the superior thyroid arteries is, as a rule, easy, but the same cannot be said of the inferior thyroids. There are cases in which, after the operation has been begun, it is found to be easier to excise half the thyroid gland than to perform proximal ligature of both arteries.

Ligature of the thyroid arteries, originally suggested by Wölfler for ordinary goitres,

[1] Brunner has shown that of 18 per cent of recurrences after thyroid operations the majority are after enucleation.

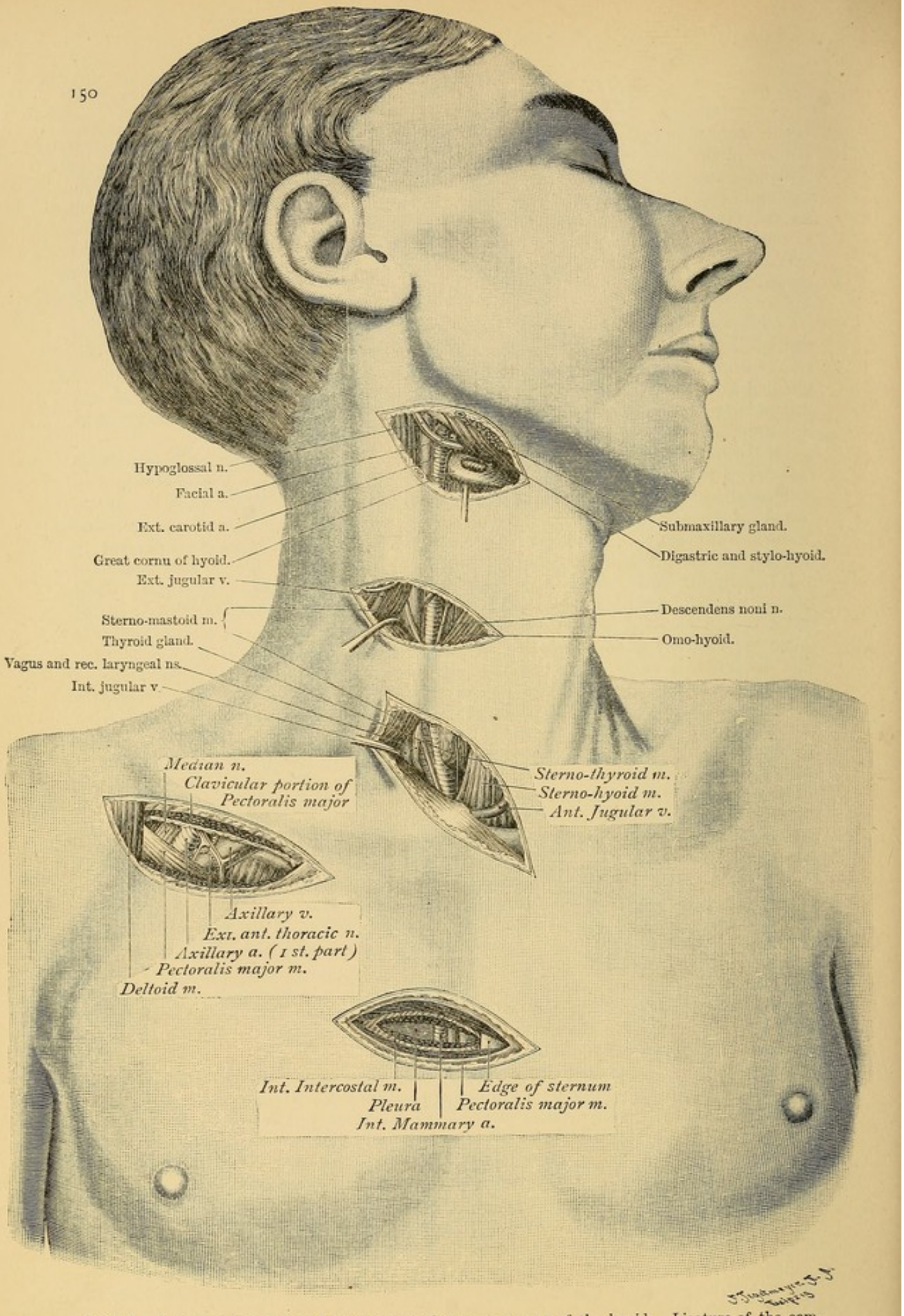


FIG. 68.—Ligature of the lingual artery above the greater cornu of the hyoid. Ligature of the common carotid at the level of the cricoid cartilage. Ligature of the innominate artery. Ligature of the first part of the axillary artery. Ligature of the internal mammary artery.

finds its chief application in the following pathological conditions of the thyroid gland :—

1. In Basedow's disease. In this affection a combined excision and ligature gives still better results than ligature alone (see Albert Kocher's monograph on Basedow's disease) ; but excision is often too dangerous, and one is very glad to leave matters alone after ligaturing the three thyroid arteries which are chiefly dilated.

2. In large vascular colloid tumours, especially of the diffuse kind, where excision is too serious an undertaking, first on account of hæmorrhage, and, secondly, on account of the sudden loss of a mass of thyroid tissue which, though diseased, was still assisting to maintain an otherwise imperfect function.

We consider that the chief importance of ligature of the arteries is as a preliminary operation to excision. It diminishes the size of the tumour, causes shrinking of the vessels, improves the local as well as the general conditions, and allows of the performance with safety of an operation, which, without preliminary ligature of the vessels, would have exposed the patient to the greatest danger.

87. Excision of Inflamed and Malignant Tumours of the Thyroid. In inflamed goitres, and in malignant goitres, the enveloping muscles on the anterior aspect, as well as the outer capsule, must be removed, just as in the case of the cicatrical condition alluded to in paragraph 79. The operation is, however, more difficult and dangerous, because one must cut round the gland before dislocating it, and veins as large as the internal jugular are frequently met with which are firmly adherent to the capsule and which must be divided. Moreover, the arteries lie very close to the infiltrated surface, and are difficult to secure. Hence, although excision is the quickest method of cure, it has often to be abandoned when the goitre is inflamed.

In malignant conditions portions of the trachea and larynx may have to be removed. If the œsophagus is also involved its outer muscular coat must be divided first, for one can often satisfy oneself that the mucous membrane at any rate can be left behind as a continuous tube, which makes a great difference to the healing of the wound. The result of excising malignant goitres will not be satisfactory until early operation becomes the rule, *i.e.* until every case of goitre which is rapidly enlarging is at once operated on, instead of submitting it to measures which favour the formation of adhesions and of malignant thrombi.

In all cases where a goitre is to be excised for severe dyspnœa, general anæsthetics must be absolutely dispensed with, on account of the danger of asphyxia, or of a subsequent aspiration pneumonia. The latter depends on the aspiration of the tracheal and bronchial secretions, and as these are often copious, ether is contraindicated, especially if administered with a mask without renewal of air. A mixture of ether and air, administered in proper proportions by Braun's apparatus, may be allowed.

During the last five years we have, like Roux, performed, except in very rare instances, our operations for goitre under cocaine (a 1 per cent solution, not repeated), and we can assert that by its use not only is the immediate risk of asphyxia obviated, but also subsequent pneumonia, bronchitis, venous hæmorrhage, and the disturbance of the healing of the wound caused by vomiting.

88. Innominate Artery (Fig. 68). This is the nearest artery to the heart which it is permissible to ligature. The operation is a dangerous one on account of secondary hæmorrhage. As a rule, therefore, the simultaneous ligature of the two chief branches in which the recurrent circulation takes place is preferable. These two vessels are the common carotid and the vertebral arteries.

The pulsation of the innominate artery can be felt at the suprasternal notch. To ligature it 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 dividing the skin and fascia, 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 last-named muscles the carotid is followed 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 are left uninjured.

J. THE INFERIOR LATERAL TRIANGLE OF THE NECK

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.

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. 69).

89. Subclavian Artery (Fig. 70). 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-breadth above the clavicle, 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 dividing 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 dividing 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.

Of the three branches of the subclavian artery already mentioned, two pass

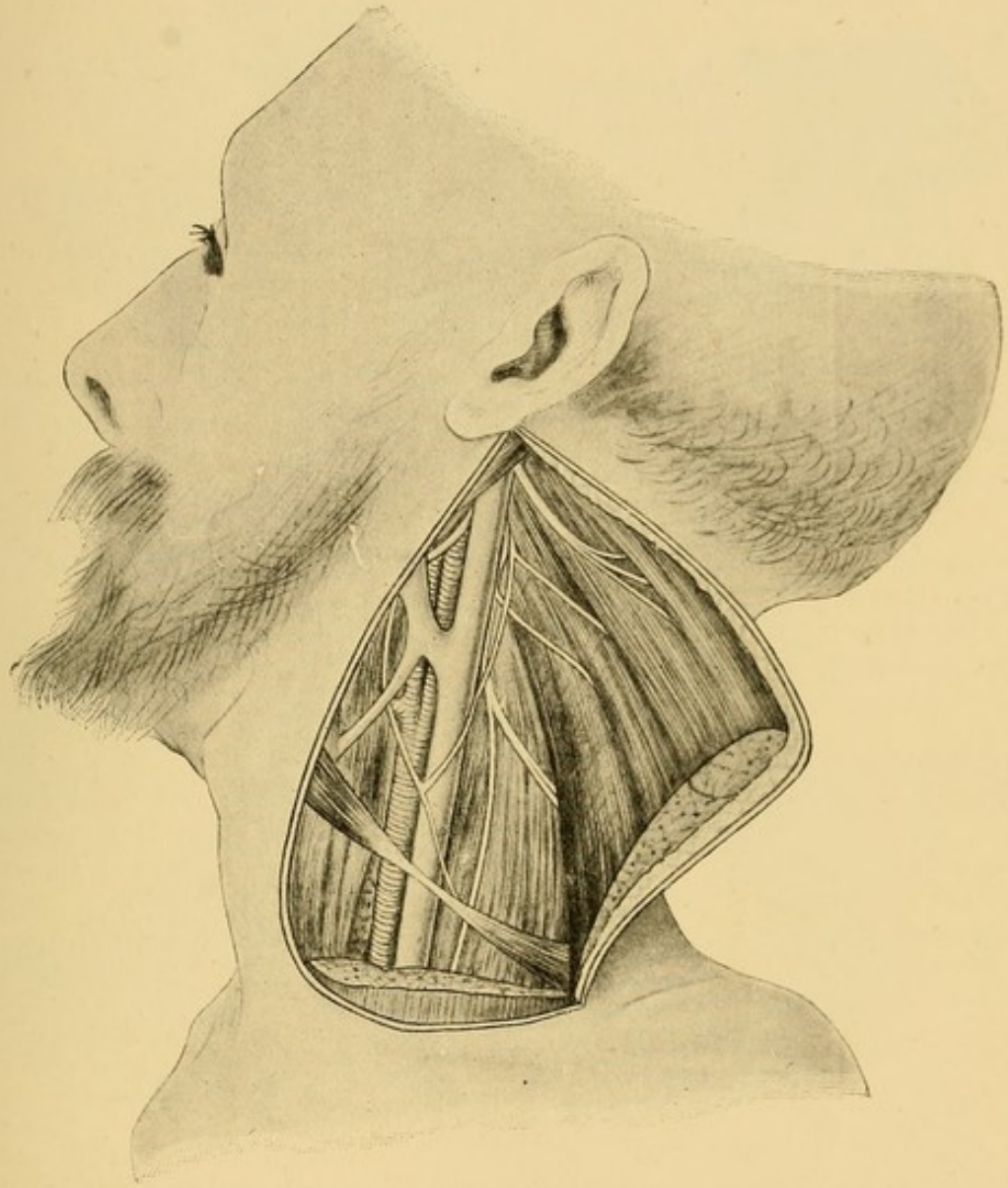


FIG. 69.—Quervain's muscle flap for exposing the deep structures of the neck.

inwards; the third, namely the transversalis colli, passes outwards in front of the scalenus. Ligature of the vertebral and inferior thyroid arteries has already been described.

For ligature of the internal mammary artery see No. 93.

In relation to the operation of stretching the *brachial plexus*, it should be remembered that, of the three trunks, the uppermost (formed by the fifth and sixth cervical nerves) gives origin especially to the musculo-cutaneous and median nerves; the middle (from the seventh cervical nerve), which is situated more posteriorly, to the

musculo-spiral and circumflex nerves ; the lowest (from the eighth cervical and first dorsal nerves), which lies most deeply and in contact with the artery, to the ulnar and to the fibres of the musculo-spiral and median nerves which go to the muscles of the forearm and hand.

90. The Spinal-Accessory Nerve (Fig. 71). The spinal-accessory enters the posterior triangle of the neck after appearing from beneath the middle of the posterior border of the sterno-mastoid muscle. It lies quite superficially beneath the deep fascia, and passes obliquely downwards and backwards to the under surface of the

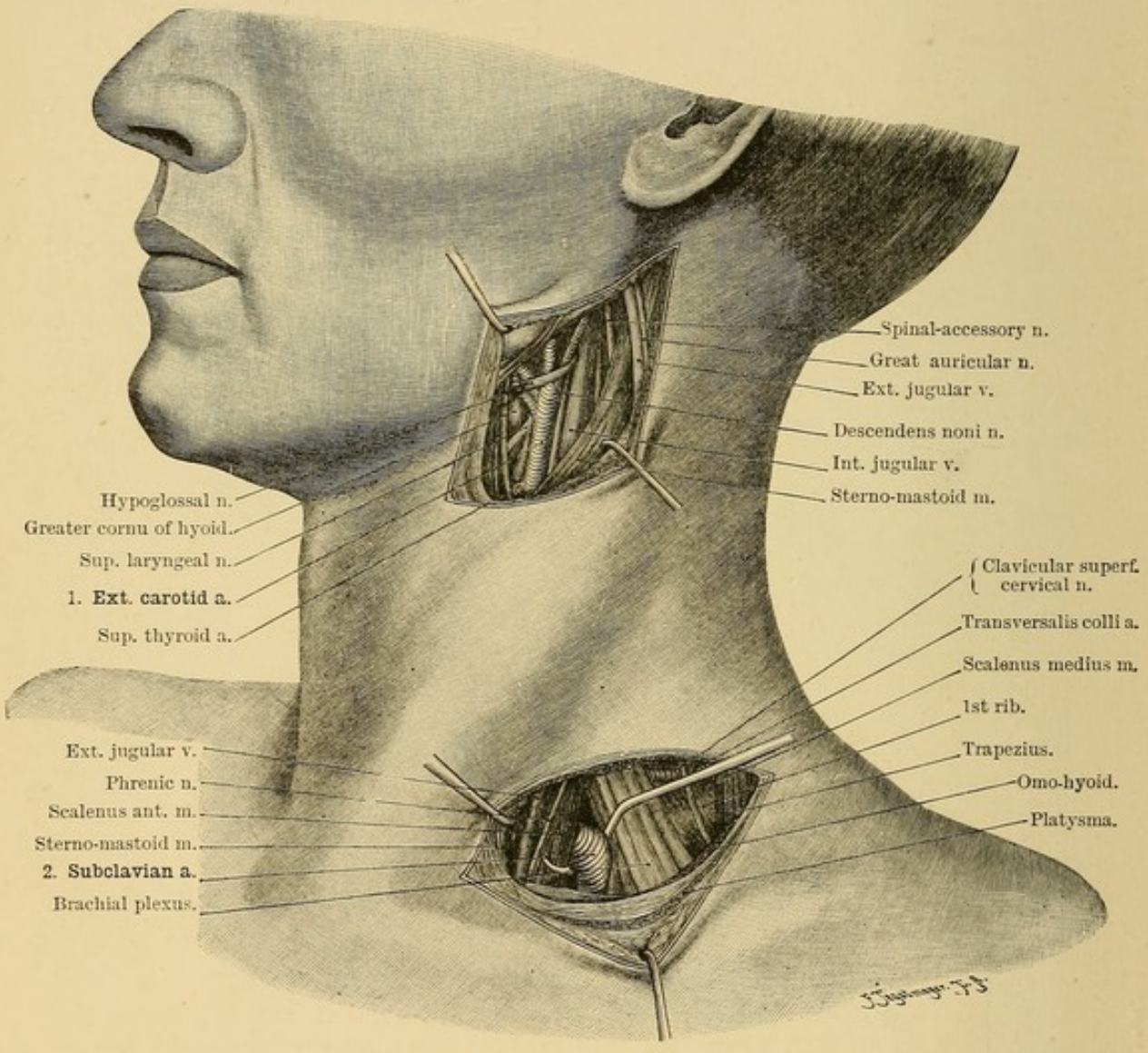


FIG. 70.—Ligature of the external carotid with the origins of the lingual, facial, and occipital arteries. Ligature of the subclavian artery.

trapezius. In stretching or dividing it for spasmodic conditions, the nerve is exposed by making a transverse incision across the middle of the posterior border of the sterno-mastoid muscle.

91. The Transverse and Descending Superficial Cervical Nerves, and **(92) the Great Auricular Nerve** may be secured by the same incision as for the spinal-accessory (Fig. 71).

The short branches, as well as the trunks of the brachial plexus, can be exposed through the normal incision for the posterior triangle. The former diverge from one

another, and pass backwards, outwards, and forwards over the thorax. The *nerves to the levator anguli scapulæ and rhomboids* pierce the scalenus medius and pass backwards; the *suprascapular nerve* passes outwards through the suprascapular notch to the supra- and infraspinatus muscles; the *circumflex nerve* passes through the quadrilateral opening (bounded by the teres muscles, the long head of the triceps, and the humerus) close to the outer wall of the axilla, to the under surface of the deltoid,

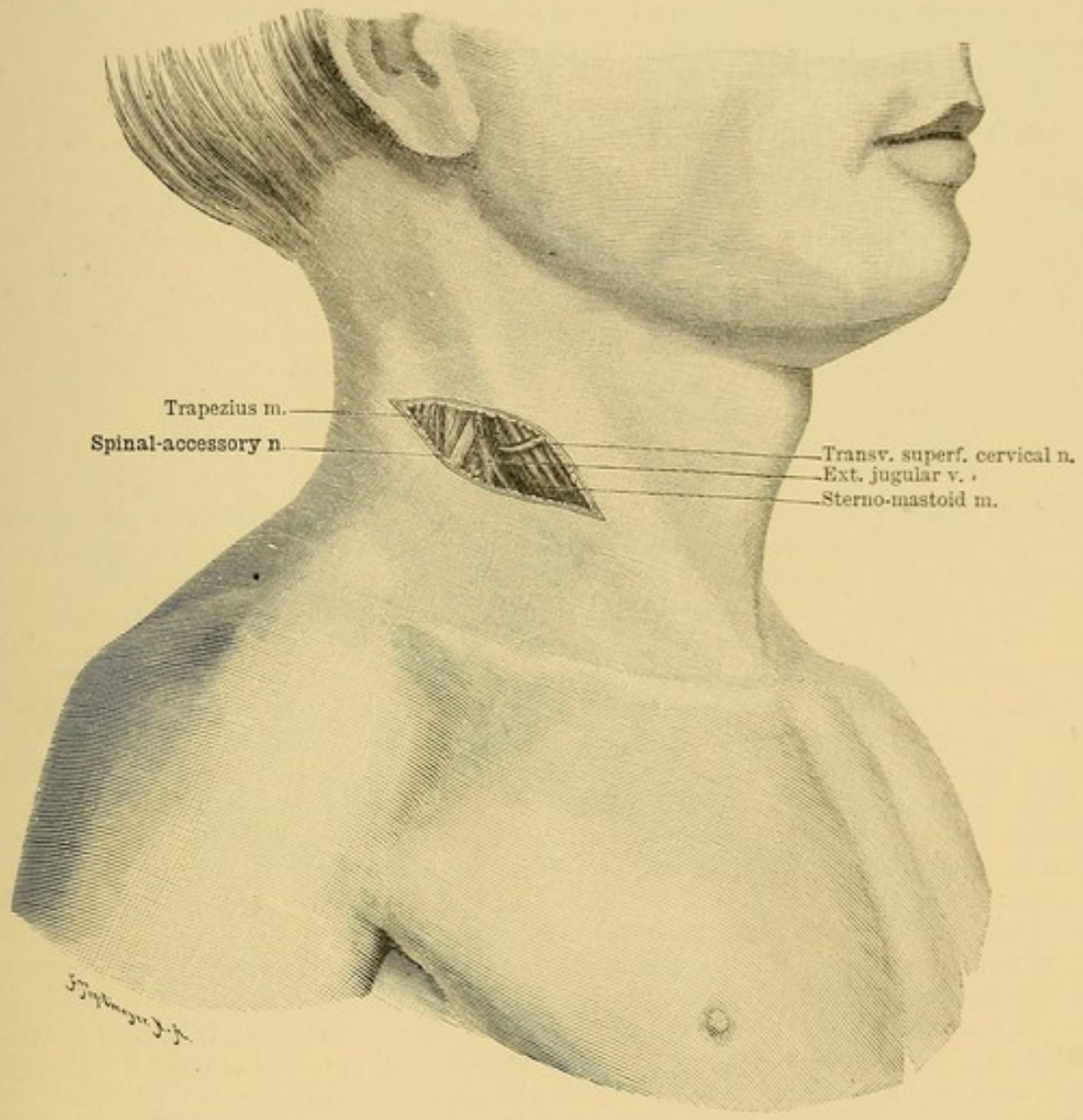


FIG. 71.—Exposure of the spinal-accessory nerve in the middle of the neck.

the teres minor, and the skin upon the posterior aspect of the upper arm; the *three subscapular nerves* descend upon the posterior wall of the axilla to supply the teres major, the subscapularis, and the latissimus dorsi muscles; the *posterior thoracic nerve* passes along the inner wall of the axilla to supply the serratus magnus; lastly, the *anterior thoracic nerves* embrace the first part of the axillary artery and pass forwards to supply the two pectoral muscles.

K. BACK OF THE NECK

The surgery of the suboccipital region has already been dealt with along with the back of the head (see occipital artery and the great and small occipital nerves) page 56.

No large vessels and nerves lie in the lower part of the back of the neck. Incisions are often required in this region in inflammations, especially boils and carbuncles, and may be made without fear of injuring important structures.

For the operation of opening the spinal canal, see page 178.

In the distressing condition of spasmodic wry-neck we have obtained excellent results by dividing all the muscles which rotate the head, including the small suboccipital muscles, at the same time preserving their nerves of supply. The mobility of the head is only interfered with to a very slight extent. The division is carried out through a transverse incision (see Quervain's description of our procedure, *Semaine Médicale*, 14th October 1896). In the same publication are given the theoretical grounds on which we regard myotomy rather than neurotomy as the proper method for spastic conditions.

L. THORAX

The indications for surgical interference in the thorax have become greatly increased in recent years. Not only do diseases of the external soft parts (including the mamma) and the ribs play a very large part, but diseases of the pleura have also become accessible to surgical treatment; and the surgery of the lungs, and even of the heart and pericardium, has made great advances. Even diseases of the mediastinum have been attacked surgically.

The peculiarity of operations on the chest is due to the interrupted bony wall. It has been proved that access to the deep structures is obtained, as a rule, with least injury by excising the ribs, and not by going in through the soft parts between them.

93. Internal Mammary Artery (Fig. 68). It supplies the inner surface of the anterior wall of the thorax, and 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 are 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 $\frac{1}{2}$ to 1 cm. from the border of the sternum. The vein lies 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.

94. Intercostal Artery (Fig. 72). 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, and an aneurism needle is carefully passed round the artery. To secure

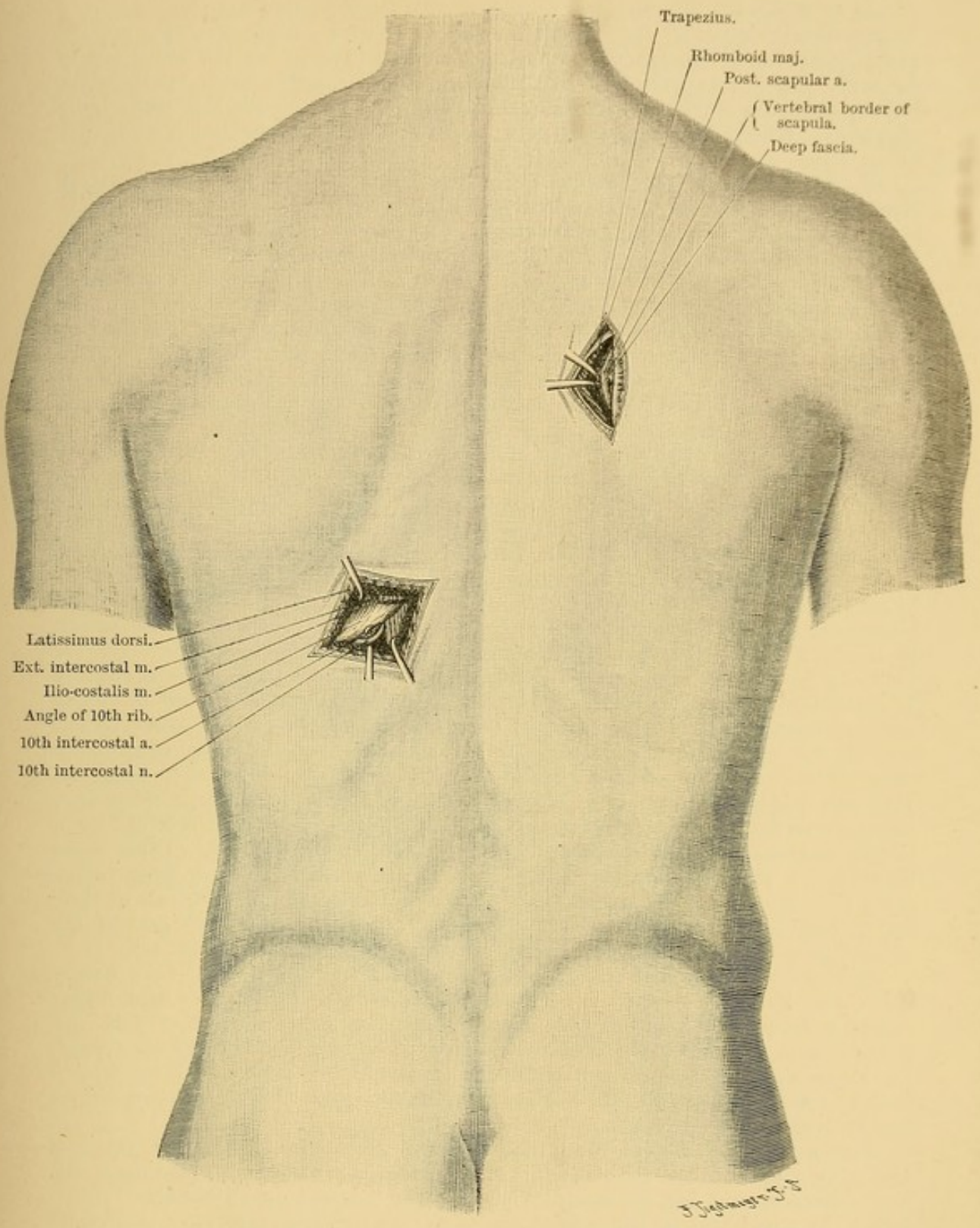


FIG. 72.—Exposure of the 10th rib and the 10th intercostal artery and nerve. Ligature of the posterior scapular artery.

the vessel with greater safety a piece of the overlying rib may be resected subperiosteally.

95. 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. 72). 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.

96. Amputation of the Mamma. The removal of the mamma alone is a very simple operation, and may be done by means of a curved incision with the concavity upwards along the lower border of the gland. The gland is 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 kystique*). 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. When the tumour is situated superficially a simple radial incision is preferred, the skin, superficial fascia, and a thin layer of gland tissue being divided and the tumour shelled out.

97. Radical Operation for Cancer of the Breast (Figs. 73, 74). When we have to deal with carcinoma of the mamma the extent of the operation is quite another matter. In this case 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 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, 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.

The excellent work and statistics of Halsted, Rotter,[4] and Joerss[5] have clearly shown 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 last twenty years we have obtained relatively good results in the 212 cases which Dr. Meyer has tabulated; 31 per cent of the cases were 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 results 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.

To ensure good results in carcinoma of the breast the whole gland and its processes, the skin and subcutaneous fat, and the pectoral fascia, must be removed in every case. The pectoral fascia cannot be properly removed without at the same time removing the pectoral muscles. The operation described in the previous edition must therefore be modified as follows :—The operation is begun by employing the uppermost part of the incision shown in Fig. 73. The incision is at first carried only from the clavicle downwards to the anterior fold of the axilla. This portion of the incision (which we employ also for excision of glands in the axilla) is different from that of Halsted, and leaves a very good scar. The main incision is marked out on the skin with a few scratches with the knife so as to show the extent to be excised, and is later deepened.

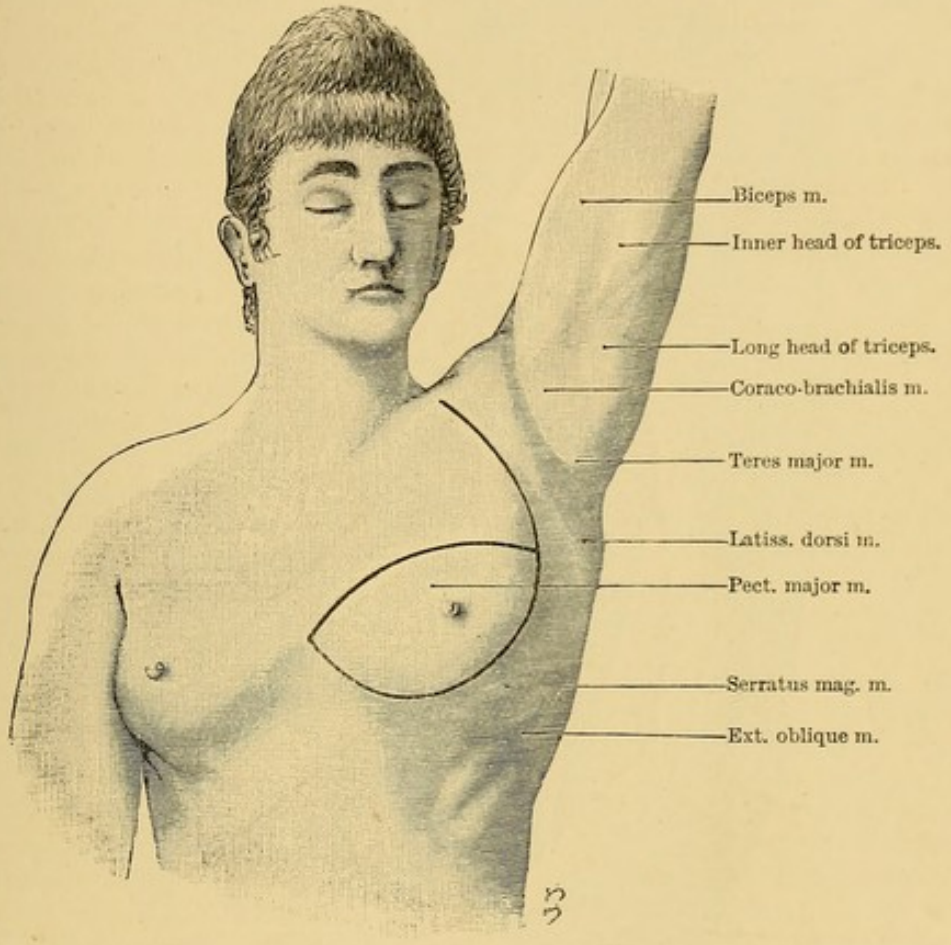


FIG. 73.—Skin incision for removal of a carcinomatous breast.

After dividing the skin and the superficial and deep fascia, the cephalic vein is to be avoided in the furrow between the upper border of the pectoralis major and the deltoid. The vein is the guide to the interval between these muscles. The pectoralis major is freed with a blunt instrument an inch or so from the arm, the finger is then passed underneath it, and the muscle is divided, two or three artery forceps being applied to the vessels supplying it.

The pectoralis minor is then freed and divided close to the coracoid process. The nerves and large axillary vessels now appear surrounded by fat. By carefully dissecting off the fat and glands downwards from the clavicle and coracoid process the axillary vein is exposed in its whole extent. The branches of the axillary vessels are grasped with forceps close to the main trunks before they are divided. With the left hand the fat and glands are further stripped off the anterior surface of the sub-

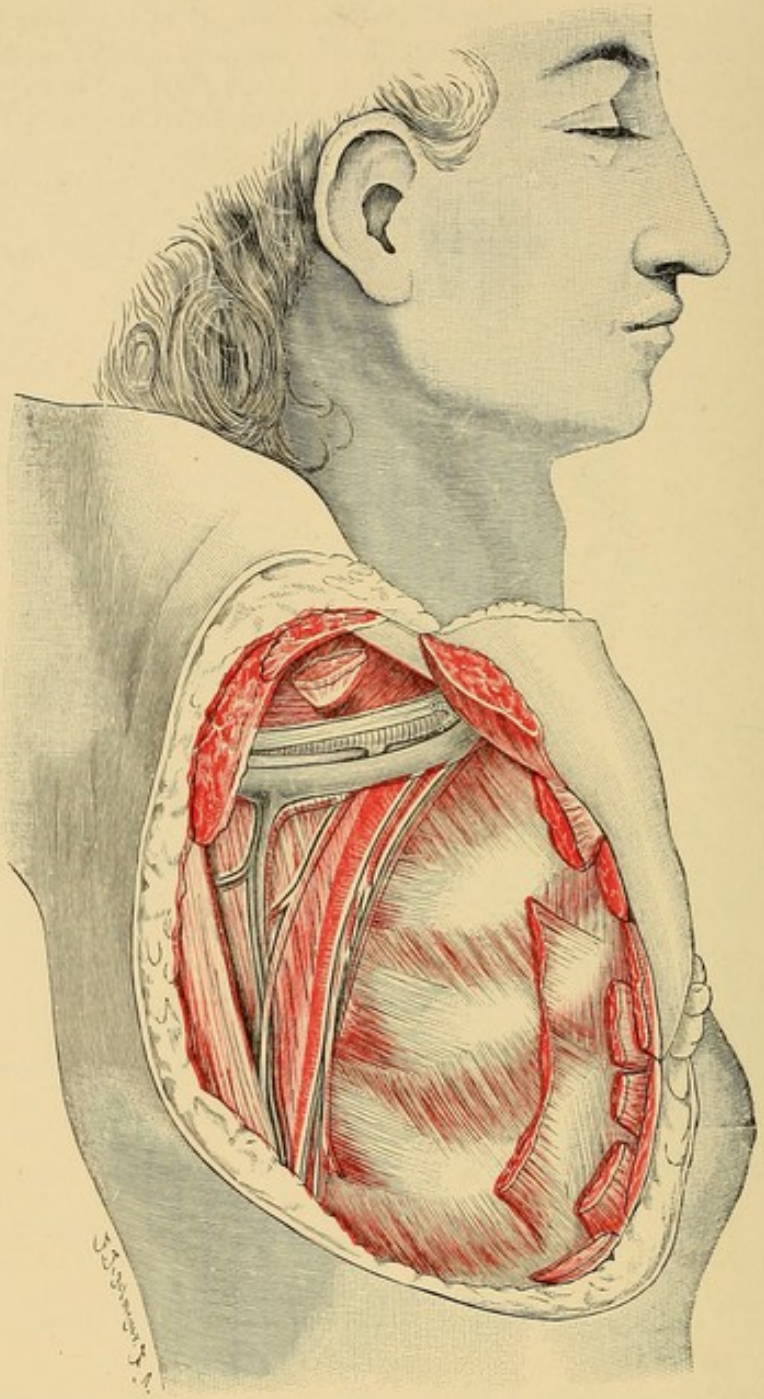


FIG. 74.—Excision of the breast for carcinoma. The entire breast has been removed, along with the skin and pectoral muscles. The clavicle is seen in the upper part of the wound, to the left the distal portion of the pectoralis major; the clavicular portion and the origin from the ribs are seen towards the middle line, underneath the reflected skin. The insertion of the pectoralis minor into the coracoid process is represented turned upwards; its origins from the 3rd, 4th, and 5th ribs are also shown. The intercostal muscles are seen between the ribs and, arising from the latter, the digitations of the serratus magnus. The smooth anterior surface of the subscapularis has been exposed, with the subscapular artery and subscapular nerves lying on it; the posterior thoracic nerve and its accompanying artery are seen lying on the serratus magnus. Posteriorly is the latissimus dorsi. The drawing is taken from an actual operation while the numerous arteries were being tied.

scapularis and latissimus dorsi muscles until the surface of the serratus magnus muscle appears covering the ribs. The posterior thoracic nerve and long thoracic artery which lie on the chest wall, as well as the subscapular nerves on the posterior wall, cannot always be preserved. They must often be removed, as the lymphatics accompanying them frequently contain cancer cells (Heidenhain). In this way, by removing the fat and glands along with the fascia, the axilla appears like a dissecting-room preparation. 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 its thick sternal origin 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.

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 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. If pressure forceps are preferred, ligatures can be dispensed with.

In this operation the axillary glands, the pectoral fascia, both pectoral muscles, as well as the mamma and skin covering it, are removed in one piece.

The last step consists in cleaning the vessels behind the clavicle and removing one or two lymphatic glands which are occasionally found lying subcutaneously close to it. If diseased glands are met with still higher up, the best procedure is to prolong the incision over the clavicle into the supraclavicular triangle, so that the dissection may be continued along the subclavian vessels as far as the angle between the subclavian and internal jugular veins, where a malignant gland is often found. If necessary the clavicle must be divided, the supraclavicular triangle thoroughly cleared out, and the bone wired (Madelung).

The supraclavicular triangle is cleared out by a number of surgeons (Halsted, Cushing) in every case of cancer of the breast. On two occasions Cushing injured the thoracic duct, and obtained in one case a perfect result by suturing it. We have occasionally divided the thoracic duct in other operations. In one instance we were informed by the assistant who looked after the dressing of the case that the œsophagus must have been injured because the milk which the patient swallowed came out through the wound! As a rule the duct heals perfectly without being sutured.

The operation for carcinoma of the mamma can be performed with very little loss of blood, and therefore, in spite of its extent, with little shock. The branches of the axillary vessels (superior thoracic, acromio-thoracic, long thoracic, and subscapular) are ligatured proximally, and only salt solution is used for irrigation. The free exposure of the vessels allows of the axillary vein being resected if the glands are adherent to its wall.

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 adduct it. 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.

It is to be considered a great advance that careful investigations have taught us that in cancer of the breast, as in cancer elsewhere, operation can bring about radical cure to an extent formerly believed to be impossible, and that the main duty of the surgeon is to prevent local recurrence and recurrence in the nearest glands.

The above operation is a severe procedure, but it is certainly that which gives the best prospect of cure, and it should be performed even in the early stages of the disease. In cases where definite reasons exist for not carrying it out, the mere excision of the tumour sometimes gives a surprisingly satisfactory result. According to the table of our cases drawn up by Dr. Meyer, six (75 per cent) out of eight partial excisions of the breast for cancer were free from recurrence after three years. This, which is much better than that obtained by total excision, is only natural, as the disease was still in an early stage. These cases show, in spite of Heidenhain's demonstration of early epithelial changes going on in the neighbourhood, that the wandering of cancer cells in the gland itself is less to be feared than the spread in the efferent lymphatics leading to the axilla.

Surgery of the Chest Wall and Pleura

98. Thoracocentesis. As the pleura closely invests the deep surface of the chest wall, its surgical treatment will be best considered with that of the chest itself.

Puncture of the pleural cavity has in recent times been extensively employed in the medical wards for diagnostic as well as therapeutic purposes. If merely a hypodermic needle or the canula of an aspirator be used, it may be pushed through any intercostal space, provided care be taken that the skin and soft parts be firmly pressed into the intercostal space by the fingers of the other hand in order to make sure of the proper place for puncturing. This is all the more necessary when a very large trocar is used for the purpose of establishing puncture-drainage (Bülau). In this case the puncture should be made at the upper border of the lower rib, as with a large instrument there is no danger of injuring the small artery which lies here. The large intercostal vessels and nerves which run at the lower margin of the ribs must be avoided, and it should be remembered the space is often pretty narrow. A 1 per cent sterilised solution of cocaine should be injected at the point of puncture. In using a large trocar it is desirable to make a small skin incision to facilitate its introduction.

The value of puncturing the pleura for diagnostic purposes has been fully recognised ; but all punctures are mere half measures, and where the indications are to make an opening into the pleura, it is far more satisfactory to resect a piece of rib so as to obtain an opening of sufficient size.

99. Resection of Ribs and Pleurotomy (Figs. 75 and 76). A portion of rib is frequently removed without there being any intention of opening the pleura, as for example in tuberculous and acute infective osteomyelitis, and in chondroma and sarcoma of the rib. The operation is very simple and may be quite easily performed under cocaine.

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 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, 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 incised in the direction of the rib. In doubtful cases the presence of the exudate may be previously ascertained by an exploratory puncture.

Very often resection of one rib is not sufficient. In this case a portion of the rib above is removed through the same incision by drawing the skin well upwards, the pleura being opened in the same way as before. A threaded aneurism needle is now introduced, first at the outer and then at the inner 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, 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.

When a permanent drain is to be provided the opening should be made at the lowest part of the cavity. In the mammary line this is done by removing the cartilage of the sixth rib; in the lateral region the right pleura will still be opened by removing

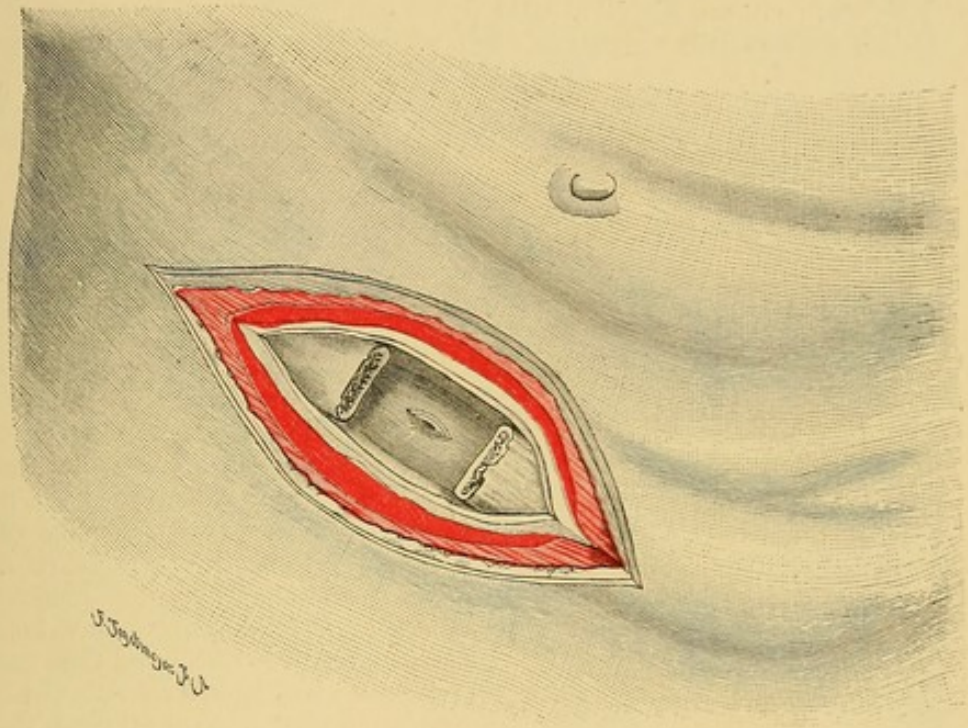


FIG. 75.—Simple resection of rib. The periosteum covering the rib anteriorly has been divided and retracted with the intercostal muscles; a small incision has been made through the posterior layer of periosteum and the subjacent pleura. As a rule, if the ends of two ribs are bared of periosteum they should not be left, but should be snipped off with cutting forceps.

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, therefore, 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 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.

Broca is right in asserting that an "empyema necessitatis" should never be allowed to develop. A purulent pleural exudation cannot be too early evacuated, for it is only in recent empyemata that there is a prospect of the lung fully expanding again. Physicians do not yet sufficiently appreciate this. In those cases where, as the result of injury, a virulent septic pleurisy develops (a frequent occurrence in military campaigns) the success which attends prompt surgical treatment is very striking. Complete mobility and expansion of the lung is obtained by early and thorough operation. Beck (New York) has published statistics which prove the value of early operation, including resection of rib. Of one hundred and ten uncomplicated cases under his observation, where the diagnosis had been made early, all recovered. Schede has also shown the advantages of resection of rib over aspiration, not only as regards mortality, but also as regards permanent cure.

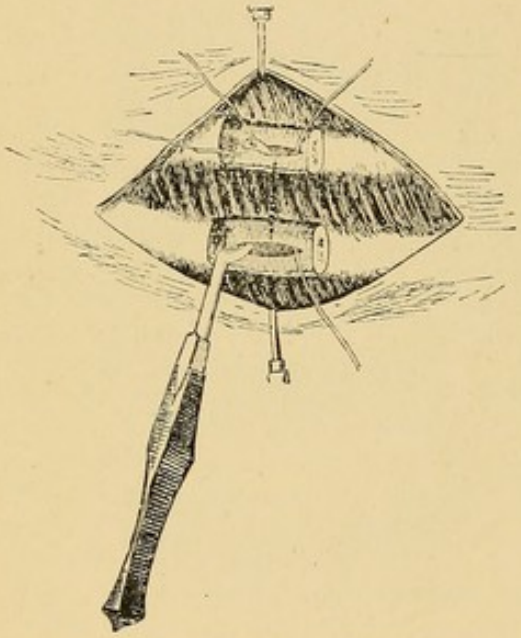


FIG. 76.—Making a free opening into the thorax by resecting portions of two ribs.

100. Extensive Resection of the Chest Wall. Thoracotomy and Thoracoplasty. Extensive excisions of the chest wall are called for in empyema with collapse of the lung. Closure of the abscess cavity is here a mechanical impossibility in consequence of the rigidity of the wall. The operation is also performed for new growths, especially for chondromata and sarcomata of the ribs which have invaded the pleura. The operation goes by the name of Estlander's operation, although individual extensive resections had previously been performed and published (Cerenville). Estlander, who further developed the procedure which Simon 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 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, which, when available, is better than the above operations. After opening the pleura he separates extensively its adhesions to the

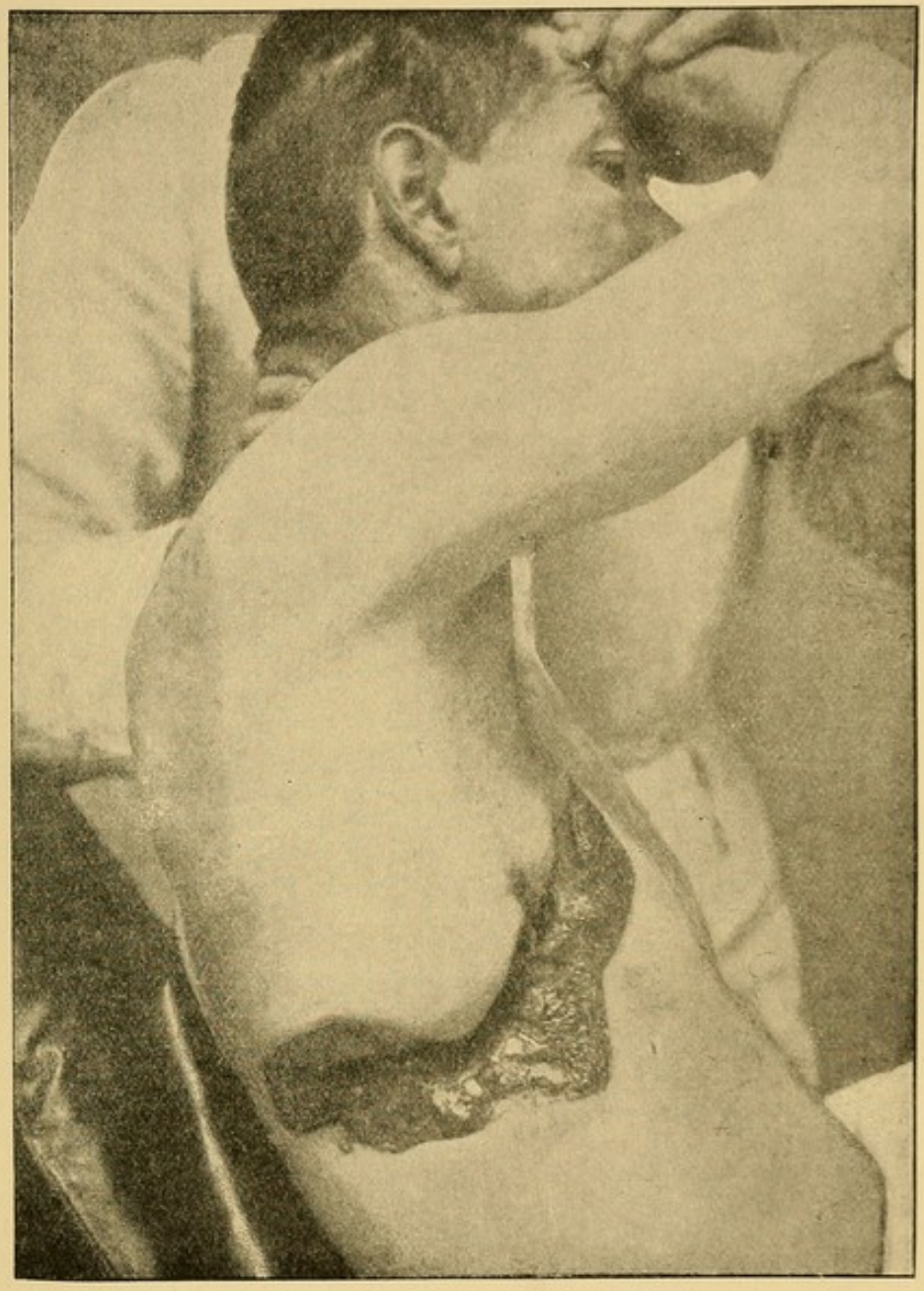


FIG. 77.—Thoracotomy with division of 9 ribs (3rd-11th) for fistula after empyema.

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.

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 high as the second rib, or as far as the preliminary exploration has shown that the cavity extends. The ribs and intercostal spaces are divided seriatim along this incision. If the cavity reaches as high as the first rib it also must be resected.

The dissection is now carried forwards from the first incision. The lower and 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, rib after rib 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 the subclavian vein may be torn, as happened to us recently notwithstanding all care. 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 occasionally 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. 77 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. The dense and thickened visceral pleura covering the collapsed lung is incised and stripped forward and backward off the lung until it expands again.

101. Transthoracic Laparotomy. Opening 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. 78, 79). Transthoracic laparotomy may be performed also in opening subphrenic abscesses.

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

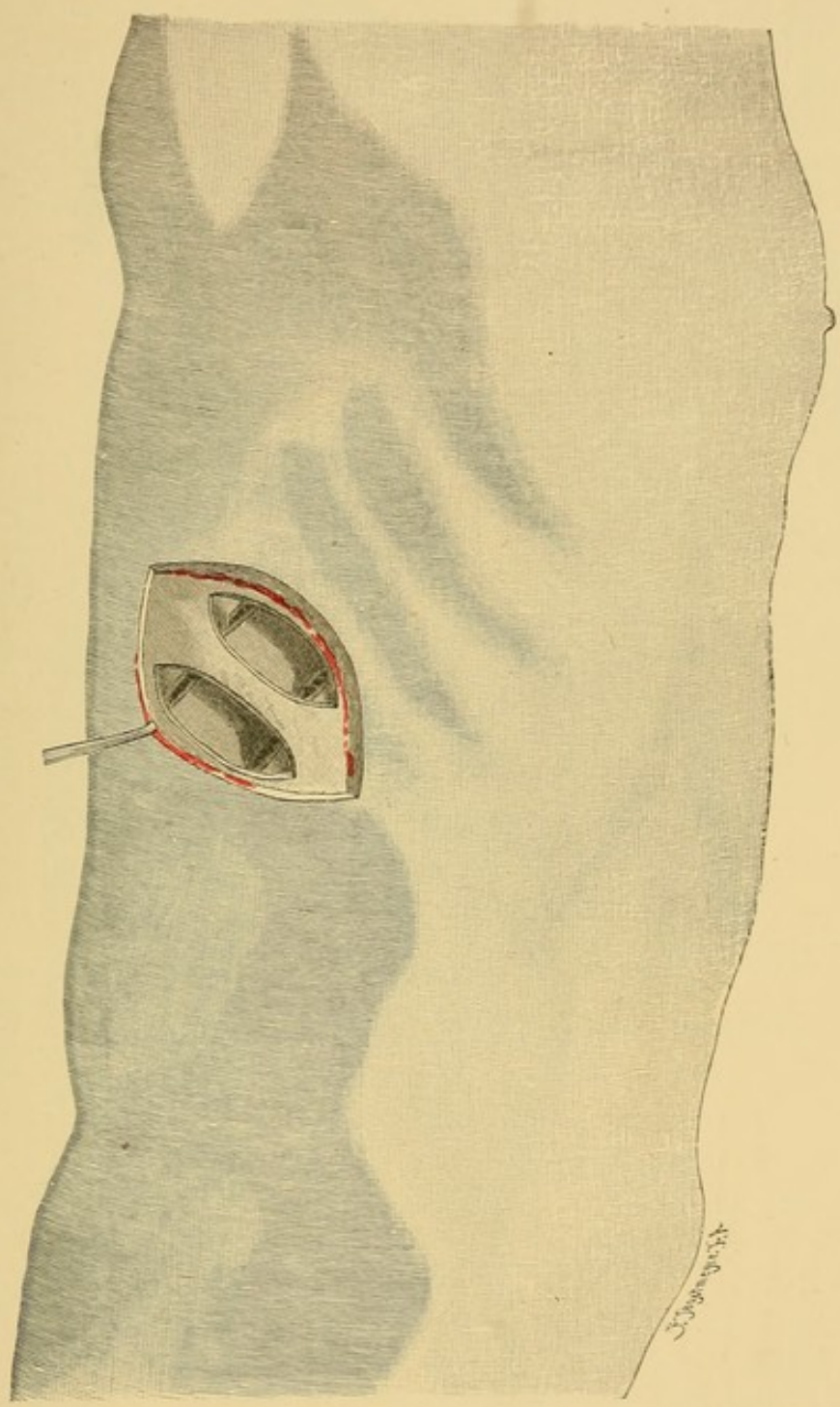


FIG. 78.—Exposure of the convex upper surface of the liver through the pleural cavity in the 8th intercostal space. The 8th and 9th ribs are resected subperiosteally through an incision along the 8th intercostal space.

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 4 cm. in diameter, can then be excised within the sutured area, and

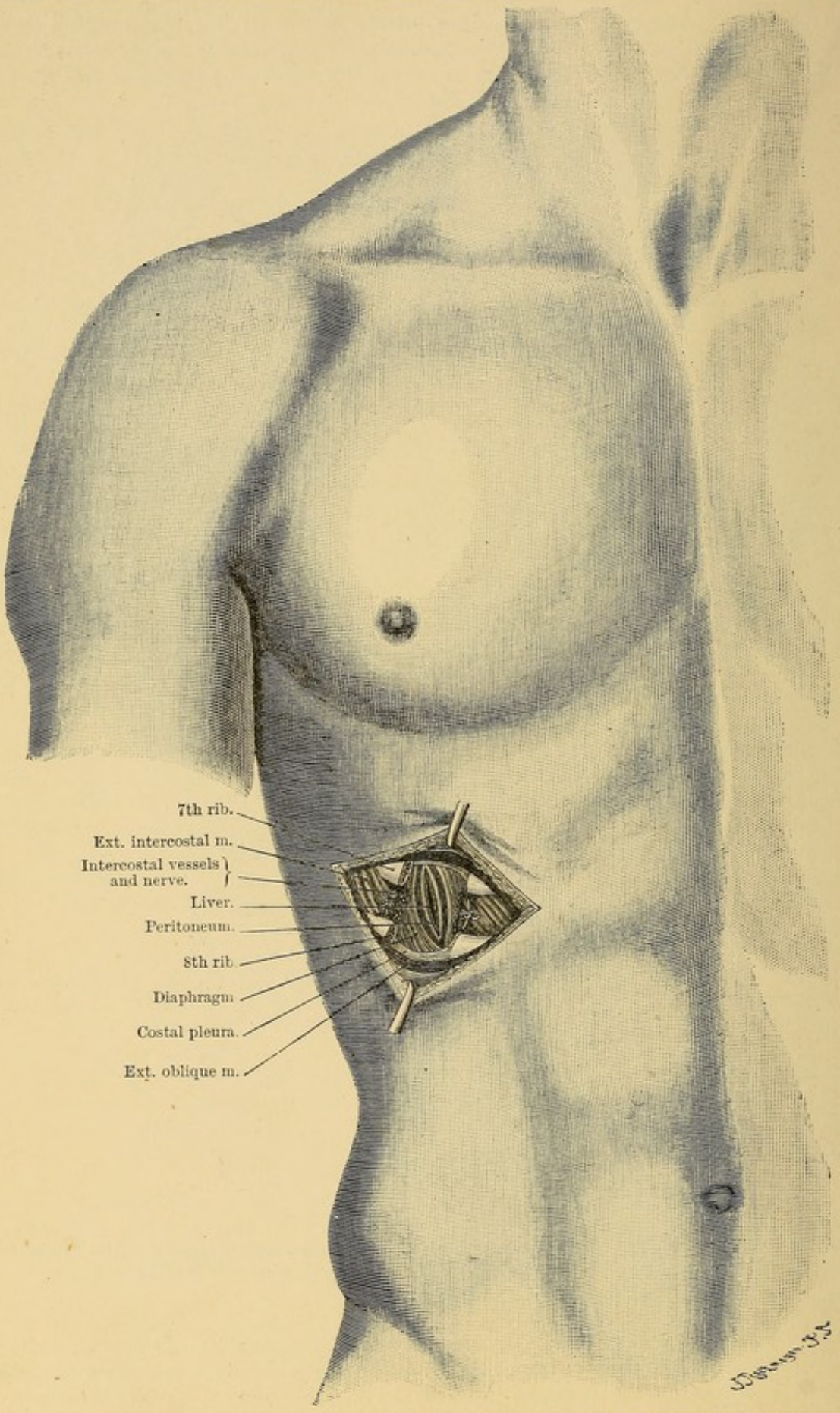


FIG. 79.—Exposure of the convex surface of the liver through the 7th intercostal space.

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 thermocautery if deeply situated—and the cavity is then stuffed with iodoform gauze.

102. The Surgery of the Lungs. Surgical interference on the lungs is at the present time practically limited to the evacuation of abscesses. It is almost always useless for tubercular cavities owing to the presence of tubercle in the neighbourhood, while in bronchiectasis its advantage is doubtful on account of the number of cavities. Tumours and hydatid cysts are, however, occasionally accessible to surgical interference. Whenever the presence of a circumscribed abscess has been diagnosed on physical examination, and when the bacteriological and histological characters of the pus have

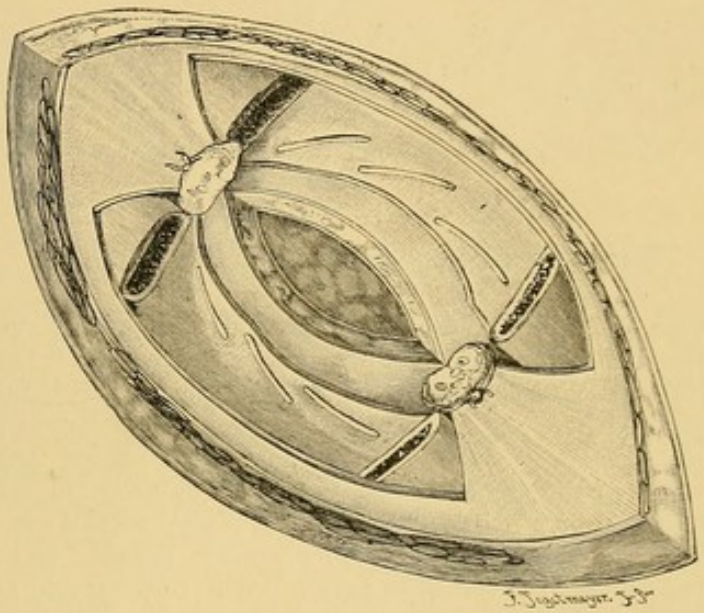


FIG. 80.—Transpleural exposure of the convex surface of the liver. The soft tissues of the intercostal space have been ligatured at the extremities of the divided ribs; the part between the ligatures has been cut away. The costal and diaphragmatic pleura are stitched together with a deep suture which 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 exposed.

shown that it is curable (elastic fibres are absent in bronchiectasis, while in phthisical cavities tubercle bacilli are present), Korte (see Borchert, Langenbeck's *Archiv*, Bd. lxiii.) recommends the following procedure: Chloroform is administered, but as two cases of asphyxia have been recorded, it is better to perform the entire operation, or at any rate the second part of it, under cocaine.

The soft parts are turned up in the form of a flap, with its convexity downwards, and the ribs are extensively resected over the abscess. The pleura is then opened, air being prevented from entering it by shutting off the area with a continuous suture. The sutures should not include too much of the lung, and should not be drawn too tightly; moreover, suppuration being present, they should, of course, consist of some absorbable material. The situation and depth of the abscess are ascertained by an exploratory puncture if palpation is not sufficient. In opening the abscess it is a good plan to use the thermo-cautery.

Hæmorrhage is the chief danger as large vessels often traverse the abscess. If it is impossible to ligature the vessel or to pass a suture beneath it, the cavity should

be stuffed with iodoform or xeroform gauze, which is also the best form of after-treatment.

To open cavities at their most frequent seat, namely, the apex of the lung, proceed as follows:—Carry an incision outwards from the inner end of the first intercostal space parallel to the clavicle. The skin, fascia, pectoralis major, and both intercostals are divided, but the internal mammary vessels internally, and the axillary vein externally, must not be injured. The periosteum having been divided at the lower border of the first rib and carefully detached, the lower two-thirds of the rib are resected, leaving a bridge towards its inner border so as not to injure the large vessels lying upon the rib. The position of the cavity is ascertained by an exploring syringe, and a small incision is then made through the pleura and widened with forceps.

Though surgical interference with the lung has met with so little success, statistics show (provided pneumothorax can be prevented) that we may in future expose the lungs with less timidity in cases of injury, foreign bodies, inflammatory conditions, and tumours.

According to the researches by Tuffier, Hallion, Qúenu, and Lorget, on exposing the lung, sudden pneumothorax can be prevented not only by accurate suturing of the visceral and parietal pleuræ, but also by inflating it artificially, by inspiring and expiring into compressed air.

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 Terrier and Raymond (translated and enlarged by Lardy and Beck) and of Braun. 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, to suture the wound in the heart.

103. Puncture of the Pericardium (pericardiocentesis). Puncture of the pericardium is now only performed for diagnostic purposes. Pericardiotomy is to be preferred for evacuating fluids. According to the researches by Ferrand and Voinitsch-Sianojentzky, fluid collects in the pericardium between the heart and the diaphragm, chiefly anteriorly and towards the apex when the patient is in the sitting posture; when the patient is in the recumbent posture it also collects between the

chest wall and the anterior surface of the heart towards its base, and round the large vessels.

In paracentesis of the pericardium we must avoid the internal mammary vessels, which lie 1 to 2 cm. from the edge of the sternum. If the puncture is made in the fourth or fifth intercostal space $2\frac{1}{4}$ ins. from the edge of the sternum, as recommended by Dieulafoy, the pleura will almost certainly be encountered, and occasionally the edge of the lung. If it is made in the fifth intercostal space (Baizeau) and directed upwards, the heart itself may be injured, as happened in West's fatal case. The best point at which to puncture is, therefore, in the sixth intercostal space, close to the edge of the sternum (Delorme, Mignon, and Voinitsch).

104. Pericardiotomy. Ollier led the way in opening the pericardium by resecting a costal cartilage, and it was he who had previously recommended resection of a rib as the best means of opening the pleural cavity. Larrey went in along the lower border of the seventh rib, between the chest wall and the diaphragm. We do not agree with Voinitsch (to whose valuable papers we owe so much) in considering it advisable to alter the method of operation according to the amount of fluid present. It is much more important to adopt one definite procedure which will suffice for all cases, because the operation is very rarely called for, and has to be done in an emergency. It is necessary, therefore, to know how to cut down upon and open the pericardium as rapidly as possible and with the least injury. In this way the urgent symptoms are combated, after which a more extensive opening may be made if necessary.

The interpleural space through which the pericardium can be reached without interfering with the pleura is, according to the careful investigations by Terrier and Raymond, very limited as well as very variable in position. All are agreed that the junction of the sixth costal cartilage with the sternum is the spot where, in the majority of cases, neither large vessels, pleura, nor lungs intervene between the chest wall and pericardium ; it is here, therefore, that the primary opening should as a rule be made. The sixth left costal cartilage is resected, and this should be the first step in the operation of pericardiotomy. Delorme and Mignon had previously proposed to remove the sixth costal cartilage, but they now remove the fifth also. Voinitsch removes also part of the seventh costal cartilage as well as part of the sternum.

Statistics show conclusively that in injuries to the heart the pleura is generally damaged as well, and contains extravasated blood, hence special care need not be taken to avoid injuring it. It is true, however, that the precise steps of the operation will depend on the site of the injury ; for example, the same procedure may not be equally suitable for a lesion of an auricle as for a lesion of a ventricle near the apex of the heart. But if, by a definite method, we are able to open the pericardium without interfering with the pleura, and if we can then extend the field of operation according to the nature and place of the injury, such a procedure certainly deserves the preference.

We have found in the cadaver that the following method enables one to meet the requirements : an angular incision is employed, the one limb passing down the middle line of the sternum, the other running outwards along the sixth left costal cartilage. Should a very large opening be required, the vertical limb may be prolonged as high as the second intercostal space, and the other limb along the upper border of the sixth rib, as far as the mammary line.

The periosteum of the sternum and the perichondrium of the sixth left costal cartilage are stripped back along with the pectoralis major until the elevator can be passed behind the costal cartilage, which is then divided with forceps close to the sternum. If still more exposure is desired, the periosteum of the sternum is stripped upwards along with the attachment of the pectoralis major, and the costal cartilages of the fifth, fourth, and third ribs should be exposed subperichondrially and divided. In the outer part of the incision the attachments of the pectoralis major and rectus abdominis are separated along the upper border of the sixth rib. The aponeurosis of the external intercostal muscle and the fibres of the internal intercostal muscle

along with the perichondrium are stripped off the cartilage. The triangularis sterni is thus exposed, with the internal mammary vessels lying on it. The tendinous attachments of this muscle to the sternum and the sixth costal cartilage are carefully divided, and the internal mammary artery and vein are ligatured if the branches passing towards the middle line are well developed. By passing the finger into the cavity left by the removal of the sixth rib, the tough glistening pericardium can be reached. If necessary, the pericardium can now be punctured or incised, or the edge of the pleura (to be distinguished by the pad of fat covering it) is pushed aside by the finger and raised from the pericardium. The intercostal muscle, along with the internal mammary vessels, is pushed aside with the pleura, as, according to Delorme and Mignon, it is firmly adherent to it.

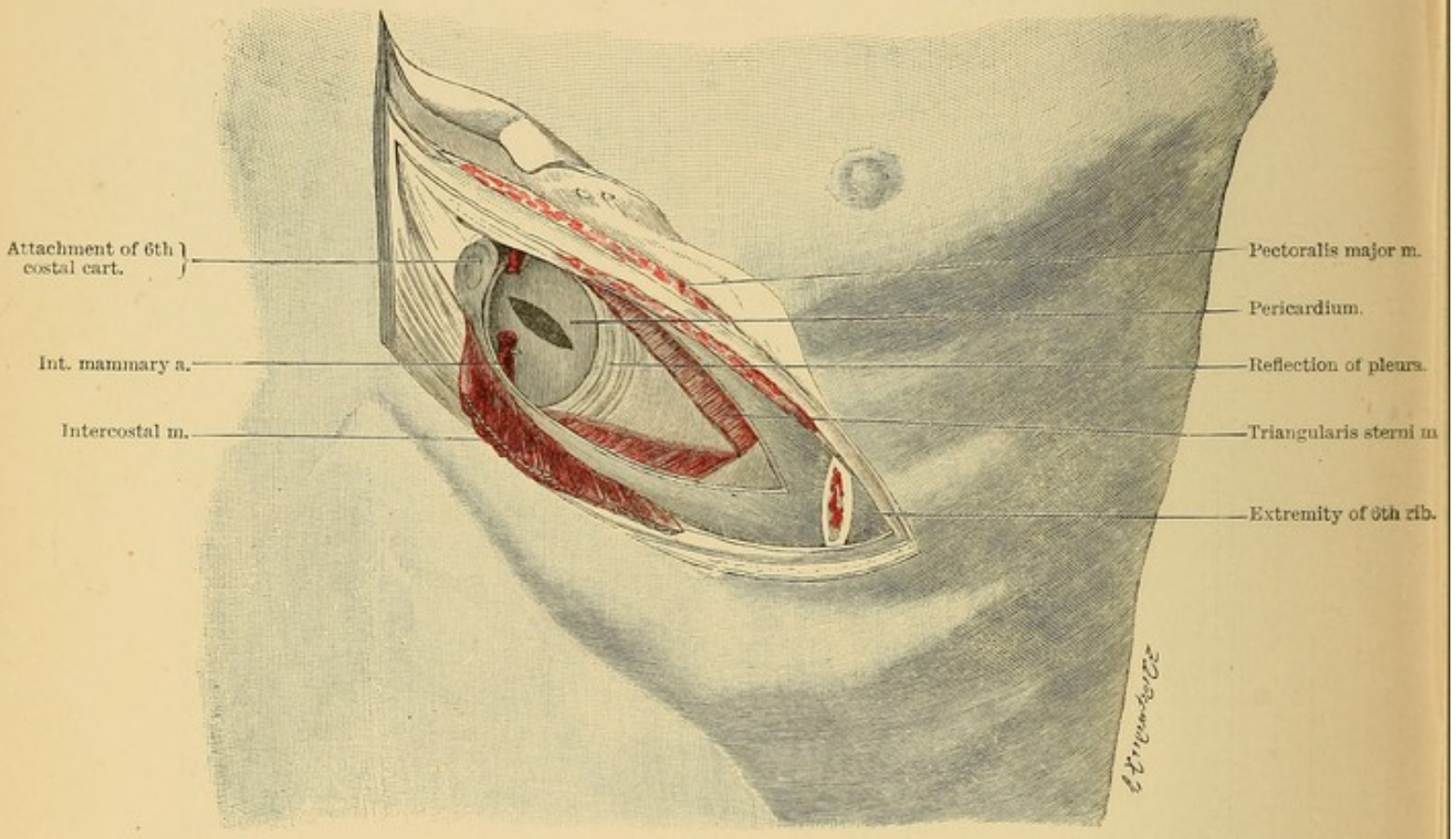


FIG. 81.—Opening the pericardium. The 6th costal cartilage has been entirely excised; the reflection of the pleura has been retracted outwards, after dividing the triangularis sterni. The internal mammary artery has been double ligatured and divided and the pericardium opened.

The fifth costal cartilage, and, if necessary, the third and fourth also, are gradually raised as their sternal attachments are divided, and at the same time the pleura is stripped back from their inner surfaces; unless this is done carefully the pleura is very liable to be torn. In this way the thin costal cartilages and the muscles attached to them are thrown upwards, and by wrenching the cartilages from their attachments to the ribs they can be folded backwards as one flap.

By dividing the pericardium along the edge of the sternum and outwards along the line of the fifth intercostal space, the heart can be inspected and palpated from the auricles down to the apex.

In Fig. 81 the sixth costal cartilage should be removed close to the sternum, the muscles should be separated from their attachments and not divided, and the triangularis sterni should not be separated from the pleura.

If enough room is not got by dislocating the costal cartilages, it is quite easy either to remove portions of the sternum (Durand) or to separate the pleura from its posterior surface, and to divide the sternum (subperiosteally) transversely above and below; by dislocating the right costal cartilages the flap of sternum can be folded over to the right side.

In urgent cases where it is important to expose the heart rapidly, we are of opinion that it is too serious a matter to begin to resect the sternum at once. There can be no doubt, however, that Podrèz's method of dividing the sternum in the middle line and throwing it over to the left side along with the left costal cartilages gives very good access, as also do the methods of Wehr, Rydygier, and Pagenstecher.

According to Ninni, Rotter has introduced a method which on principle particularly refrains from preserving the pleura, because this membrane is almost always implicated in the injury, and the removal of blood from it cannot, therefore, fail to be of use. The incision is similar to that of Wehr, and consists of a flap, the base of which is towards the right, but while Wehr divides the sternum above and below, Rotter leaves it intact. Rotter carries two incisions outwards for 4 to 5 ins., each commencing $\frac{3}{4}$ in. from the left edge of the sternum, the upper at the level of the lower border of the third rib, the lower at the lower border of the fifth rib. The outer extremities of these incisions, which extend right through the chest wall, are united by a vertical incision in the mammary line. The pleura is opened, and by dislocating the costal cartilages the flap is folded inwards, the fourth and fifth ribs having been divided through the vertical part of the incision and the intercostal arteries ligatured. The internal mammary artery is preserved.

As a matter of fact, surgeons who have had opportunities of operating on the heart have up till now not avoided injuring the pleura. Where an injury to the pleura has obviously occurred, *i.e.* when hæmothorax is present, Rotter's procedure must be considered, for it is a comparatively simple procedure. But, judging from our experience in other cases, it is still open to question whether free exposure of the pleura does not add considerably to the collapse which is already present. Moreover, in women the vertical limb of the incision is complicated by the presence of the mamma.

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 method. Rehn was the first to successfully suture the heart, and his case proved that the procedure may be the means of rescuing a person from certain death. Parozzanni and Pagenstecher have also reported successful cases. The latter surgeon was able to collect ten cases of heart suture with six recoveries (all in wounds of the ventricles). Farina was the first to attempt suture of the heart in the living subject, but his case was not successful. A study of the reported cases of heart suturing and of the numerous cases in which the heart has been exposed shows that many different procedures have been adopted.

When the operation is performed, not for wounds of the heart or the coronary arteries (which can be ligatured), but merely to expose the pericardium, *e.g.* in suppurative pericarditis, complicated and severe procedures must be avoided, and we should rest satisfied with resection of the sixth, and if necessary also the fifth, costal cartilages.

Infective exudative pericarditis, as well as all other suppurative conditions of the pericardium, constitute an absolute indication for pericardiotomy; as in suppurations elsewhere, mere puncture or expectant treatment is to be denounced.

A few words must be said regarding the treatment of the heart after it has been exposed. According to L. Braun, Heitler has recommended that the heart should be painted with cocaine before introducing the sutures, so as to prevent reflex arythmia. Longo prefers catching the wound with toothed forceps and holding the edges together. Rehn leaves the first suture long so as to facilitate the introduction of the others.

There are still three other directions in which the surgery of the heart has tended to develop, viz. massage, cardiocentesis, and cardiolysis.

Tuffier has exposed and massaged the heart of an animal for paralysis after anæsthesia, and for syncope resulting from embolism.

Watson, Senn, Bergouin, 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 of distension of the right side of the heart. The procedure has also been employed in the human subject.

In "adherent pericardium" Delorme exposes the heart and separates the adhesions between it and the pericardium with the hand. We have endeavoured to perform a similar operation on the cadaver, but in spite of the utmost care the heart was torn.

M. THE BACK

105. Ligature of the Posterior Scapular Artery (Fig. 82). 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 the artery will be found upon its under surface passing backwards from the transversalis colli artery. 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. At the level of the middle of the infraspinous fossa the artery will be found by making an incision along the inner border of the scapula (Fig. 105). At the upper angle of the incision is the oblique lower edge of the trapezius muscle. On detaching 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.

106. Suprascapular Nerve. An incision is carried upwards and inwards through the skin and fascia from the root of the acromion towards the vertebra prominens. The trapezius is divided in the direction of its fibres. The supraspinatus muscle is separated from the spine of the scapula up to the suprascapular notch, where the nerve will be found lying upon the bone.

107. The Dorsalis Scapulæ Artery from behind. The incision is made along the upper border of the latissimus dorsi, which can be defined by palpation a little behind and above the posterior axillary fold. After dividing the skin and fascia, the upper borders of the latissimus dorsi and teres major come into view, and the lower border of the teres minor is seen at the axillary border of the scapula. The artery will be found at the inner border of the long head of the triceps by exposing the lower margin of the teres minor two finger-breadths below the humerus.

108. Surgery of the Posterior Mediastinum. It is chiefly the posterior mediastinum and the organs contained in it, especially the œsophagus, which have been subjected to surgical interference.

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 it; 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 going in 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

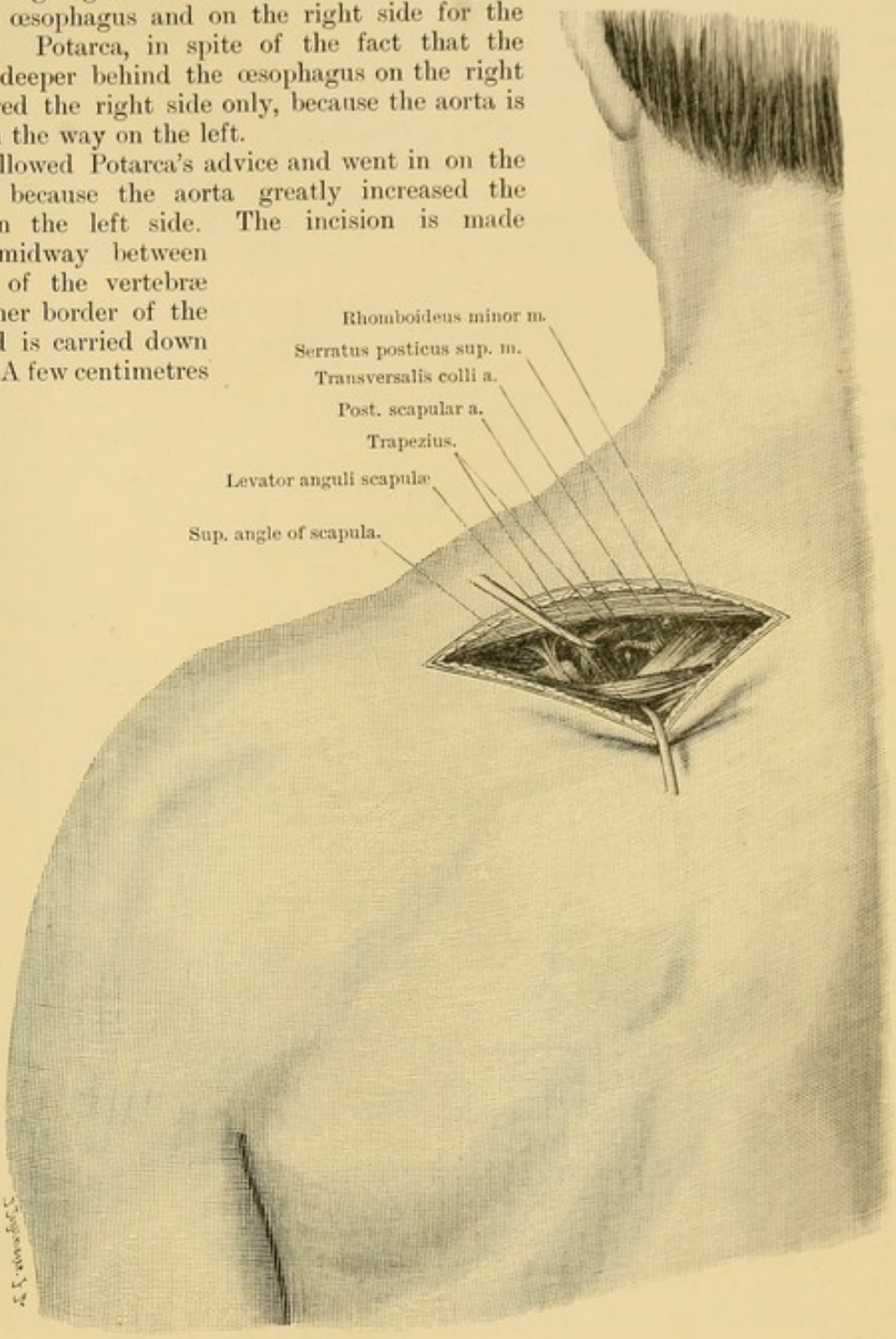


FIG. 82.—Ligature of the posterior scapular artery.

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.

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 Faraboeuf 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

[1] *Transactions of the American Surgical Association*, 1895.

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 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.

109. Opening of the Anterior Mediastinum. Part of the sternum is resected, the amount varying in size with the extent of the disease. We have resected the sternum on many occasions, chiefly for the removal of metastatic growths secondary to malignant goitres. They always involved the manubrium sterni. On one occasion resection was performed for tuberculosis, on another for hæmorrhage from the innominate artery. We adopted the procedure of Bardenheuer, but were satisfied with merely disarticulating at the sterno-clavicular articulation. Bardenheuer makes a transverse incision at the upper margin of the manubrium, and a longitudinal one downwards over the same bone. He then divides the clavicle and the first two ribs subperiosteally on both sides 3 or 4 cm. from the margin of the sternum, separates the periosteum from the deep aspect of the latter, and divides it vertically.

Giordano has devised the following osteoplastic operation :—He makes a longitudinal incision to the right of the sternum and divides the costal cartilages after carefully separating them from the pleura. A transverse incision is then made above and below, the pleura is pushed back, and the sternum divided transversely in both places. This bone flap is reflected, the costo-sternal articulations of the left side being luxated.

Milton's is the most radical procedure. He makes a longitudinal incision down the whole length of the middle of the sternum and detaches the xiphoid cartilage and the ligamentous attachments in the region of the suprasternal notch. The two halves of the sternum are then pulled apart by means of powerful hooks. His patient, who suffered from tuberculosis of the sternum, made a good recovery.

110. Opening of the Spinal Canal. Laminectomy. Puncture of the lumbar region of the spinal canal, the introduction of which is due to Quincke, is of growing import-

ance, although the latest indication for its use, namely, for medullary anæsthesia, has proved unsatisfactory by the means hitherto employed.

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.

The brilliant operations of Horsley have shown what excellent results can be attained, even in very advanced cases, by removing the pressure upon the spinal cord caused by tumours; and other surgeons have produced effects no less satisfactory by the removal of pressure caused by fractures and dislocations of the vertebræ or by the opening of abscesses.

The operation is performed in the following manner:—A long median incision is made over the vertebral spines, and the muscles on either side (semispinales and multifidæ spinæ) are separated with the knife close to the bone. The strong fascia covering the muscles may, if necessary, be nicked transversely. The exposed spines are cut through at their bases with bone forceps, and removed together with the interspinous ligaments. The laminæ are removed by first dividing the ligamenta subflava transversely close to their upper and lower edges, and then snipping through the laminæ on both sides, and levering them out one after the other until the spinal cord is sufficiently exposed. The fatty tissue is pushed aside. The large spinal veins are cut across after being ligatured on either side, and the dura is divided in the middle line. The dura is, of course, not opened when it is merely a case of pressure from a displaced or fractured vertebra, or an extradural tumour or abscess.

In cases in which the dura has been opened it is to be accurately sutured. Complete primary union should result within forty-eight hours.

N. REGION OF THE LOIN

111. Nephrotomy (Fig. 83). Nephrotomy is performed in cases of floating kidney in order to moor it to skin and fascia, to open the pelvis of the kidney and the renal calyces in cases of hydro- and pyonephrosis, for nephrolithiasis, and for neoplasms. A very important indication for nephrotomy has been recently introduced, namely, for the relief of tension. Thanks to mistaken diagnosis, Reginald Harrison, first in 1878, and again in 1896, established the fact that in acute nephritis with increased tension and induration of the kidney an incision into it was followed not only by disappearance of the pain, and of the blood and albumen in the urine, but also that the condition of the other kidney was much improved by the diminution of the functional demands made upon it. Korteweg has quite recently stated that any engorgement of the kidney, such,

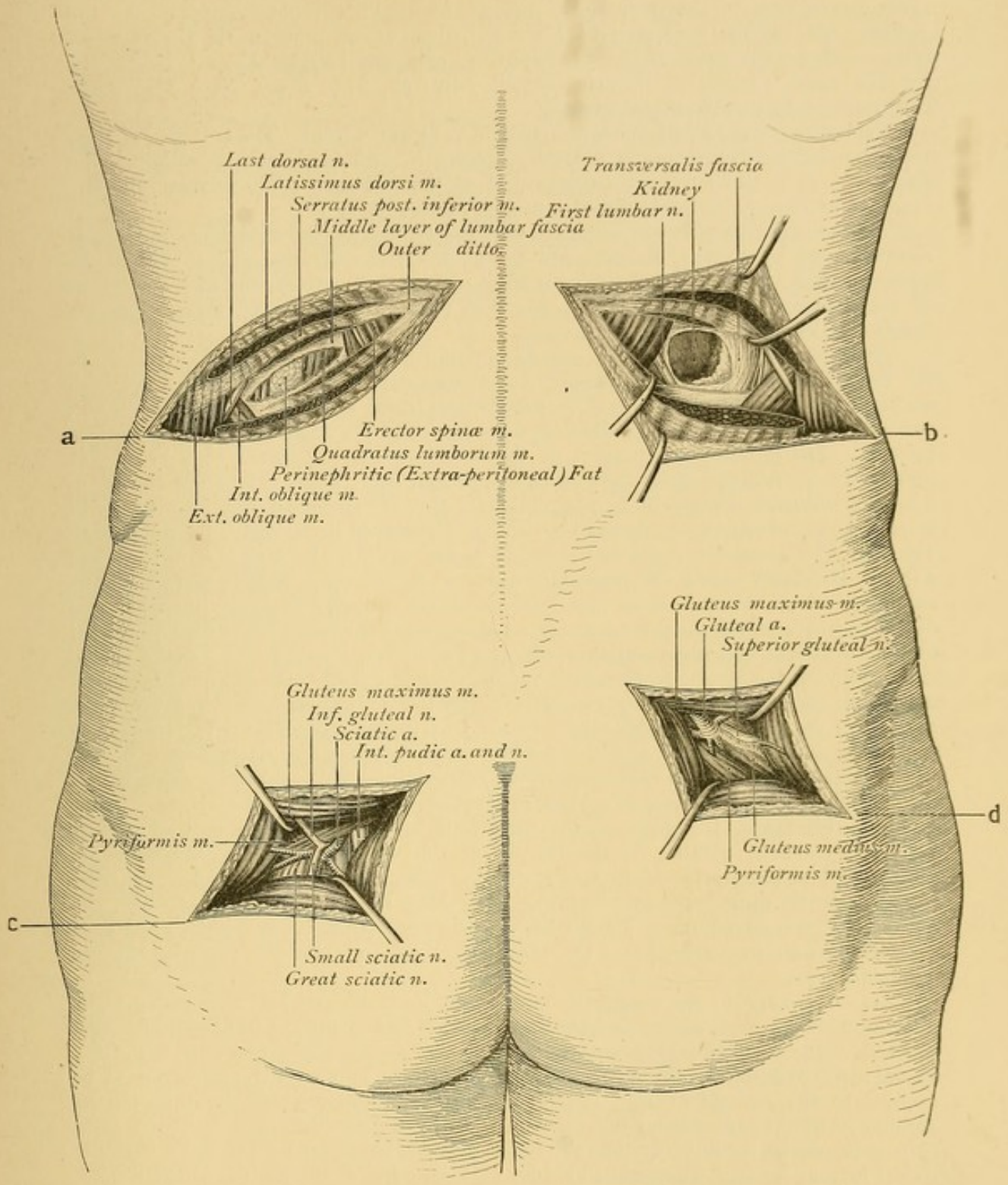


FIG. 83.—(*a*) and (*b*) Nephrotomy. (*c*) Ligature of the sciatic and internal pudic arteries; exposure of the great sciatic, small sciatic, and pudic nerves. (*d*) Ligature of the gluteal artery and exposure of the superior gluteal nerve.

for instance, as may occur from increased pressure in the ureter and renal pelvis, may lead to a sort of strangulation as the result of venous congestion. This may cause anuria, and, on account of the sympathetic connection of the two kidneys, the second

kidney may also be threatened with engorgement. Pain in the loin, high remitting fever, diminution in the quantity of urine, and slight anæmic symptoms, are the definite signs which, according to Korteweg, demand an incision for the relief of tension, whereas in cases of chronic nephritis, pain and hæmorrhage are indications for the same procedure. Israel, Guyon, Albarran, and Braak have also made contributions to this important question.

Nephrotomy can be performed from behind or from the front. The anterior incision, recommended by Bergmann, is generally known as the lateral incision, although the chief part of it lies on the anterior aspect of the abdomen. The angular and flap incisions of König and Bardenheuer cause too much injury.

For the majority of cases of simple nephrotomy the posterior oblique incision, as recommended by Czerny, Küster, and Braun, is quite sufficient, and should be regarded as the normal incision in the lumbar region, as it corresponds with the course of the vessels and nerves and gives the best access to the deeper parts. Simon's longitudinal incision gives too little room.

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 (under which is the quadratus lumborum) and the posterior edges of the oblique abdominal muscles, the muscles themselves being left uninjured. After dividing this fascia, 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. It is only in cases of floating kidney that pressure must be applied to the abdominal wall from the front. In nephroraphy the thin fibrous *capsula propria* of the kidney is incised and stripped from the organ, so that a good grip of it may be included by the four to six sutures which are used to unite it firmly to the lumbar fascia. The exposed kidney substance lies at the bottom of the wound, which is left open in order that the firm scar tissue may extend from the skin to the kidney substance. The nerves already mentioned must not be included in the suture.

When the pelvis of the kidney is dilated an incision is made directly into it from behind. This succeeds admirably in cases where foreign bodies (calculi) have to be removed, or where a ureteroplastic operation is proposed after opening the pelvis, as, for example, in cases of hydronephrosis where the opening into the ureter is unfavourably situated. If the pelvis cannot afterwards be sutured a fistula is very apt to form.

When there is danger of a fistula being formed, or when there is no need to make an extensive opening into the pelvis, it is preferable to obtain access to it from the convexity of the kidney by a short longitudinal incision, through which the finger can be passed in the direction of the hilus. It is most desirable that such a longitudinal incision into the convexity of the kidney ("Tuffier's sectionsschnitt") should not be made too long.

Zondeck has demonstrated, by means of beautifully injected preparations, that the incision should be made slightly on the dorsal aspect of the convex border, in order to avoid the anterior and posterior vascular areas as much as possible. If this is not attended to dangerous hæmorrhage may occur. In a case which we saw in the practice of one of our colleagues, the patient died as the result of an incision into a healthy kidney. It is advisable to ligature large vessels which are cut in incising the kidney substance.

When the kidney substance has been interfered with, it is desirable to treat the wound by the open method, or to use a secondary suture, not only on account of the escape of urine, but because it has been our own experience, as well as Dr. Tavel's, that the surrounding tissues are readily infected in kidney injuries. The kidneys generally harbour and excrete micro-organisms which give rise to inflammation. It is well, therefore, to give such patients a course of salol (45 grains a day) before the operation. The wound in the kidney, on the other hand, should be very carefully closed, unless this is contraindicated by the infective nature of the contents of the pelvis or parenchyma of the kidney. Careful suturing is the best means of arresting the hæmorrhage. If infection be present, a tampon is inserted down to the pelvis of the kidney, or better, a drain is introduced after thoroughly washing out the pelvis with sterile salt solution. The drain should be surrounded with xeroform gauze, and fixed in position with a strip of gauze and collodion. The outer dressings should be frequently changed.

112. Nephroraphy or Nephropexy. The incision employed is that described in paragraph 111 and illustrated in Fig. 83. After division of the lumbar fascia the outer capsule of the kidney, frequently very fatty, is exposed. It is best to grasp the fat in large pieces with artery forceps, and to pull on it forcibly so as to bring the kidney into the wound. The assistant presses on the ventral surface of the abdomen so as to bring the kidney—which is often much displaced when the patient is lying on one side—within reach. The surgeon seizes the capsule of the kidney with forceps and drags it upwards, then catches it with a second pair lower down, and so on till the kidney has been drawn upwards as far as possible.

A curved needle is now passed through the lumbar aponeurosis and through the capsule of the kidney where the lowest pair of forceps is attached. The capsule proper, together with the fatty capsule, is then fixed, and with it the kidney. The renal capsule is now incised upwards and artery forceps are applied to both edges, each cut edge of the capsule being then united to the lumbar aponeurosis with five to seven sutures. If, at the beginning of the operation, the fatty capsule has been pulled up and the renal capsule proper sufficiently incised, an area of kidney substance about 2 ins. in diameter is exposed in the deeper part of the wound, and after the sutures have been put in as above described, it can be demonstrated that the kidney is no longer pushed down during inspiration. The capsule is separated up a little farther in all directions, xeroform gauze introduced, and the wound packed. The skin, which may be provisionally closed over the packing, is covered with xeroform gauze and collodion, and over this an antiseptic dressing is applied, which is changed after eight days.

It is essential that the cicatrisation which follows should involve a considerable area of the kidney substance itself, for it is only in this way that we can guarantee a certain and permanent fixation. This, however, may be attained by the plan above described. The endeavour to obtain union by first intention has given us much less satisfactory results than has the open method of treating the wound. The wound is

completely healed in six weeks. It is useless to pass the sutures through the kidney substance, as they always cut their way out.

113. Nephrectomy (Simon's Operation). One kidney may be removed when it is the seat of a malignant neoplasm or other disease which endangers or prejudices the life of the individual, as in infective processes, especially in tuberculous and suppurative affections of the kidney. Total extirpation of the kidney should only be performed after it has been clearly proved that the other kidney is capable of satisfactorily performing the double function.

In nephrectomy we have for years past adhered to the practice of dividing the transversalis muscle as far forwards as to expose the reflection of the peritoneum on to the colon in the region of the posterior axillary line, and at this point to open the peritoneum. The incision, therefore, is almost the same as Bergmann's, which runs downwards from the twelfth rib behind to the middle third of Poupart's ligament. Such an incision is only required in the case of large tumours. We have always succeeded in passing the hand through this opening far enough into the abdominal cavity to be able to touch the opposite kidney and form an opinion regarding its size and consistence, and also to feel the renal artery. The under surface of the liver and the region of the gall-bladder can also be palpated, a step which is often desirable in order to settle the diagnosis. After having ascertained the presence of a well-developed kidney on the other side, the peritoneum is closed with a fine continuous silk suture. Undoubtedly the method of direct palpation gives a certain assurance as to the condition of the other kidney if careful attention be paid to the size and condition of the renal artery. But in very fatty individuals considerable damage may be done by introducing the hand.

Quite recently, by the introduction of the kryoscope, we have been provided with a much more convenient means of judging of the condition of the other kidney. To Koranyi is due the credit of having shown that the determination of the molecular concentration (*i.e.* the freezing-point) for blood and urine gives us a definite clue to the functional capability of the kidney. If the freezing-point of the *blood* (normal 0·56) does not sink *below* 0·58, the molecular concentration of the blood is not abnormal, and the products of the decomposition of albumen are being satisfactorily excreted, as shown by the researches of Kasper, Kümmel, and others. If the freezing-point of the *urine* be not *higher* than 0·9 (normal 1·0 to 2·0) it contains enough organic molecular constituents for the excretory function of the kidney to be considered satisfactory. One healthy kidney functionates at once just as well as the pair. To obtain information as to the secretion of the individual kidney, catheterisation of the ureter may be employed, but this should be limited as far as possible to the diseased side.

The method of removing the kidney depends on the disease. If possible, the kidney is freed *in toto* after all the large vessels entering the capsule have been carefully ligatured, and the structures at the hilus are then carefully isolated. Tumours, even the size of the fist, can be removed from behind. The ureter, which lies lowest, is ligatured last, the renal artery and vein being first firmly tied, by the use of an aneurism needle and several strands of silk.

Where suppuration is present, or where infective processes exist (as in tuberculosis), it is better to employ catgut. When the kidney is freed, except for its attachment to the ureter, the latter is tied in two places and divided with the thermo-cautery if there be any chance of its containing infective material. In this case, unless it can be completely extirpated, it is stitched to the wound. In cases of tuberculosis great good may be done to the secondary cystitis, when this is present, by injecting iodoform emulsion along the ureter. Excision of the ureter is, however, preferable. We have had excellent results from this method. The wound is closed, two short glass tubes being introduced for twenty-four hours.

For very large renal tumours the lumbar incision is not suitable. In this case recourse must be had to Bergmann's anterior oblique incision, which extends from the apex of the twelfth rib (or it may require to be the eleventh, or even farther

forward still) to the middle third of Poupart's ligament. This is also the proper incision when the kidney is dislocated downwards, or when it is proposed to excise the ureter at the same time.

The external oblique muscle is split along the course of its fibres, but the incision is not carried through the second muscular layer. The fibres of the internal oblique are separated with a blunt dissector, and, along with the nerves of supply, are drawn apart with broad retractors. The same is done with the transversalis muscle. After the transversalis fascia has been divided, the peritoneum external to the colon is exposed and raised with the fingers from the posterior abdominal wall as far as the vertebral column. In doing this the ureter, which is raised along with the colon and easily recognised, can be followed upwards as far as the pelvis of the kidney and downwards into the pelvis. Above, the kidney can be shelled out from its fatty and fibrous capsule. In operating for tumours it is important to strip the capsule off entirely, for otherwise they cannot be got out. If the renal capsule is very fatty its separation is often attended with considerable hæmorrhage, and also after the fibrous capsule has been separated it is often necessary to plug and wait for a few minutes. One is often glad, after the tumour has been freed, to be able to apply a ligature including all the structures forming the pedicle, as the space is too limited to allow of the various constituents being isolated.

114. 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 dividing 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.

115. Ureterotomy and Ureterectomy—*a. Anterior Ureterotomy.*—The lateral incision (Bergmann's) is employed, *i.e.* an incision similar to that for ligaturing the common iliac artery. We have excised the ureter by this method in a case of tuberculosis of the ureter which had been diagnosed by vaginal palpation. An incision is made three finger-breadths above the outer two-thirds of Poupart's ligament, its outer extremity being continued vertically upwards, as for exposure of the common iliac artery. Skin, superficial fascia, and the aponeurosis of the external oblique are divided. In the vertical part of the incision the muscular fibres of the external oblique, together with those of the two deeper muscles, and especially those of the strong internal oblique, are separated and forcibly pulled apart with blunt retractors.

The fascia transversalis is then divided, and the peritoneum, which is not to be opened, is now stripped off the iliac fossa as far as the psoas. This is easy when there are no abnormal adhesions. The external cutaneous nerve lying on the iliacus muscle, and the iliac vessels on the psoas, remain undisturbed. The ureter may readily be recognised as it descends in front of the common iliac artery into the true pelvis towards the lateral part of the base of the bladder. It is still easier to follow it upwards external to the vertebral column. As the ureter by this method can be exposed from the kidney to the bladder, and as the kidney may, when necessary, be excised at the same time (as was done in the above case), we regard this procedure as the best for diffuse disease: it allows of excision of the ureter in its whole extent. Anterior ureterotomy gives the best access also for merely incising the ureter; for example, for the purpose of removing an impacted calculus the exact situation of which cannot be made out with certainty.

b. Posterior Ureterotomy. The upper part of the ureter can be well exposed by an incision similar to that given for nephrotomy (Fig. 83), except that it is placed more nearly vertically.

c. Inferior Ureterotomy. The lowest part of the ureter near its termination in the bladder can be exposed by the parasacral incision as described for excision of the rectum. It can also be reached from the perinæum by the curved prerectal incision,

as will be described later for the exposure of the prostate and the base of the bladder, or by means of Roux's paramedian sagittal incision.

116. Splenectomy.—The spleen may be exposed in a manner similar to that of the kidney by prolonging forwards the incision on the left side. We give no complete description of the operation, which necessarily varies very much in different cases, being influenced more especially by the size and nature of the tumour.

O. ABDOMEN

Celiotomy (Laparotomy)

117. 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.

It is every day becoming a more pressing necessity that practitioners should recognise the almost absolute safety of opening the abdomen, provided that the operation be performed by an experienced surgeon and that the patient be otherwise healthy. We should then no longer have to complain 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 only come for surgical treatment when the presence of numberless 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 no exact diagnosis has been arrived at (as in all cases of ileus), or where there is a suspicion of a malignant growth in the stomach or intestines, the culpable procrastination of the practitioner should, in the present state of abdominal surgery, cease, and 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 to the patient the certainty of a satisfactory result by non-operative treatment. It is not necessary that all medical men in practice should undertake the necessary surgical treatment, 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.

To open into the peritoneal cavity was, till recently, looked upon 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

is often the best and most speedy mode of bringing about recovery, provided that the principal part of the operation is performed on healthy peritoneum.

To open the peritoneal cavity only exposes the patient to serious danger 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, 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. How best to proceed under the circumstances to save an apparently hopeless case is shortly stated below.

We must now consider a few of the secrets of success in laparotomy.

1. Correct posturing of the patient. This is easily provided for in operations in the region of the hypogastrium and pelvis by means of the "Trendelenburg position." This position is of no use for operation in the region of the epigastrium and mesogastrium, and the reverse position is not permissible on account of the danger it adds to anæsthesia. In these latter cases local elevation by raising the back greatly facilitates matters (in stomach, gall-bladder, and kidney operations). It is essential that a heated table should be used to keep the body warm.[1]

2. 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 can a movable appendix, an ovarian tumour, a movable tumour of the intestine, or a gall-bladder, etc., the incision must be of sufficient size.

3. As soon as the abdominal cavity has been opened, the healthy regions of the abdomen should be shut off from the diseased parts on which the operation is to be carried out. This should be done by packing with gauze. The introduction, through a sufficiently large external wound, of hot, sterile, soft gauze compresses, wrung out of a ·8 per cent salt solution, so as to shut off the field of operation, ensures against the harm which results, especially in septic cases, from the escape of gastro-intestinal contents, bile, urine, or infective inflammatory products.

4. 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 irrigation, or by applying compresses and gutta-percha tissue over them.

5. Complete 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 such a toxic action on the peritoneum, xeroform or some other non-toxic antiseptic should be preferred.

6. Prevention of any collection of blood or effusion into the wound by most careful arrest of hæmorrhage, no matter how long the time required to effect this, and by careful suture of every injured surface of the peritoneum. This is a most 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

[1] Henle has shown by the statistics of a large number of authenticated cases how frequently pneumonia follows laparotomy; 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 it.

[2] See remarks on previous page.

omentum gradually becomes covered over with epithelium which grows in from the edges of the opening.

7. Careful suture of every cut or tear in the peritoneum, and complete closure of the main wound in every case when there is no question of draining away infective fluids.

118. 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.

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. Pfannenstiel, in cases where a large incision is unnecessary, has endeavoured to avoid both disadvantages by his "transverse incision above the symphysis." He makes his 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 he 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 now 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, and so forms 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 taken away. But we may go still farther, and say that those who cannot bring themselves to employ permanent sutures, and 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.

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 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 cicatrical tissue round it that it is much better to include it along with the aponeurosis of the linea alba.

In the latter case, and always when the aponeurosis (which forms the chief support to the abdominal wall against hernia) is sutured alone, permanent sutures should be used—either silk or metal. To most people metal sutures left in per-

manently 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 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. 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. 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.

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 not dividing the muscles at all, 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 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. 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.

We consider that Lennander's incision is specially indicated in place of the mesial incision where there is marked separation of the recti, the muscles being afterwards approximated by mesial sutures.

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, just as one would turn over a door upon its hinges.

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

[1] Pfannenstiel declares that the "French" introduced this substance. It was Socin, in conjunction with Hägler, who introduced it into practice.

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: 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.

119. Laparotomy in Cases of Peritonitis. Where an exudate which can be demonstrated clinically has formed in the peritoneal cavity, the only certain way of preventing extension of the inflammatory effusion is by early operation.[1] When exploring the deeper parts in such conditions it is quite unnecessary to use any other than the normal incision with splitting of the muscles. According to Burney's method all circumscribed abscesses, both those with fluid contents and those in which there is merely a free inflammatory exudate, can in this way be thoroughly evacuated and drained through a small incision.

Difficulty is first apparent in the treatment of peritonitis when numerous small or large abscesses surrounded by fibrous adhesions have formed in different parts of the peritoneal cavity. Many cases have been recorded of satisfactory results in so-called diffuse peritonitis, which, however, were not diffuse in the sense that the whole peritoneal cavity up to the diaphragm was involved, but which represented merely encapsulated inflammations occupying a large area of the peritoneum.

There is only one certain means of dealing with such diffuse forms with numerous encapsulated foci of infection, and that is by prophylactic treatment. A circumscribed abscess may lead to multiple abscess-formation either by the spread of the infective material or by perforation, or an *a priori* diffuse peritonitis with fluid exudate may lead to multiple suppurative areas by the pouring out of fibrin and the formation of adhesions. The only way to prevent this extension is to treat every attack of inflammation at its commencement on surgical principles, *i.e.* to open and remove the infective material. In this respect the advocates of immediate operation in early cases of perforative appendicitis are undoubtedly right, as a definite percentage of the cases in which expectant treatment is employed in preference to immediate operation must be lost from peritonitis. When an incision is at once made, as advocated by Bernays, Rehn, and others, and the source of infection removed, although death cannot be avoided in every case, yet, as Bernays has proved, the results, if all the cases be taken into account, are better than those where expectant treatment is employed.

In peritonitis which is diffuse from the outset, with a fluid exudate, it is quite justifiable, after the cause has been removed, to make a median incision, and to thoroughly irrigate the peritoneal cavity with physiological salt solution at the body temperature for as long a period as may be required.

For diffuse peritonitis with multiple encapsulated abscesses, not only between the intestinal coils, but also between the liver, spleen, and diaphragm, a long laparotomy incision is indicated so that free access may be gained to all the abscesses. But such a long incision is attended with danger from shock, the result of injury to the hyperæsthetic peritoneum; it reflexly inhibits or paralyses the vasomotor centre, and, by a direct action on the abdominal vessels, increases the venous hyperæmia in the abdomen, and with it the secondary cerebral anæmia.

In the prevention of shock one important factor is the inclined position of the body, a second is the use of physiological salt solution at the proper temperature for washing the abdominal contents, and a third is the use of narcotics.[2] In shock it is customary to dread the use of an anæsthetic, because chloroform, and even ether,

[1] As a very efficacious means of preventing the spread of peritonitis to the upper part of the abdominal cavity, Fowler recommends that the patient should be placed in an inclined position with the upper part of the body raised. That this position is of value has been shown by gynæcologists in cases of vaginal extirpation of the uterus, where, in spite of only partial asepsis, good results are obtained, thanks to the excellent drainage obtained.

[2] According to a private letter Cirle succeeded in counteracting shock very successfully by compression.

finally leads to paralysis of the vasomotor centre. Evidence is gradually accumulating, however, to show that shock is best prevented by the use of anæsthesia. The observations of Cushing, Cirle, and others point in this direction (injection of cocaine into the trunks of nerves before dividing them). A sufficient quantity of morphia, injected hypodermically (this being the method of administration which affects the circulation least), followed by narcosis with a definitely diluted mixture of ether (Braun), has been advised. How far the painting on of a very dilute cocaine solution can be borne (Schleich's weakest solution) remains undecided.

In peritonitis it seems to be important to empty the intestines by washing them thoroughly out through an opening above and below in order to prevent absorption of toxic products from the intestines, and to keep them empty by the administration of magnesium sulphate. Further, after the operation, hyperæmia of the abdominal organs should be reduced as much as possible by proper posturing of the patient, combined with the application of ice and compression of the abdomen.

A matter of great importance in the treatment of peritonitis is to drain off all inflammatory products and infective material. For this purpose the insertion of one drainage tube is not to be considered sufficient. Each area of suppuration must be opened and drained. If this be done it will be found unnecessary to irrigate in cases of diffuse multiple collections of pus, and the resulting shock is much less.

120. Laparotomy in Tuberculous Peritonitis. In tuberculous peritonitis a free incision may be made in the middle line, for in this case the shock is not nearly so severe as in acute peritonitis. If the operation is to be of any use there must be room not only to empty out the fluid exudate, but also to remove the caseous foci, and especially to determine the original seat of disease and to remove the organs involved (in the female these are very often the Fallopian tubes). Under these conditions the operative treatment of tuberculous peritonitis often gives unexpectedly satisfactory results. Dr. Lauper has published the results of our own operations.

121. Laparotomy and Omento- and Splenopexy for Ascites (Drummond-Morrison-Talma operation). When ascites is caused by hindrance to the return of venous blood through the portal vein, it can be cured by providing new anastomoses for the venous channels leading to the portal vein. Tillmann put the operation on an experimental footing. It consists in opening the abdomen in the middle line, and after evacuating the fluid and, if necessary, introducing a drain, in fixing the omentum, the spleen, or the liver to, or in, the abdominal wall. The peritoneal surfaces, between which it is desired to cause adhesions, are thoroughly roughened, or scraped, and the border of the liver and the omentum, or merely the latter, or the spleen, is sutured to the abdominal wall, or the spleen or omentum may be pushed into a pocket between the layers of the abdominal wall.

Though the results of the operation are still limited to a small number of cases, and mishaps have been recorded, yet autopsies have shown that very large vessels (as thick as the radial artery) may form in the adhesions. Compare Friedmann's monograph in the *Centralblatt fur die Grenzgebiete der Med. Chirurg.*, Aug. 1900.

122. Laparotomy for Peritoneal Adhesions. Lauenstein emphasised the good 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 existed for years.

A short time ago we 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 be correct that silk, being a permanent foreign body, is more liable to cause adhesions, preference must be given to catgut, which is easily absorbed.

123. Operations on the Gastro-intestinal Canal. Whenever the alimentary canal is opened septic influences have to be combated, for the gastro-intestinal contents, under normal conditions, harbour a far greater number and variety of bacteria than does the skin. Our first care must, therefore, be to endeavour to prevent the risk of infection of the peritoneal cavity from the lumen of the gut, or to limit such infection to as small an area as possible. The means by which we seek to avoid these contingencies are very varied, and cannot be the same for every case. The method of preventing a spread of infection by means of compresses has been considered under the general remarks on laparotomy. But the protection of the immediate neighbourhood from contamination depends chiefly upon whether the organ which has been opened can be entirely closed, as, for example, in Billroth's second method of pylorectomy, and in our method of performing resection of the pylorus, where the stomach is completely closed after the removal of the neoplasm; or whether the opening which has been made has to be joined to some other part of the gut in order to form an anastomosis, as in gastro-enterostomy and the various entero-anastomoses.

We shall first describe the different ways of preventing the escape of intestinal contents. These can be divided into two chief methods. The first consists in closing the gut at a point remote from that at which it is opened, and the second in closing the gut at the point of division. The former method can be carried out in various ways. After emptying the bowel by squeezing its contents along the lumen, a ligature or pair of forceps is applied above and below the emptied portion. The gut (or stomach) is then cleaned as far as possible and the sutures are inserted.

This method of closing the gut remote from the site of operation is well worthy of recommendation. It may, however, be employed in two very different modifications, especially if "closure" forceps are used. Either the mesentery, and with it the vessels, can be included (in the case of the stomach this applies to both greater and lesser curvatures), or the bowel alone may be closed. There is no doubt that this method of temporarily closing the gut, remote from the site of operation, combined with prophylactic arrest of hæmorrhage, renders the operation materially easier. The sutures can then be inserted without any difficulty, first a continuous suture through the mucous membrane, then a suture through the whole thickness of the wall, and finally a serous suture over all. How the forceps are to be applied in any particular case will be seen later when the individual operations are described.

In all cases, and without exception in those where the mucous membrane of the gut has been exposed, a thorough cleansing of the surrounding parts must be effected after the suture including all the layers has been introduced, and before the serous suture is applied, and, if necessary, soiled swabs used in shutting off the field of operation must be replaced by fresh ones.

A more certain means of preventing escape of the intestinal contents is the method in which the place where the gut or stomach is to be divided is gripped and firmly compressed with powerful forceps, and then divided close to the forceps with a knife or the thermo-cautery. In 1883 our observations and results proved that forcible compression of the gut in no way interferes with subsequent primary union, for the simple reason that the muscular and mucous coats cannot be crushed sufficiently to cause necrosis, because as the pressure rises above a certain point the parts of the muscular and mucous coats which contain vessels are cut across (Lantz has proved this again recently in his more minute observations), and all that remains between the forceps is the perfectly dry elastic connective tissue, reduced to a membrane the thickness of a piece of paper. That this is so has been proved recently by the employment of a third method, in which a pair of powerful crushing-forceps (angiotribes) are used to compress the gut. First Doyen, and then Tuffier, introduced "angiotribes" into abdominal surgery. Souligoux has applied them in a very

original manner. Besides employing our compression forceps (histotribes) for operations on the stomach and intestines, we have long used them in dividing the isthmus in excision of goitre.

The difference between the second method and this, the third method, is that the latter also arrests the hæmorrhage. In the second method it must be arrested by the sutures which are inserted before the forceps are removed, or, if this is not practicable, by applying forceps to the bleeding points after the pressure forceps have been removed. If angiotribes of Doyen's pattern are used no hæmorrhage follows their removal. Absolute closure of the gut and complete arrest of hæmorrhage are both secured. Of course both must be permanent. This method has the further advantage that the compressed tissues are crushed to so thin a membrane that they can easily be included in a ligature.

Where, on the other hand, a very extensive piece of tissue, as, for example, the stomach, has been seized in the forceps, suturing must be employed as in the second method. This we do as follows while the forceps are still in position :—A suture (Fig. 99) is quickly passed through and through with a straight needle along the whole length of the wound (see description of the occlusion of the stomach in resection of the pylorus, page 219). After the forceps have been removed, a continuous suture (Fig. 100) is put over the last through all the coats, and, lastly, the continuous-inverting serous suture is applied.

We consider it right to put the first suture (which not only closes the stomach but keeps the edges from retracting) behind the forceps while they are still on. Only in the small intestine, and particularly in the appendix, may the forceps be removed after pressure has been applied. The compressed part is then simply ligatured (as we have described for the isthmus of the thyroid) and a suture superimposed.

If we now inquire which is the best method to employ, we find that the first, on account of its great convenience, is the most suitable for all anastomoses, because the insertion of the uniting sutures is least interfered with. It has only the disadvantage that, if the forceps are also used as a prophylactic measure against hæmorrhage, it may predispose to thrombosis. The forceps should, therefore, not be left on longer than is absolutely necessary, and they should be put on as late as possible. They should be removed immediately the suture which penetrates the whole thickness of the wall has been put in, and before the serous sutures are begun.

The second method (as is proved by the success of our gastro-duodenostomy after resection of the stomach) deserves preference where a large hollow viscus is to be closed, and where any escape of the contents is to be carefully guarded against. Infection is thus rendered impossible.

The third method is the one most quickly carried out where small hollow viscera have to be closed, as in the removal of the appendix, in intestinal anastomosis, and in closure of the duodenum in gastro-jejunostomy after resection of the pylorus.

The certainty of closure of gut or stomach always depends on the union of the peritoneum of both ends of the gut, but exact apposition of the mucous and muscular coats is worthy of more attention than has for some time been paid to it. If these layers are properly united function is more quickly restored, and, what is far more important, necrosis of the margin of the wound towards the lumen of the gut is avoided. Such necrosis rarely, but nevertheless occasionally, gives rise to phlegmonous infiltration of the stomach wall; while more frequently it leads to the formation of small foci of infection and to metastatic inflammation (pneumonia).

A sufficient blood-supply is the essential condition for obtaining primary union of all the coats of the alimentary canal, and we have already pointed out that direct examination of the pulsation in the mesenteric arteries, which supply the wall of the gut in question, is the only certain way of ascertaining that a sufficient blood-supply is present. The row of sutures on the peritoneal aspect must, of course, be quite aseptic.

Thorough preparation of the patient must never be neglected before an operation on the alimentery canal. Stomach and intestine must be emptied, the former by means of lavage, the latter by laxatives. As, however, laxatives temporarily increase the

number of bacteria in the intestines, they should not be given later than two days before the operation. Consequently the food must be such as will not result in the formation of fæcal matter (soups, with nutrient powders, such as somatose, etc.), and such as will diminish as far as possible the number of bacteria (sterilised milk). The latter should, however, only be used for rectal feeding. With such a sparing diet of solids the supply of fluids must be proportionately large. Two days before operation we

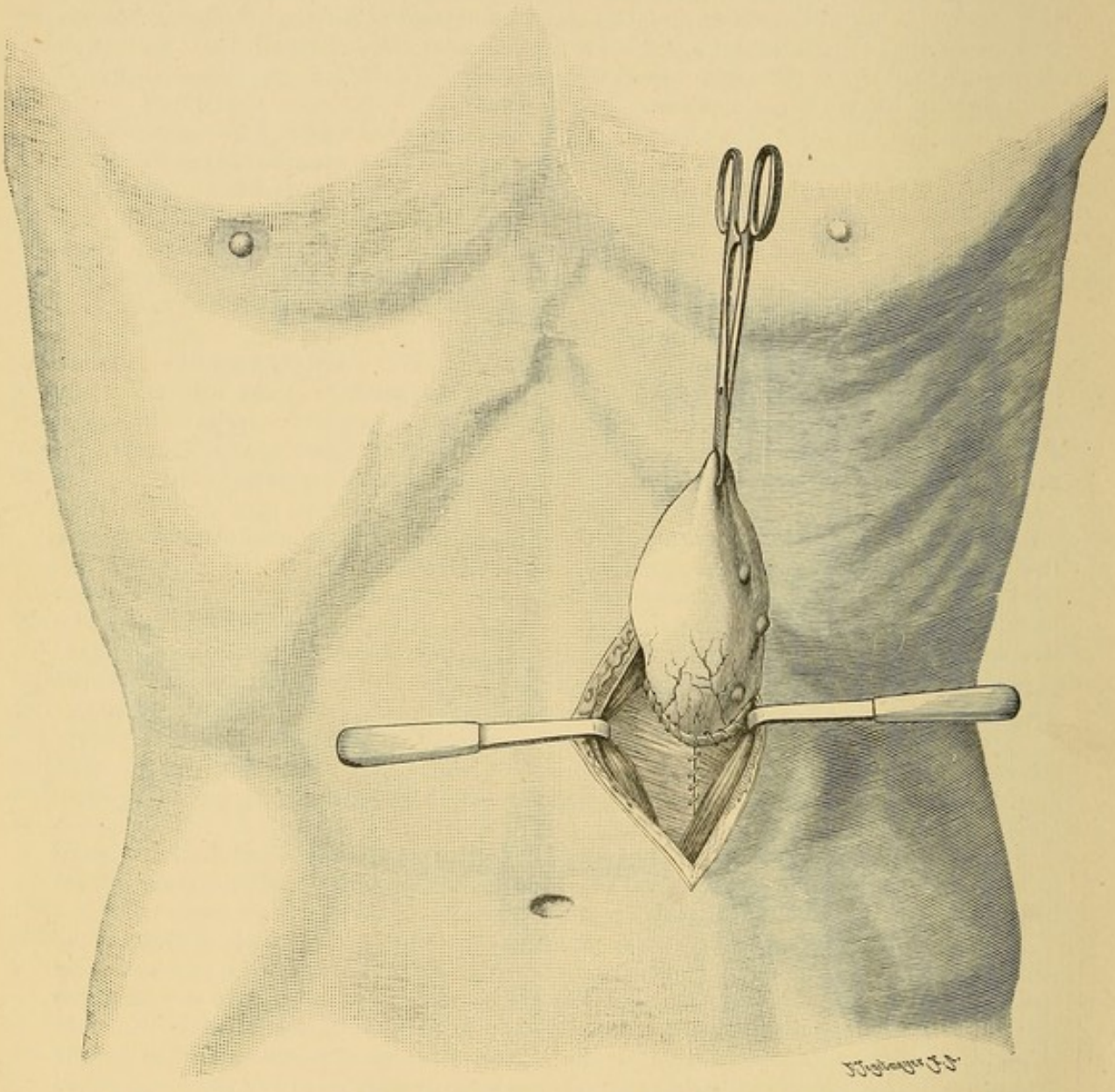


FIG. 84.—Gastrostomy according to Frank (somewhat modified). A portion of the stomach is drawn forward out of the abdominal wound and sutured at its base to the peritoneum and posterior layer of the sheath of the rectus, the muscular fibres of the rectus being held apart. (The entire rectus should be drawn to the outer side, not as represented here partly retracted inwards.)

give bismuth powders to limit as far as possible the fermentative changes in the intestinal contents, and where the diet has to be very limited we even give opium.

124. Gastrotomy and Gastrostomy. When the stomach requires to be opened, be it for the removal of a foreign body, for the treatment of an œsophageal stricture, or for the formation of a permanent opening in cases of malignant disease of the

œsophagus, it will be found a great advantage to draw the stomach out of the wound in the abdominal wall, and, before opening it, to fix it to the abdominal wall by a ring of fixation sutures. In this way the abdominal cavity is shut off before there is any fear of escape of gastric contents, and the risk of peritonitis from this cause is abolished. The opening is then made into the exposed portion of the stomach in whatever direction the case demands, and the contents can be allowed to escape with

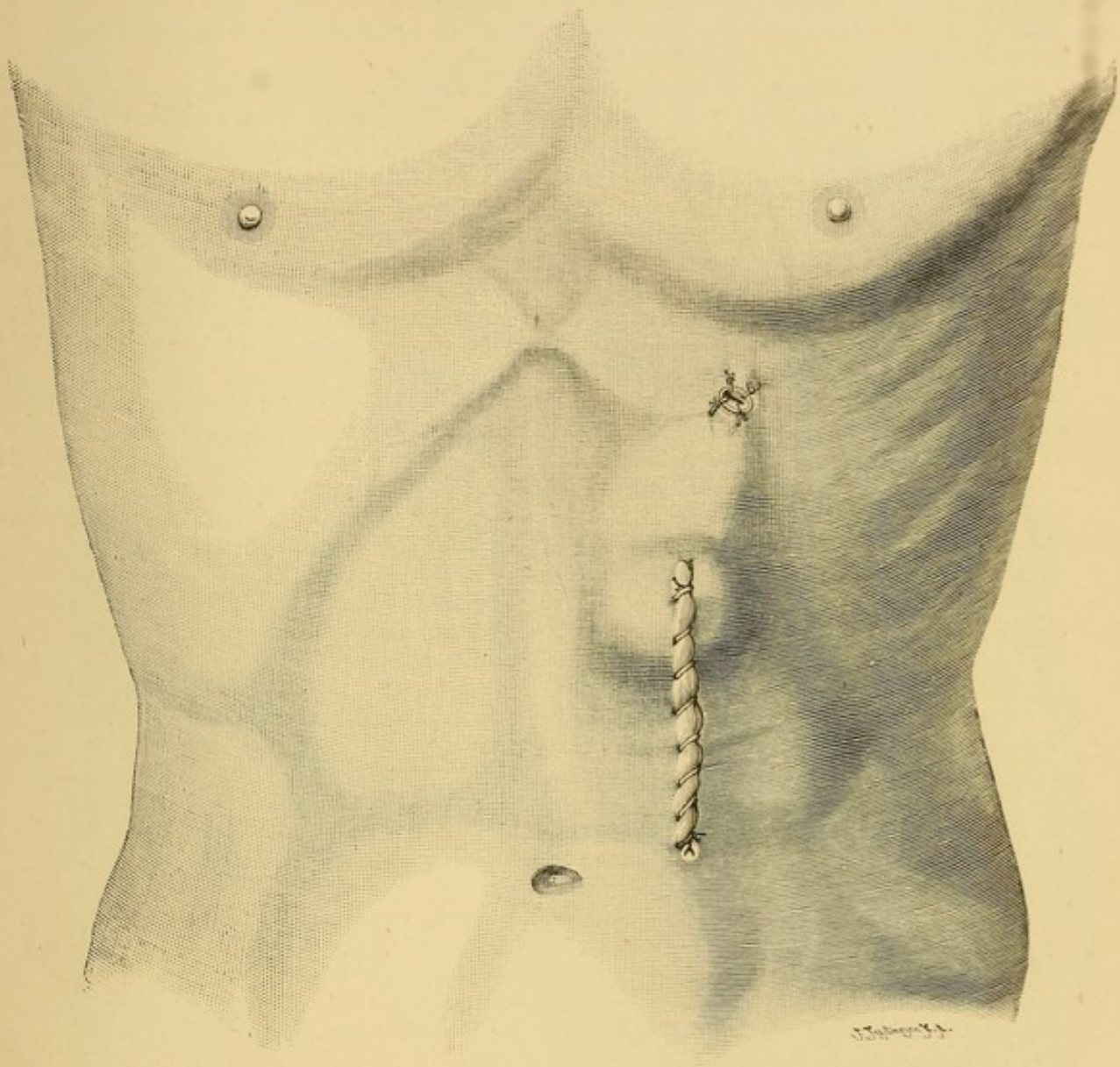


FIG. 85.—Gastrostomy according to Frank, completed. The main wound is sutured; the apex of the drawn-out portion of the stomach is sutured to a small opening in the skin above the costal margin, and is then opened.

perfect assurance that nothing can flow into the abdominal cavity. The abdomen is best opened by a vertical incision over the middle of the left rectus muscle, so that the whole of the uninjured muscle can be drawn outwards after its sheath has been incised. The tough fascia transversalis and peritoneum are then divided, and the stomach is stitched into this opening with a short curved needle and a continuous silk suture, the stitches including a layer of muscle in addition to the serous coat.

Gastrotomy consists in merely opening the stomach parallel to the vessels and catching the bleeding margins with artery forceps. After extraction of a foreign body the wound in the stomach is at once closed. A fine continuous silk suture is used for the mucous coat, a second for the remaining coats (muscular and serous), and a third for the serous coat alone. On the other hand, in an œsophageal stricture, after the constriction has been dilated with a bougie, the latter must be left in position for a few days, and, on its removal, the wound in the stomach is closed with a continuous suture which traverses the whole thickness of its wall; the stomach is then freed from the abdominal wall by dividing the ring of fixation sutures, and the first row of sutures is invaginated by a serous suture.

In carcinoma of the œsophagus, gastrostomy is the best expedient for prolonging the patient's life and rendering it as pleasant as possible. Since we have discovered how to make an opening into the stomach which will remain closed spontaneously, and so prevent irritation of the skin by the acid gastric contents, and at the same time not necessitate the wearing of any kind of support, this operation should be recommended in the earliest stages of œsophageal stenosis. The patient by this means is always assured sufficient nourishment; moreover, he is freed from the necessity of undergoing any other treatment locally for the stenosis, except such as may be of service to him, without at the same time injuring him. Occasional dilatation may still be performed, but at the same time no compunction should be felt in stopping a course of dilatation whenever it is apparent that it is causing the growth to break down, is setting up inflammation of the surrounding parts, or giving rise to pain. Permanent tubes may be worn in cases where their presence gives rise to no pain, and where they can be borne without injury.

Figs. 84 and 85 illustrate Frank's method, which we formerly employed. We have, however, now limited its application, because in some cases where the stomach is much shrunken it cannot be drawn far enough through the abdominal wound to enable it to be carried upwards under a bridge of skin. Moreover, in some of our cases the fistula leaked. It appears also much simpler to retain only that part of Frank's procedure in which the part of the stomach pulled out is sutured to the uppermost part of the wound and so stretched and bent upwards.

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 it. Care must also be taken not to suture the stomach too close to the pylorus, as the outflow through it would be hindered. A 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 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. 86). Just below the suture a small opening is made into the stomach, 3 to 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. 87, *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 put in above and below, under the sutured skin wound.

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.

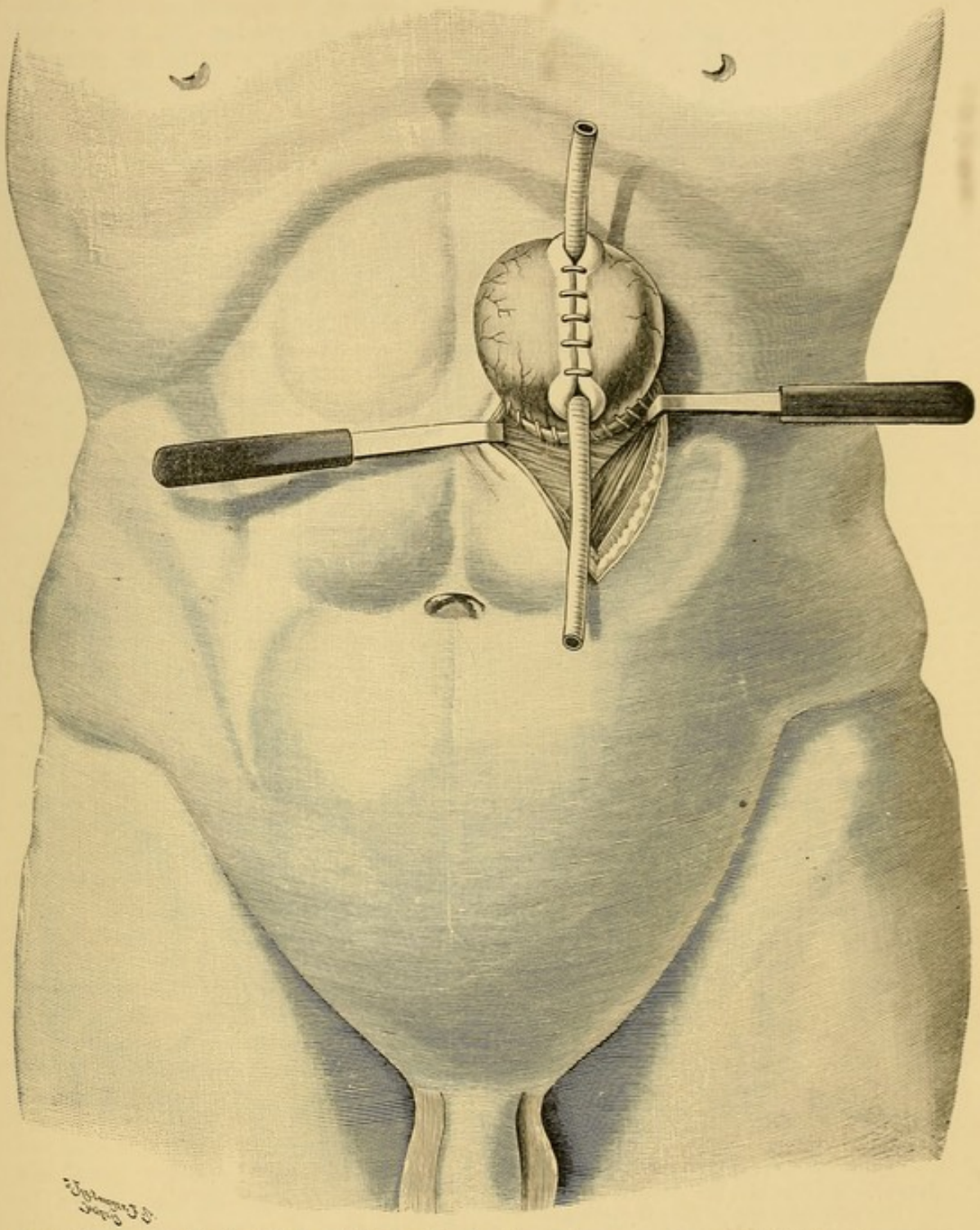


FIG. 86.—Hacker-Frank-Witzel method combined with gastropexy. A vertical incision is carried downwards from the edge of the ribs along the middle of the rectus muscle, which is drawn to the side; the peritoneum and transversalis fascia are stitched to the serous coat of the stomach all round; the stomach is folded and sutured over a drainage tube.

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 cicatrical tissue to the abdominal wall; 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 $1\frac{3}{4}$ ins. long, which had no mucous lining and was perfectly smooth.

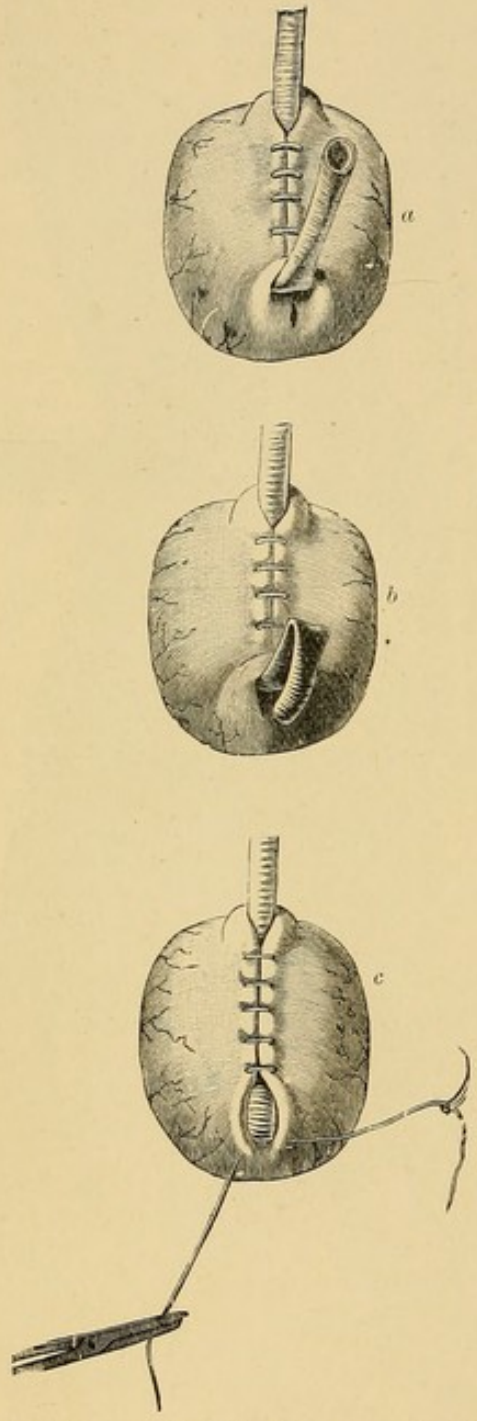


FIG. 87.—*a-c* illustrate the manner in which one extremity of the tube is introduced into the stomach through a small opening, and how the latter is covered over by another folding suture.

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 good, and some of our patients have been unable to reintroduce the feeding tube after leaving hospital. We do not leave the tube in permanently, on the ground that it would be difficult to do without some sort of a bandage. Care must therefore be taken not to make the canal too long and too narrow.

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. 88 to 89).

The cone of 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. 88) 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. 89, 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.

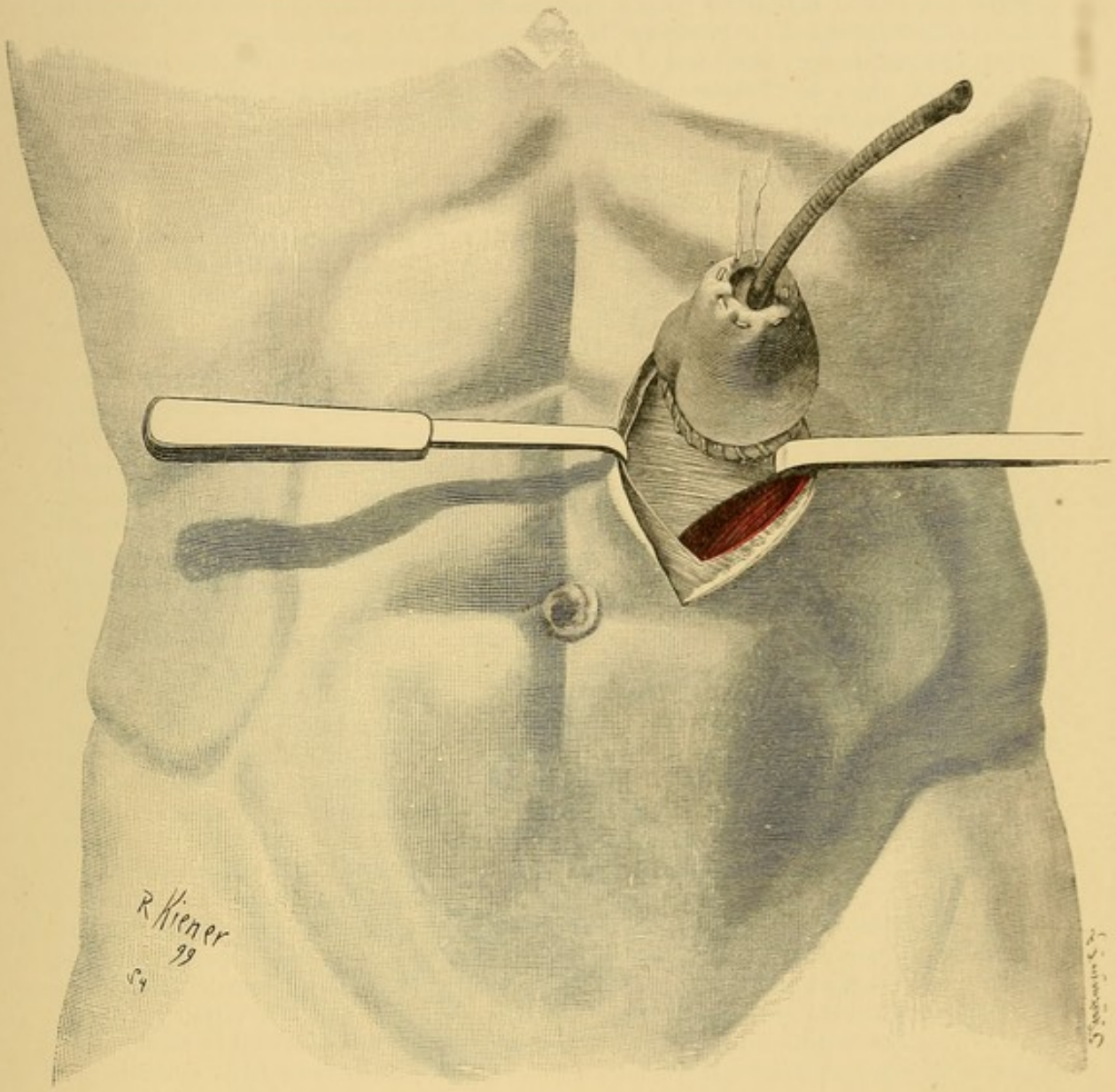


FIG. 88.—Gastrostomy. Kader's method of making a canal. A cone of stomach is drawn out and sutured to the peritoneum and fascia transversalis, the rectus being well retracted outwards. A rubber tube has been introduced at the apex of the cone and fixed with sutures; the tube has then been pushed farther in and a purse-string suture applied, which, however, is not yet drawn tight.

The difference between this and the method just described is, in the first place, 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.

(*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 point 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 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.

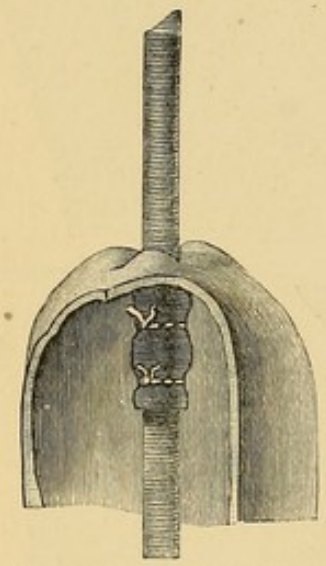


FIG. 89.—A longitudinal section of the stomach cone showing how a canal for the rubber tube is formed by a process of invagination.

125. Gastroenterostomy (Gastroenteroanastomosis). When Maisonneuve first originated the idea of performing an enteroanastomosis, the technique was not sufficiently well developed to allow of its being put into practice. But at the time when Nicoladoni and Wölfler made the proposal, pregnant with possibilities, to perform a gastroenterostomy, Billroth's success with resection of the stomach had already shown what a fruitful field was being opened up in abdominal surgery. The gastroenterostomy generally known as Wölfler's operation has made an advance such as no one could have anticipated, and satisfactory cures are to be counted by thousands. These have been attained by operation on patients whose illnesses had dragged on their course for years under medical treatment. Doubtless the field of gastroenterostomy will still further widen when the physicians have acquired, by the publication of the results of the operation, a thoroughly clear understanding of its possibilities. We may refer to two publications from our clinique dealing with about one hundred cases which have been recorded by Drs. Kaiser and Humbert, three-fifths performed for innocent and two-fifths for malignant affections.

They show the very interesting transformation that in our first sixty cases the operation was done especially for carcinoma of the stomach, whereas in the last forty cases this affection was quite in the background. This proves that we, in common with others, have largely given up palliative operations for carcinoma in favour of the radical operation. Steudel has reported, for Czerny, forty-seven cases of gastroenterostomy, twenty-nine being for malignant and eighteen for innocent affections.

The field in which gastroenterostomy is now celebrating its triumph is that of simple ulcer of the stomach and its results. Undoubtedly this affection—to judge

from its consequences—is much more frequent than even physicians are inclined to accept, and we should do well in all persistent painful affections of the stomach, which drag on for months under medical treatment, to allow surgical treatment to take its rightful place.

The majority of practitioners do not sufficiently realise what brilliant results are to be obtained by operative means in chronic affections of the stomach, commonly known as gastric catarrh.

Not only can the numerous dangers of ulcerating affections of the stomach, such as hæmorrhage, perforation, transition into cancer, be prevented, but the disease and its results may be so rapidly and certainly cured that the medical treatment of obstinate cases must be put in the background. Dr. Kaiser, by careful examination of our cases, has been able to establish the following facts:—

1. The pain in the stomach disappears immediately after the operation. This is the invariable rule, and is independent of the state of the motor and chemical functions. The patient does not require to pay any further attention to the nature of his food.

2. The vomiting disappears. We have to mention only one exception, for which we will give an explanation.

3. The bowels when previously constipated become regular, and the occasional diarrhœa improves.

4. Persistent gastric disturbances remained in only one case—a posterior gastro-enterostomy.

5. Although the existing dilatation of the stomach does not disappear within the first months, the much better manner in which the stomach empties itself can be demonstrated (not in an abnormal manner as Steudel, Carle, and Fantino have sometimes seen). Mintz has proved that the dilatation does disappear later.

6. Repeated investigation of the gastric contents shows that there is a progressive improvement in the process of digestion; hyperacidity diminishes; if too little acid is present it becomes increased, a statement which is in agreement with Steudel, Carle and Fantino, Kautsch, Hartmann, Sipault, and Mintz; Rosenberg has found the same complete utilisation of food in animals.

7. The artificial opening acquires the power of closure, as the stomach can be distended. Mintz has also proved the formation of a new and functionally active sphincter, as also have Hartmann and Sipault.

8. The flow of bile into the stomach occurs least frequently with the Y-method, and has no deleterious influence either on the health of the patient or on the function of the stomach.[1] Hartmann and Sipault have come to the same conclusion.

9. The general health of the patient improves provided no carcinoma is present.

10. It is very remarkable that the so-called vicious circle is never found in any of the methods which we have employed when dealing with innocent affections of the stomach. In gastroenterostomy for cancer of the stomach, on the other hand, death frequently (one-third of the author's cases) occurs as a result of auto-intoxication caused by decomposition of the contents of the stomach. Kaiser ascribes this to the regurgitation from below, which is also to be observed in resection of the pylorus as a result of the paresis of the bowel being increased by the operation.

From such deductions we may conclude that the operative treatment of the results of ulceration is the true cure for this frequent and serious disease. In cancer, on the other hand, all that can be attained by operation is diminution in the suffering and temporary improvement in the general condition for some months. We do not overlook the fact that individual cases have been published by Steudel (from Czerny's clinique), and by others, in which the improvement was maintained for some years. But we cannot help thinking that in these cases the radical operation would have been possible, and that still better results might have been obtained. Körte, with his

[1] This point has been gone into by careful inquiry and examination of the patients, and we may hold this in opposition to Roux, who says that surgeons have come to regard the entrance of bile as harmless because it does no harm to themselves.

large experience, not only proposes that gastroenterostomy should be done as early as possible for cicatrical stenosis of the pylorus with dilatation of the stomach, but advises timely operation also in painful conditions, and in small frequent hæmorrhages. The healing of the ulcer is thereby greatly assisted.

The same views are expressed by Mayo Robson and Czerny, according to the latter of whom the operation has an extraordinarily beneficial influence on recent ulcers of the stomach.

Lastly, the tendency which an ulcer of long duration has to become malignant is not sufficiently appreciated. Hauser and Heitler have shown that there is a tendency to the development of malignant disease in the glands secondary to the process of cicatrisation, while in uncicatrised ulcers the tendency to cancerous development is still more marked, as we have seen in quite a number of cases. Probably the cases in which gastroenterostomy prolonged the life of patients suffering from malignant disease of the stomach for five and a half years (Czerny) belong to those which had developed from simple ulcers.

For cicatrical stenosis and dilatation of the stomach we have the alternative methods of Bircher's gastroplication, of gastropexy, and of Heineche's pyloroplasty, all of which, however, according to the experience of most surgeons, are inferior to gastroenterostomy (see Roux's paper, read at the International Congress, Paris 1900, also Doyen). Kelling has brought forward experiments in explanation of this which show, amongst other things, that the power of contraction of the longitudinal muscle of the pylorus may be too much injured by the angular kinking of gastroptosis, as well as by the overstretching in dilatation to overcome the sphincter. Further, the presence of too much acid (Serejokow), which has a stimulating effect on the sphincter, is unfavourable to emptying of the stomach.

After what we have said as to the functional results of gastroenterostomy, all that we now need is evidence of the fact that the immediate result of the operation has become incomparably better than formerly. But, as Brunner has rightly insisted, one must certainly separate cases operated on for malignant disease of the stomach from those operated on for innocent affections. The above-mentioned circumstance, that in cancer, almost without exception, decomposition of the stomach contents followed the operation in our cases, proves that the conditions are here distinctly less favourable. As regards mortality, we refer the reader to the two papers shortly to appear by Kaiser and Humbert. In them one will see that the assertion is justified that the danger of gastroenterostomy for non-cancerous affections of the stomach is to be looked upon as surmounted. In our 100 cases we have not experienced a single fatal result as a consequence of the operation, *i.e.* the three fatal cases were not referable to complications of the operation, but to the disease itself.

Hæmorrhage played the chief part in our few fatal cases; two patients died from hæmorrhage, one from a gastric, the other from a duodenal ulcer. The operation, therefore, was performed too late, as the ulcer had already so far broken down that one of the larger vessels was eroded. A third patient had, in spite of express warning, waited so long that he took an exhausting hæmatemesis, which caused him finally to submit to the operation. He died of bronchitis and pneumonia, the wound remaining healthy, as it did also in the other fatal cases. Eiselberg has drawn attention to the danger of hæmatemesis in abdominal operations, and we have elsewhere stated our views on the matter.

We believe we are justified in asserting that the methods employed by us are to be recommended, as the mortality is infinitesimal, and as in non-cancerous stomach affections the final result is, as a rule, a complete functional cure.

It is well that nature is not so ungracious as the surgeon. She allows, just as God allows the sun to shine on the good and evil, methods which theoretically are good and bad to be successful. Our method differs in essential particulars from those usually employed, and has often been pronounced to be a bad one on theoretical grounds just because of these peculiarities. We have remained true to the transverse opening of the bowel as well as to the vertical placing of the loop of the

intestine, and our results can be favourably compared with the very best obtained by other surgeons.[1]

All the supposed horizontal appositions of the intestine to the stomach, or indeed those in which it hangs down vertically, are just as temporary as the formation of spurs. The movements of the intestine cause the loop of the bowel to loosen itself again at the stomach and to take up the position which we gave it from the first. It is of great importance to ensure that the flow of the stomach contents takes place into the distal bowel from the outset, and to guarantee the permanence of a thorough emptying by the formation of as large an opening as possible.

We have fulfilled both these requirements by the proper modification of Wölfler's original gastroenterostomosis antecolica anterior, although it cannot be doubted that good results are obtained with Wölfler's actual method, which Hahn declares to be the best.

The gastroenterostomosis antecolica anterior of Wölfler, with or without modifications, is, at any rate, by far the simplest method of operation, and it is very noteworthy that surgeons like Bergmann (in his communication to the twenty-eighth Surgical Congress in Berlin) and Mikulicz (according to Kautsch) have again gone back to it. It is strange that disturbances from pressure on the transverse colon are still spoken of. They occur, as Wölfler distinctly mentioned, only when too short a loop of jejunum is employed, so that strangulation takes place. The anastomosis must be made 16 to 20 ins. below the commencement of the jejunum. In cases where this has been done we have never seen the slightest disturbance of the colon, and we know of no proof of such.

The position of the opening in the stomach must, of course, be chosen on a definite principle, and in order to sufficiently emphasise this point, we have designated our present method by a new name, viz. **Gastroenterostomosis antecolica inferior.** We now always place the opening at the lower border of the empty stomach, and select that part which reaches farthest down, or which can be drawn farthest downwards. By this process we succeed in procuring a complete emptying of the stomach by physical means without further artificial interference.

A study of the interesting investigations of Rosenfeld on the position of the stomach will convince us that when the stomach is empty its lowest part belongs to the pyloric portion, *i.e.* the lesser fundus, which crosses transversely in front of the vertebral column, and which is often the chief seat of the dilatation.

If the intestine be sutured to the posterior wall of the stomach (Hacker's gastroenterostomosis, retrocolica posterior) by perforating the transverse mesocolon at a point where there are fewest vessels, the choice of the place is influenced by the condition of the mesocolon, and we are not able, as in the front, to choose a spot which fulfils these indications. Therefore in Hacker's method the stomach is only completely emptied when the patient is recumbent. Kelling has shown that it makes all the difference whether the anastomosis is made towards the fundus or towards the pylorus. In the latter case a muscular closure is obtained, as has been distinctly proved in our own and other cured cases, and which is of such important functional significance afterwards. For it does not signify whether all the food which enters the stomach flows at once into the intestine, but it is important that—by the contraction of the stomach and the forwarding of the stomach contents towards the pylorus after proper gastric digestion—there should be no abnormal hindrance to its emptying. In our cases it is in the gastroenterostomosis retrocolica posterior that we have seen the greatest interference with the emptying of the stomach, because by this method extensive peritoneal adhesions had taken place in the neighbourhood of the anastomosis.

[1] This applies especially to the mortality, but also to the restoration of function. It is interesting to read how Brunner, in a case operated on by Stierlin, wondered how well the artificial pylorus acted for a year, "although" the two limbs of the jejunum hung down parallel from the seat of anastomosis, where they formed an acute angle. Autopsies of cases where function had been restored would show this often enough. We do not know of a single surgeon who has adopted our plan and been dissatisfied with it; on the contrary, Plettner, for example, has obtained excellent results with it.

We do not place any value, therefore, in applying the intestine to the posterior surface of the stomach through the mesocolon; on the contrary, we maintain, in agreement with Socin, Hahn, Lücke, Röckwitz, and others, that the anterior or, better still, the inferior anastomosis is preferable. To the less experienced the posterior method is distinctly more difficult, and the greater the lesion to the peritoneal folds from the introduction of sutures, the greater also will be the adhesions, and marked adhesions are responsible, more often than is thought, for the symptoms of the "vicious circle," because they narrow the passage for the outflow.

Quite different is the further question as to whether a loop of intestine with a lateral opening in it, or the transversely divided gut, should be sutured to the stomach. There is between these two methods a difference in principle.

The Y-method forms the type of those methods which are especially intended to prevent the so-called vicious circle—the flow of the stomach contents into the upper segment of the intestine, and of the intestinal contents along with the bile and the pancreatic juice into the stomach. Wölfler is the theoretical originator of this procedure, in the same way that Nicoladoni is the ingenious originator of gastroenterostomy, but it is through Roux that the idea has been brought to fruitful recognition, and it may therefore be described as Roux's method.

It is *a priori* beyond question that the most certain method of preventing the vicious circle is obtained when the jejunum is cut across, its lower end implanted into the stomach and its upper end into the descending intestine. It is true, however, that by Roux's plan also a regurgitation of bile into the stomach has been observed, for the reason that, on account of the shortness of the mesentery, the upper part of the intestine can often not be implanted into the descending loop at a sufficient distance from its junction with the stomach. But the chief reproach of the method is, that it entails a double anastomosis, and, in spite of all dexterity and practice, the duration of the operation is prolonged.

In patients who are reduced, we have, on these grounds, already had reason to regret that we decided on this procedure: here it is often the most rapid method which is alone the proper one, since any prolongation of the operation and of the anæsthesia may favour the occurrence of complications, especially on the part of the lungs. We maintain, therefore, that it is going too far to insist on the adoption of Roux's method in all cases.

We regard Roux's method, however, as very valuable, and as indicated in all cases where there is a danger of decomposition of the stomach contents, or where marked decomposition is already present. In these circumstances it is so essential that the stomach contents should flow rapidly and completely into the intestine, that keeping the stomach empty comes before all other considerations. It appears to us, therefore, that in carcinoma, where putrefaction of the ulcerated surface is so often present, it is the only proper method, and also in other ulcerations, if marked decomposition of the stomach contents has set in, especially in great atony of the stomach.

In these cases we shall do well also, having regard to Kelling's observations, to place the communication with the stomach nearer the fundus (cardiac end), where the danger of a contraction of the muscle does not exist, but where the opening, like an atonic sac, allows of the flow of its contents into the intestine. Carle and Fantino, who quite agree with our views, as expressed by Kaiser, have come to the conclusion that, in the presence of feeble contractile power and decomposition, an immediate free escape of the contents of the stomach is much more important than when dealing with a simple stenosis. Also in very nervous individuals, who become melancholy with slight gastric disturbances, the Y-method is useful, especially where the objective stomach changes are slight and the subjective symptoms very prominent. Lastly, we maintain that the Y-method is better in the cases where the great omentum is very fatty and large, and forms, when folded, too thick a mass. In such cases it may, however, be split up from below in its entire length.

As a rule, however, our method of gastroenterostomosis antecolica inferior gives in no way inferior results to the Y-method. Dr. Humbert has, in a more recent

inquiry, received information regarding the condition of our patients, viz. of sixteen patients operated on by our method, and eight operated on by Roux's method. Only one patient vomited bile after each meal, and that a patient operated on by the Y-method; in only one patient too is the appetite poor, and he too was operated on by the Y-method. Five patients operated on by the Y-method have to be careful about their food; in all operated on by our method the appetite was "good," or "very good"; in only one was it "variable." Slight subjective symptoms existed in six by the Y-method and in five by our method.

When, however, the indication to be fulfilled is at any cost to empty the stomach as quickly as possible, then the Y-method is preferable to all other methods which attain that object incompletely, as, for example, in Braun's method of forming an anastomosis between the two limbs of the loop which is sutured to the stomach; this anastomosis, as we know from experience, does not always prevent the entrance of the intestinal contents into the stomach, especially the vicious circle, while by the Y-method the latter can never give trouble to any extent. Also the Rutkowski-Witzel plan for ensuring the flow into the descending portion of the intestine by the addition of a gastrostomy, with the object of stretching the stomach and feeding, is, in view of the advantage of the Y-method, not suitable for general employment. Of the numerous other methods of gastroenterostomy it appears to us that there are only two which are worthy of mention here:—

(1) The proposal to cut across the duodenum, to close the pyloric division (proximal end), and then to unite the distal portion of the duodenum to the lower part of the posterior wall of the stomach (Credé), as in the author's method of stomach resection.

This, which is a certain prevention against the vicious circle, admits, however, only of a limited employment, in consequence of the frequent existence of strong adhesions as a result of old ulceration in the neighbourhood of the pylorus.

Henle first originated the idea (without removing the pylorus) of employing our gastroenterostomy also in simple strictures of the pylorus, and Mikulicz was the first to make such a communication in fibrous narrowing.

2. The second procedure which appears to us of value to ensure against the vicious circle is the formation of a spur between the stomach and the proximal part of the intestine, or, preferably on the distal side of the anastomosis. Hacker is not satisfied with it, however, and Sykow considers that the value of his method lies mainly in the fact that it allows the stomach and intestine to be opened after the sutures have been introduced. The idea, however, is not to be rejected, and is valuable if properly carried out. In describing our latest method we shall show how we have carried out this principle.

We have already stated in the general remarks on gastro-intestinal surgery that after the abdomen is opened, pads of aseptic gauze are *always* to be arranged so as to isolate the field of operation from the rest of the peritoneal cavity. We shall not here trouble to repeat the rules categorically laid down, nor the warning always to employ, when dealing with the abdominal cavity, only aseptic towels, swabs, and fluids (physiological salt solution at 38° C.)

We always use silk sutures, which should invariably be continuous. Catgut may, however, be used for suturing the mucous coats.

When mucous membrane can be united to mucous membrane this should be done, and then three layers of sutures are necessary, viz. the mucous suture, the suture through the entire thickness of the wall, and the serous suture. In other cases we can, and must, be satisfied with the two last layers. All these rules are now indeed quite customary, and we need only refer the reader to the earlier editions of this work. We shall now describe the two methods we employ.

126. Gastrojejunostomosis Antecolica Inferior. The abdomen is opened by a median incision reaching down to, or even below, the umbilicus, which we no longer excise, as it is disfiguring. The stomach is carefully explored to ascertain the nature of the primary disease and the complications, and to determine the lowest point of

the stomach, which as a rule corresponds to the lower border of the dilated pyloric portion (fundus minor).[1] The gastrocolic ligament, together with the gastroepiploic artery, is separated for about 2 ins. in this situation, and the few vessels which pass on to the stomach are doubly ligatured.

The transverse colon is now turned upwards and the duodeno-jejunal flexure is sought for by following the mesocolon to the left side of the vertebral column where the finger is passed round the left side of the commencement of the jejunum, which is drawn forwards. The jejunum is then emptied by drawing the fingers along it for a distance of 16 ins. from its commencement, at which situation a loop is selected and held by the assistant. The transverse colon and omentum are replaced into the abdomen, and after the prepared portion of the greater curvature and the

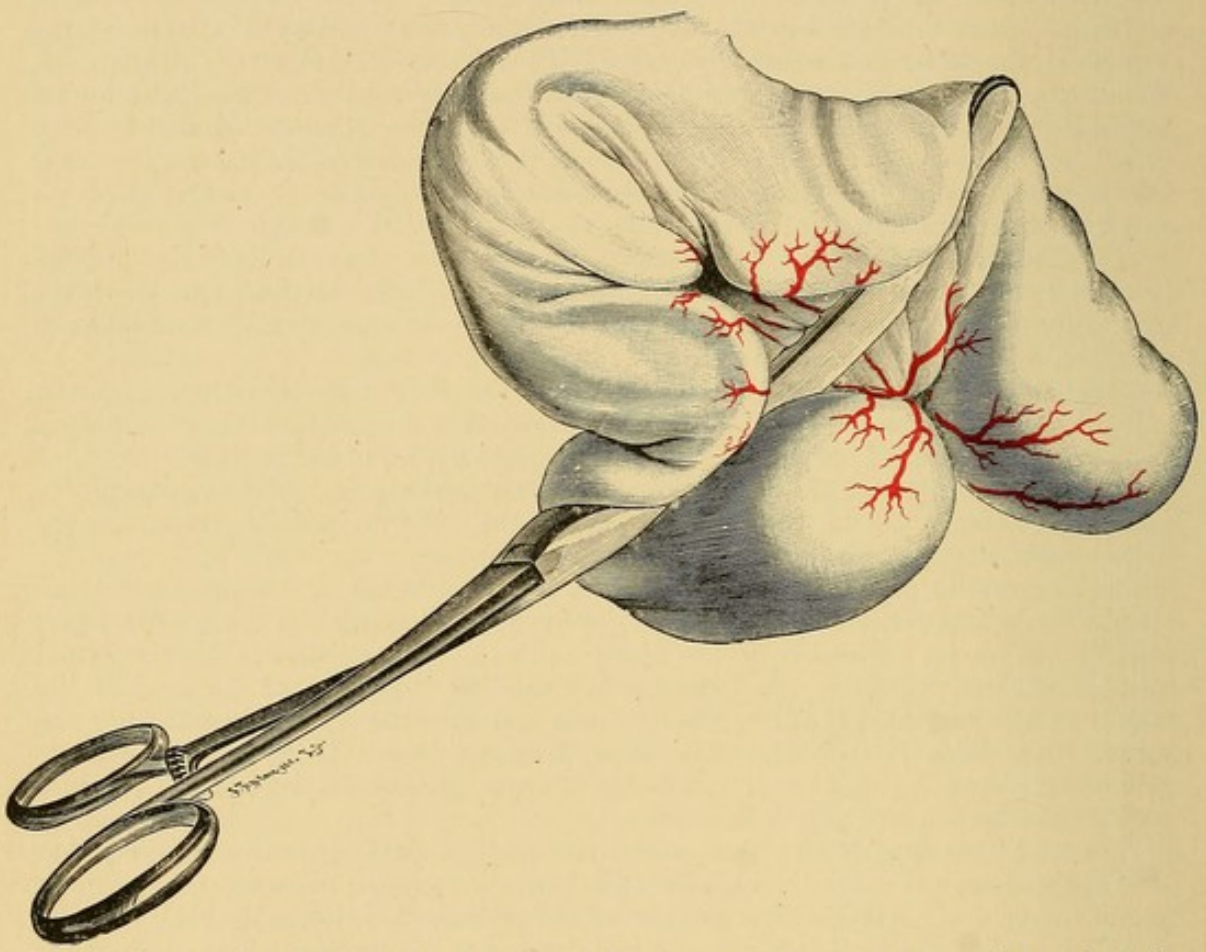


FIG. 90 illustrates how the clamp-forceps are applied to the emptied loop of jejunum, the vessels of the mesentery being at the same time controlled. The apex of the loop is applied to the stomach.

emptied loop of intestine (16 ins. below the commencement of the jejunum) have been placed in proper position for effecting the anastomosis, the parts are carefully surrounded with aseptic gauze to protect the general peritoneal cavity.

It is a great convenience to apply Doyen's clamp-forceps to the stomach as well as to the emptied loop of intestine (Fig. 90) in order not only to close securely

[1] We have already indicated above that the cases of dilatation which call for operation are, as a rule, those which Rosenfeld refers to as the vertically dilated forms, and not the horizontal dilatations. In the former the pyloric portion, which often forms a large pocket almost separated from the rest of the stomach, is the part which reaches farthest downwards. If the stomach is emptied, as it is intended that operation should bring about, the remainder of the stomach, *i.e.* the fundus major, occupies the vertical position, and any opening on its anterior or posterior wall is, in the erect position, considerably higher than the dilated pyloric portion.

the lumina, but also to temporarily arrest the hæmorrhage. We have already referred to this procedure in regard to the arrest of hæmorrhage and the danger of thrombosis. He that is more cautious will provisionally close the intestine above and below with two ligatures without including the mesentery, and will have the stomach held by an assistant in such a way that it is kept closed at the area of operation by apposition of its walls.

The loop of jejunum is now applied to the stomach vertically in such a way that the proximal limb ascends posteriorly, while the distal limb descends anteriorly (Fig. 91). The sutures are applied transversely to the intestine and in the long axis of the greater curvature of the stomach. Before, however, the sutures are introduced a transverse fold is made in the proximal limb in the following

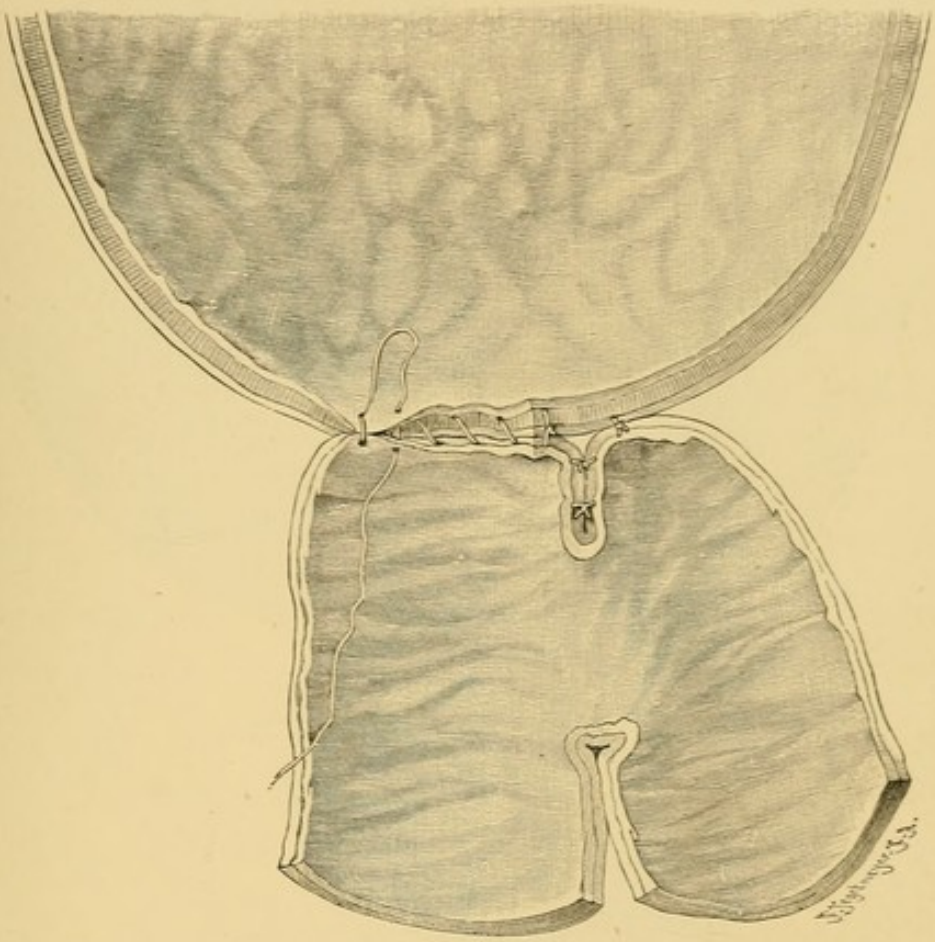


Fig. 90*a*.—Gastroenterostomosis antecolica inferior. A fold has been made in the convexity of the loop of jejunum, and this has been fixed to the stomach by sutures (sagittal section). The deep sutures for the anastomosis have been inserted through all the coats, and the continuous serous suture is 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.

manner (Fig. 90*a*): at the top of the loop the convex half of the circumference of the bowel is folded inwards towards its lumen, and the fold is maintained by a serous suture which includes also some of the muscular layer. By means of two or three stitches the folded (invaginated) area is then sutured to the stomach behind the greater curvature in a direction parallel to the line of anastomosis. The intestine and stomach now lie in contact, and in the intestine, as schematically represented in Fig. 90*a*, a spur is formed, which prevents the passage of the stomach contents into the proximal limb of the intestine, and *vice versa*. In the figure the spur is represented too short.

The posterior segment of the continuous serous suture (seen in Fig. 91 with its end left long) is now introduced transversely so as to unite the stomach and intestine parallel to, and in front of, the sutures which fix the spur to the stomach. The stomach and intestine are then incised[1] down to the mucosa, and the posterior segment of the circular suture is introduced through the muscular and serous coats; the mucous membrane is then divided, and is accurately sutured with the same thread in the reverse direction, while anteriorly it unites the two anterior

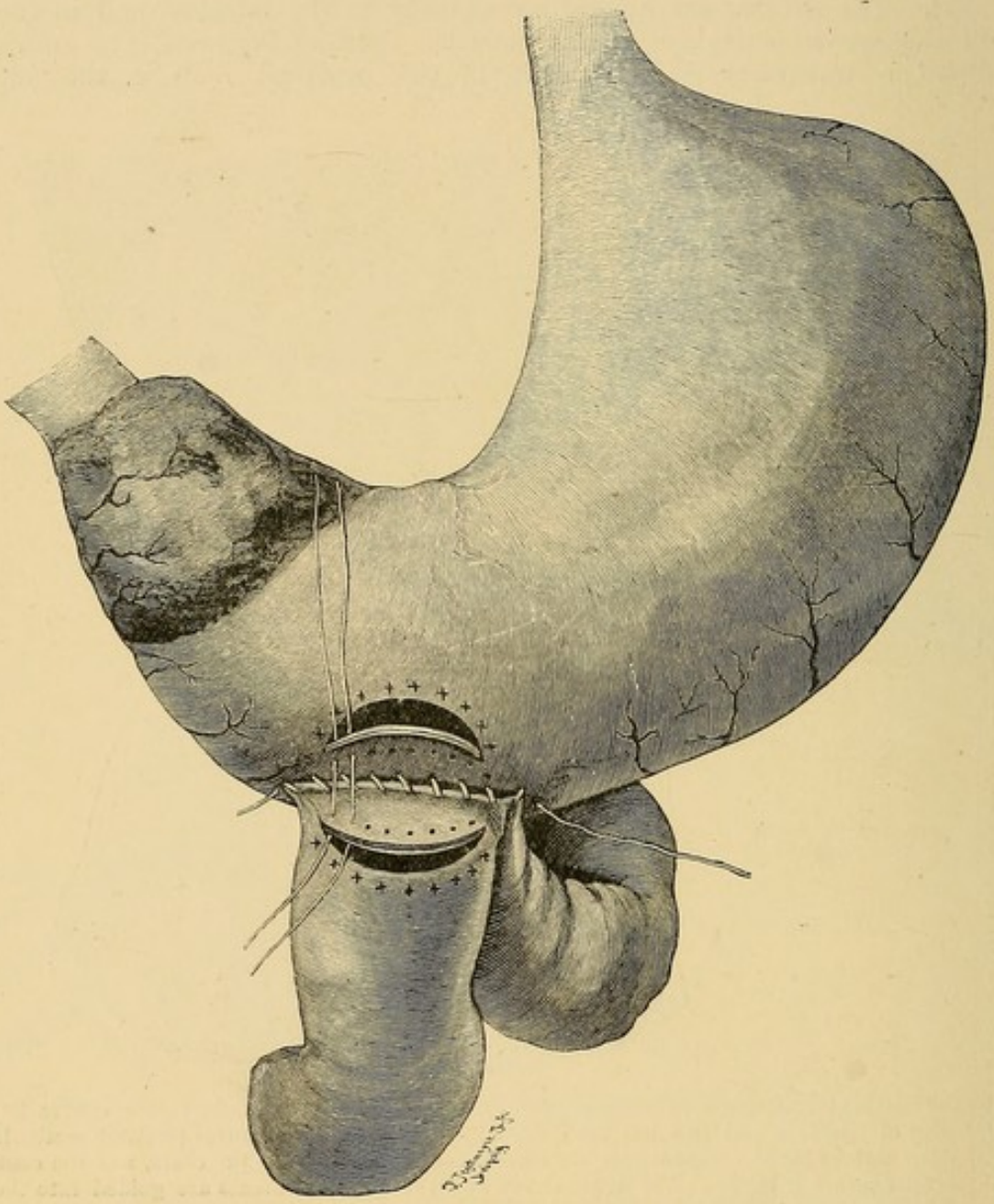


FIG. 91.—Gastroenterostomia inferior antecolica. The jejunum at a point 16 ins. from its commencement has been applied vertically to the greater curvature of the stomach (in the figure the opening in the stomach is drawn too high above the greater curvature), and the two have been united with a continuous 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.

segments of the openings by passing through the entire thickness of the wall, *i.e.* including the mucosa. Outside this, after previously cleansing the lines of suturing along with the surroundings, and changing the soiled gauze, the anterior segment of

[1] In the figure the incisions in both stomach and intestine are drawn too convex.

the circular serous suture is introduced and is knotted with the long end of the posterior suture. In Fig. 90*a* the posterior sero-muscular suture is introduced, and the mucous suture begun.

It is very essential to make the incision in the stomach as large as possible. With

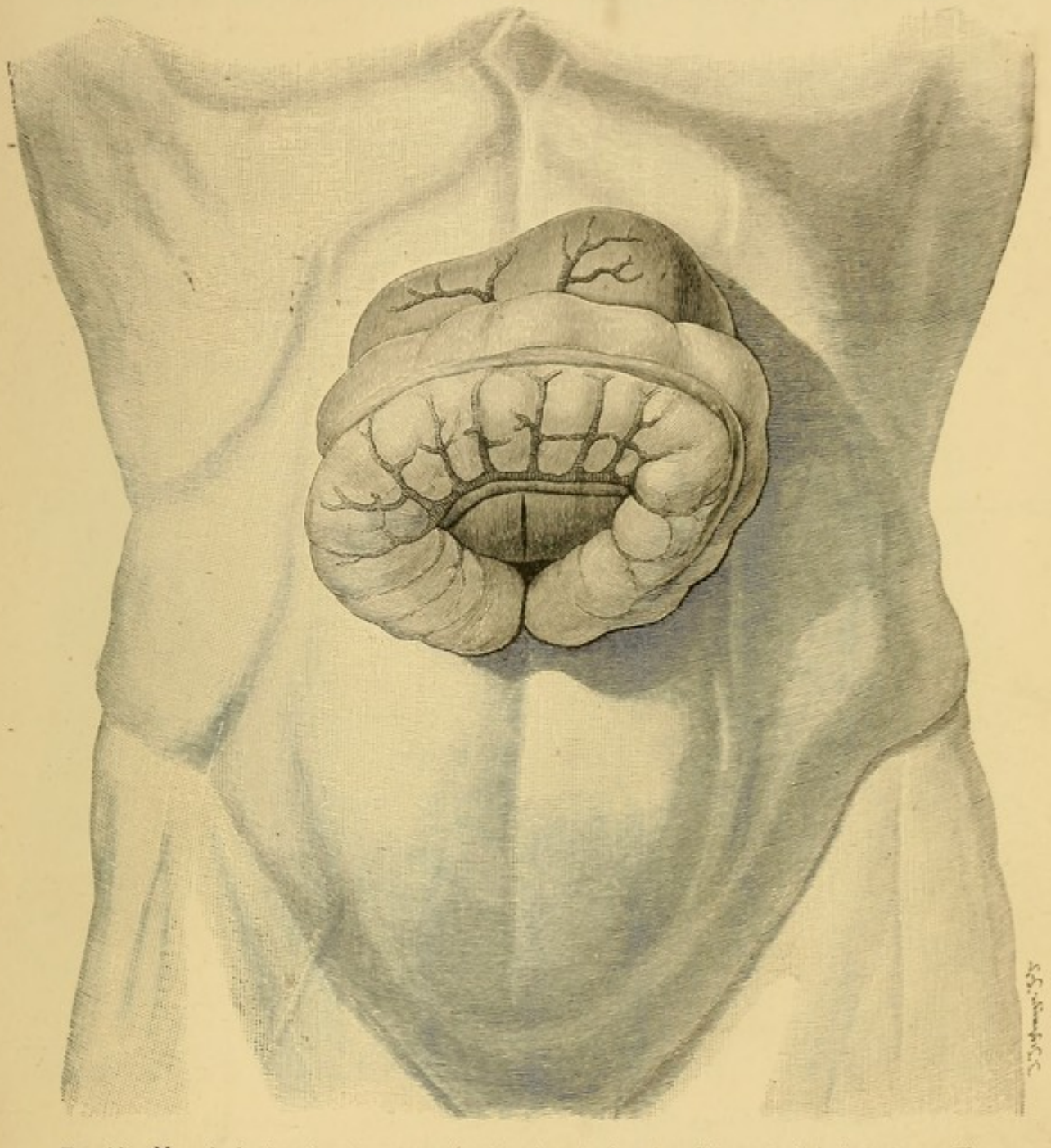


FIG. 92.—**Y**-method of gastroenterostomy (gastroenterostomia retrocolica posterior), first stage. The stomach has been pulled out and thrown upwards along with the transverse colon. Below the loop of colon the posterior wall of the stomach covered by transverse mesocolon is seen; a longitudinal incision has been made into the latter.

this object the entire convex half of the intestine must be so sutured (Fig. 91) that the incision can be made to correspond to half the circumference of the intestine. Indeed the opening in the stomach must be somewhat larger than the opening of the

intestine; in the figure (Fig. 91) it is drawn rather too small. Hacker has made a similar fold in the intestine, as also has Sykow, but Hacker gives himself unnecessary difficulty by employing his gastroenterostomosis retrocolica, while Sykow does the same by employing a complicated method of union.

It is well for the patient to occupy a half-sitting position after the operation. Everything depends on whether stagnation of the stomach contents can be prevented

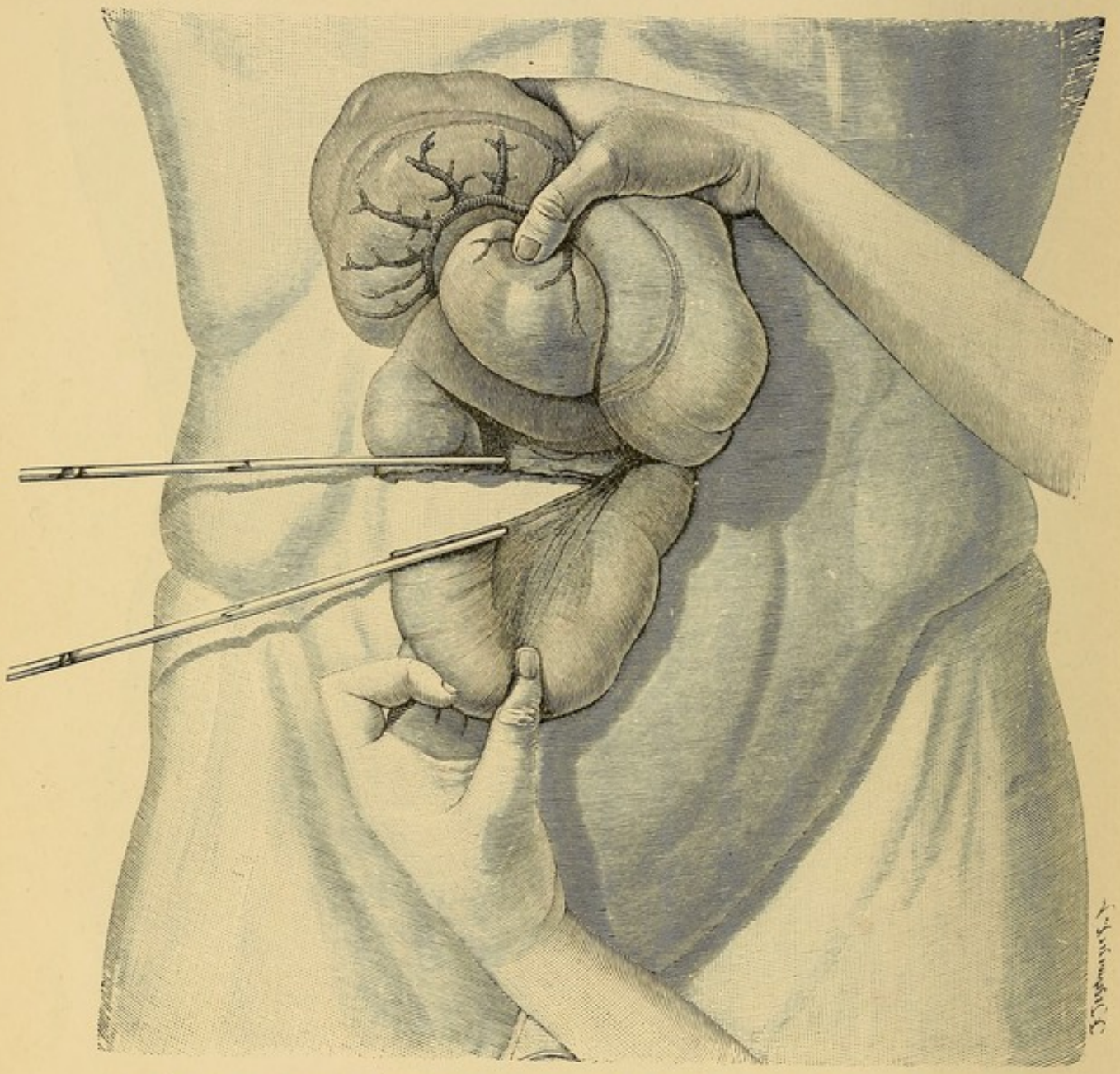


FIG. 93.—Y-method, second stage. The loop of jejunum is pulled forwards and divided between two pairs of compression-forceps, the division being carried into the mesentery; the posterior wall of the stomach is projected through the opening in the transverse mesocolon by the fingers of the right hand.

from the very first. If decomposition of the gastric contents exists, the stomach must under all circumstances be washed out on the first day. There is ample proof that the sutures hold better on the first day than later on, so that there is nothing to fear from careful washing out. Decomposed stomach contents can convert symptoms

of intoxication[1] into a real collapse, and may give rise, through absorption, to metastatic inflammations, especially pneumonia. Such marked decomposition occurs but seldom in cases of simple ulcer; it is met with especially in putrid cancerous ulcers.

127. Gastroenterostomosis Retrocolica (Roux's Y-method).[2] After opening the abdomen, the stomach and transverse colon, along with the omentum, are thrown upwards, the mesocolon is incised between the vessels, and the posterior wall of the

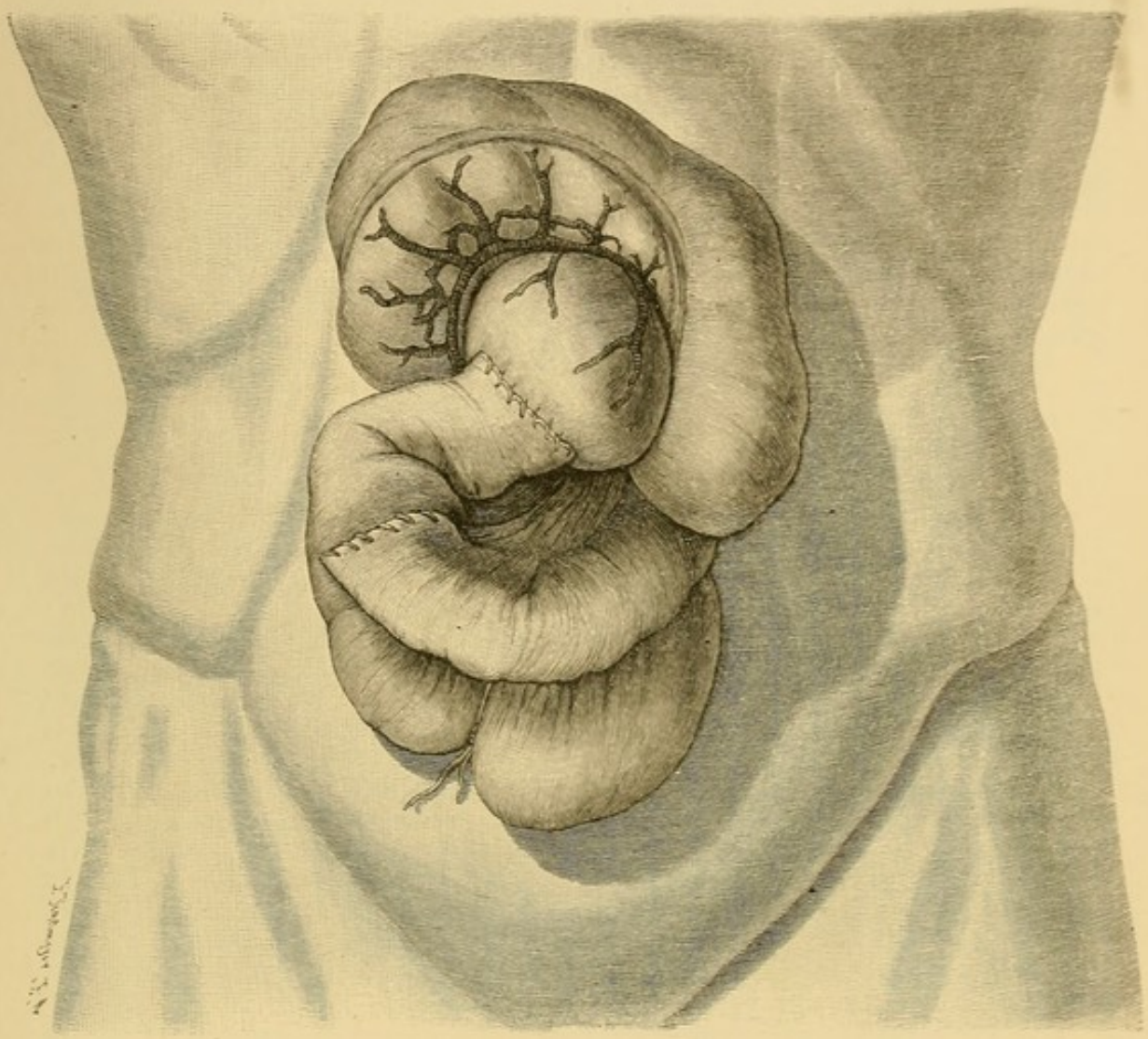


FIG. 94.—Y-Method, third stage. The lower end of the divided jejunum is stitched to the posterior wall of the stomach with a double row of continuous sutures; the upper end, after being folded downwards and to the left, has been anastomosed with the bowel below. A temporary ligature has been tied round the emptied loop of bowel.

stomach exposed. The edges of the opening in the mesocolon are stitched to the

[1] As regards the washing out of the stomach, we would remark that it must always be done with great care by the surgeon himself. If the water be cold instead of warm, if an antiseptic solution be used instead of physiological salt solution, and if the washing be continued for half-an-hour instead of a few minutes, and if it be left to the nurse to do it, one need not wonder if collapse should occur.

[2] We have already stated that the Y-method also retains all the advantages when it is performed in the simpler and more certain manner of a G. antecolica, provided the loop of jejunum which is united to the stomach is situated 16 to 20 ins. below the duodeno-jejunal flexure. By the posterior method the nearest point of the jejunum may be taken. The suturing of the intestine to the posterior wall of the stomach has no essential advantages in the Y-method.

posterior wall of the stomach by a couple of sutures. The incision through the mesocolon is shown in Fig. 92.

The jejunum is then drawn forward. The loop need not be too far removed from the commencement of the jejunum, as it does not require to be brought round the transverse colon. The intestine is grasped with two artery forceps (author's pattern) placed close together and then cut across between them, the incisions being carried into the mesentery as far as the first large arterial arch. The intestine above and below, together with the incised portion of the mesentery, may be clamped with forceps, or the two openings of the bowel may be kept closed provisionally by a ligature.

The stomach is now drawn through the opening in the mesocolon below the transverse colon (Fig. 93) and the distal portion of the bowel applied to it vertically. The proximal portion, as shown in Fig. 94, is then turned downwards as far as its mesentery allows, and is made to join the left side of the distal bowel, and to approach it from left to right.

Since we have to anastomose the divided ends of the intestine they may be closed with pressure-forceps of the angiotribe kind, and the sutures introduced before allowing the lumen to gape, but by this means accurate suturing of the mucosa is not possible. In this connection we must refer the reader to the introductory remarks on gastro-intestinal surgery (p. 190).

Gastroduodenostomy.—See Appendix.

Gastrectomy (Gussenbauer-Billroth's operation)

128. Indications and Methods. This operation is generally termed Billroth's operation. It was performed before him by Péan and Rydygier in 1879. Péan, however, had not fully appreciated the significance of the operation. Rydygier, on the other hand, gave very complete directions for its performance.

Billroth performed the first successful resection on the basis of the careful experimental researches of Gussenbauer, Winiwarter, Czerny, and Kaiser. At the present time hundreds of successful operations have been performed. We have ourselves done seventy-eight pylorectomies for cancer of the stomach, including two complete excisions of the stomach.

Broquet, one of our pupils, has reported all the fifty-two cases operated on by us from 1881 to 1898. Since 1898 we have operated on other twenty-four cases. It is obvious that, to commence with, when asepsis and the details of the operation were still incomplete, the results were distinctly worse than at present. Thanks to the continued efforts of many surgeons to improve the technique of the operation, they are now excellent. If we include all our cases, they give a mortality of 29·3 per cent, *i.e.* twenty-two out of seventy-five died as a result of the operation. Of the twenty-four cases operated on since Broquet's publication only four proved fatal.

But this statistical method gives a far too unfavourable idea of the possibilities of the operation. The fatal cases of the later period occurred almost without exception in patients who, in consequence of the far too advanced state of the disease, should not have undergone the operation; they merely prove that we have advanced very far with the operative treatment. Of the four fatal cases which have occurred out of our twenty-four operations during the last two years, there were two in which we were obliged to proceed to resection. The carcinoma in both cases was found to be so adherent to the anterior abdominal wall that it was torn during the exploratory laparotomy in the attempt to separate and investigate it; the operation had therefore to be performed against our will. Such cases must not be included if one desires to obtain a true idea of the danger of the operation. There remain, therefore, twenty-two cases with two deaths, a mortality of 9 per cent. This comes much nearer the truth. But these two fatal cases were far advanced, the one very difficult on account of adhesions, the other in a patient who was very reduced, who died as a result of putrid bronchitis and pneumonia, and who was already suffering from brown atrophy

of the heart. We may consider, therefore, that resection of the pylorus when done early enough for a movable carcinoma has now become an operation unattended with danger. Indeed, the complications formerly so much feared, such as adhesions to the transverse colon, no longer alter these favourable prospects. Of the four cases out of the twenty-two above referred to, in which a portion of the colon had at the same time to be resected, all recovered.

From the fact that we have performed so many pylorectomies in such a comparatively short time, while the number of gastroenterostomies for cancer have become much less frequent, it is very evident that we have taken a wide view of the indications for resection, and have not selected merely the favourable cases. When we take into account the methods of operation the results will be seen to be still more favourable. We have performed "resection with gastroduodenostomy," the operation which we prefer, fifty-two times, and even if we include the earliest cases (from 1888) the mortality is only 15·3 per cent. In the last twenty-two cases it reaches only 5·5 per cent, as in one of the above-mentioned fatal cases the operation was performed according to Billroth's second method.

Guinard has collated 291 resections of the pylorus performed between the years 1891 and 1898, and has found the mortality to be 35·3 per cent. Of these 148 were operated on by the Billroth-Rydygier method (*i.e.* Billroth's first method) with 37·8 per cent of deaths, sixty-four by our method, with only 15·64 per cent of deaths. It follows, therefore, that even in the hands of the less experienced the mortality by our method gives relatively favourable figures, since they are almost identical with those which we ourselves have had, when we include those operated on during the probation period, as well as those done after the technique of the operation was perfectly developed.

The conditions are different when we inquire into the *ultimate results of the operation*. Of the patients operated on by us, eighteen, perhaps twenty-one, are still alive; but if we demand as a radical cure a freedom from recurrence for three years, as in cancer of the mamma, then the majority of the eighteen cannot yet be regarded as permanent cures. On the other hand, no less than six of our cases have been well three years and upwards (two patients four years), and two of them have died without recurrence. As permanent cures we can only speak of two cases, one patient after eight, and the other after thirteen, years being still in the best of health.[1] A patient of Czerny's lived over seven years; one of Wölfler's lived five and a half years. Maydl publishes the case of a patient who lived eight and three-quarter years after operation, Chaput that of a patient who lived five years, etc. In those who survive, and in whom recurrence takes place in the glands, in the liver, or in the peritoneum, the confirmatory researches of many investigators (Kaensche and Rosenheim, Mintz) show that the chemistry of the stomach does not improve, but that the motor function is completely restored. The symptoms of which the patients had complained completely disappeared, in not a few cases for months, and even years, the patients looking healthy and being able to work until recurrence occurred, which often gave rise to grave symptoms only a few weeks before death.

The permanent cure of cancer of the stomach is exceptional, even at the present time. In 12 per cent of our cases there was a very definite prolongation of life, while improvement in the symptoms for months, and even years, can be predicted with certainty.

The question arises as to whether the method of operation is calculated to exercise an essential influence on the permanent results. That the immediate results are really influenced by the method is shown by the statistics of Guinard. Smaller statistics, however, show that with the necessary practice good results are to be obtained by all methods. Maydl, even with the Rydygier-Billroth method, has had twenty-one recoveries out of twenty-five operations.

[1] Wölfler in 1896 collected the results of different surgeons, and Defossez, on the advice of Hartmann, has completed the summary and collected eighteen cases who have lived over four years after the operation.

But of still greater importance than practice in the technique of the operation is the period at which the cancer of the stomach comes for treatment. Early operation gives a distinctly better result, and Maydl attributes his good results mainly to the circumstance that the doctors recommended the patients to him early. That is, and will always be, the prayer of the surgeon to the physician and practitioner. We have, moreover, in recent times endeavoured, as in other cancers, to make the method of operation more radical.

We are indebted to Hartmann, through the investigations of Cuneo, for the information we have as to the extent and spread of cancer of the stomach, and for the necessary modifications in the technique. Carle and Fantino, in their admirable work, also demonstrate the paths of dissemination of the cancer. Carcinoma of the pylorus spreads most markedly along the lesser curvature, and not merely in the glands which accompany the coronary artery, but also in the form of cancerous foci in relation to the lymphoid deposits in the lesser curvature. Hartmann's operation is planned to meet this tendency. Whether it will lessen the recurrence cannot yet be shown from Hartmann's statistics, which are still too recent.

We should like to draw attention to the important fact, which we have repeatedly stated, and which has been confirmed by the investigations of Cuneo, viz. that cancer of the pylorus is sharply limited towards the duodenum. Hartmann, however, always removes a strip of the duodenum, as now and then a slight infiltration is found in the lymph vessels of the submucosa running towards the duodenum. Hartmann has therefore adhered to gastroduodenostomy in all cases where the duodenum can be sufficiently isolated. This shows how unjustifiable is the scorn of a surgeon—a famous man, and a dear friend of mine—who remarks that surgeons who perform gastroduodenostomy are as bad as those who sketch out beforehand the plastic flaps in an excision of the mamma. One might turn the reproach in the other direction.

As shown by Hartmann and Cuneo, one must remove the whole chain of glands which lie in relation to the pyloric and coronary arteries, together with the arteries themselves and the lesser curvature, along which the disease is disseminated "with extraordinary frequency." The gastroduodenal artery must be ligatured, and the glands which extend along it as far as the right gastroepiploic artery must also be removed.

To quote Hartmann's comparison, in fact, one must act here as with the mamma, where, if one is dealing with a cancer nodule in the upper and outer segment, one must not painfully dissect out the ramifications of the gland, but make a clean sweep of the skin above, and the muscle below, the diseased part, and of the lymph vessels and glands up to the axilla. Moreover, we would point out to those surgeons who regard excision of the pylorus with subsequent gastrojejunostomy as preferable to our present method, that we were the first in 1887 at the Congress of German Surgeons to assert the principle that, after excision of the carcinoma, the stomach should be closed, and the operation completed by performing a gastroenterostomy, while Billroth proposed that this, his second method, should be resorted to only in difficult cases. We had also at that time recommended gastrojejunostomy and performed it a few times, until we saw that gastroduodenostomy gave still better functional results and was more rational—obviously only in cases where it admits of exact suturing and thorough removal of the disease.

We believe at the present time that the majority of surgeons adhere to this principle (Mikulicz, Garré, Hahn, Roux, Hartmann, Souligoux), and by a number of surgeons gastroduodenostomy is specially preferred (Wiesinger, Alsberg, Krumm, Zoege-Manteuffel according to Fick, Graser, Hartmann, Guinard, Carle, and Fantino, and Hochenegg according to Porges). We have at the present time, besides the original Rydygier-Billroth method of direct reunion of stomach and intestine (as adhered to by Krönlein, Kappeler, Eiselberg, and Maydl), a modification of it by Henle-Mikulicz, in which the duodenum alone is closed, while the lower part of the stomach wound is left open, and to it is stitched a loop of jejunum. Krönlein and Körte have used this method. It has the disadvantages of Billroth's method, but

is preferable to it when the duodenum cannot be drawn forward so as to admit of satisfactory suturing.

Then comes Billroth's second procedure (which we recommend for general use), in which the stomach is closed and the intestine is implanted into a special opening at the lower part of the posterior aspect of the stomach (either the jejunum according to Billroth, or the duodenum, as we recommend). This method has the great advantage that in the hands of less practised surgeons much greater certainty is afforded of preventing the escape of gastric and intestinal contents, and it enables the sutures to be much more easily introduced. Excision with gastrojejunostomy is easier than gastroduodenostomy, but the former has all the disadvantages of gastrojejunostomy, at any rate for those who do not know how to avoid the vicious circle with certainty. This can be prevented by the method of Roux (which, however, entails a second anastomosis, and therefore prolongs and complicates the operation), or by our gastroenterostomosis antecolica inferior.

We maintain, therefore, that the procedure of closing the stomach and implanting the intestine into a special opening is to be preferred. Proof of the correctness of this statement is furnished by the fact that the statistics—including those of all surgeons—are distinctly better.[1] We therefore recommend gastroduodenostomy, which gives the best functional result, in all cases where the carcinoma is strictly limited to the pylorus,[2] and where the duodenum offers sufficient mobility. We recommend gastrojejunostomy, according to our method, when the duodenum cannot be drawn forward, or when it has to be too much shortened by the operation. We advocate the Y-modification of Roux when the patient can stand the prolongation of the operation necessitated by a second anastomosis. It is true it can be very rapidly performed in practised hands, but general propositions are not primarily intended for skilled surgeons.

129. Partial Gastrectomy. In the introductory remarks on gastro-intestinal surgery we have already drawn attention to the points which are necessary to ensure success in resection of the pylorus and other parts of the stomach, and have described them fully in the earlier editions of this work. We have, therefore, only to refer to a few main points. It is obvious that the treatment of the wound and of the peritoneum must be purely aseptic, and that the general peritoneal cavity must be securely shut off by tampons from the field of operation; and it is especially important there should be no escape from the stomach in dealing with putrid cancerous ulcers.

This indication can only be satisfactorily accomplished by the application of clamps. Where clamps cannot be applied—for example, where the carcinoma has actually extended to the duodenum and its neighbourhood, or so far along the lesser curvature towards the œsophageal opening that clamps can no longer be applied on either side of the tumour, and definitely beyond it—it is better to give up the attempt to perform a radical operation. We have observed, however, from the interesting publication of Dr. Brunner, that there is still some misunderstanding as to the manner in which we recommend the clamps to be employed.

There are two uses of the clamps which must be completely distinguished: (1) the application of the clamps to the margin of the wound where the division of the stomach (and also of the intestine) is to take place, and (2) the application of the clamps at a distance from the line of section for the purpose of preventing the escape of gastric and intestinal contents from the canal beyond, as well as with the object of provisionally arresting the hæmorrhage. When the clamps are applied at the line of

[1] Roux (through Dr. Kolbe) has recently published the results of his resections of the stomach. Of thirty-nine cases fourteen died; of these sixteen were operated on by the Rydygier-Billroth method with five deaths, ten by the Billroth-Roux method with four deaths, ten by Kocher's method with four deaths, three according to Billroth-Hacker with one death. We have to remark that the explanation why Kocher's method does not appear more favourable is, in the first place, because a case of gangrene of the colon is included, which must be a mistake, and, secondly, because three deaths after Kocher's method were cases in which a Murphy's button was employed. All the cases recovered which were operated on strictly according to the author's method with suture alone.

[2] The method has yielded the longest permanent recovery so far recorded.

division they cannot be closed too firmly in order to avoid escape of contents and to prevent bleeding. The non-elastic parts of the vascular tissues and vessels are completely crushed, while the elastic parts (serosa, vessel walls, etc.) which remain within the blades like compressed paper, are sufficient to maintain, when desired, momentary closure of the lumen of the stomach and intestine during their closure with a continuous suture. These crushing and pressure forceps (the best being after the pattern of Doyen's angiotribes and their modifications) are employed to the very best advantage where complete occlusion is to take place, for example, in resection of the pylorus with subsequent gastroenterostomy.

For years we have maintained, in opposition to the method of using clamps in vogue with other surgeons (Gussenbauer, Rydygier), that these pressure clamps can also be used without fear where sutures are subsequently to be used for anastomosis, for example to the duodenum in gastroduodenostomy. The soft tissues, namely, the mucosa and muscularis, are crushed through, and there remains only the tough elastic parts of the tissues in the bite of the forceps. These, however, are compressed to such an extent that no gangrene of them is to be feared, because they have become dry, and are gradually cast off without any decomposition. Behind these compressed areas vascular tissues suitable for union and primary healing are retained.

It is very different with regard to clamps placed at a distance from the line of suture, for the purpose merely of closing the lumen and temporarily arresting the blood-supply. Crushing is here out of the question; what is wanted is merely an elastic spring closure, of the nature of Esmarch's manner of arresting hæmorrhage. That this kind of closure is very convenient there can be no question, as it leaves the cut edges quite free for convenient and exact suturing of the different layers, and relieves the surgeon from the necessity of troubling himself to arrest the bleeding from the divided edges by other means than the suture itself.

The disadvantage of the elastic spring clamps is the difficulty of hitting just the right pressure in order not to produce too severe a lesion of the mucous membrane, which may lead to ulceration and hæmorrhage; and we must not set up thrombosis by too long occlusion of the vessel, which would give rise to necrosis and inflammation. This is a matter of experience, and it is always advisable not to apply the clamps a moment sooner, or leave them on a moment longer, than is absolutely necessary. If they can be dispensed with so much the better.

We have devoted more space to this question because we find this essential distinction nowhere sufficiently brought out, and because we maintain that the method of closure by clamps is a very important factor in the result. Besides this, the definite closure by suturing must be thoroughly reliable. Next let us mention once more the necessity of using fine silk for suturing. How any one can still use catgut for the whole suture is, to us, incomprehensible. The chief suture, which penetrates the whole thickness of the stomach wall, should undoubtedly be of silk. There is nothing, however, against the use of catgut for the mucous membrane with the object of its being absorbed. We use it occasionally ourselves. If it be desired to use catgut for the serous suture with the object of avoiding a permanent foreign body upon the serous surface which might give rise to the formation of adhesions, that also can be excused, although the fine silk sutures become subsequently so well embedded in the smooth serosa that they are scarcely recognisable.

The sutures should always be continuous. Where it is possible, an isolated mucous suture is very valuable for preventing the passage of intestinal contents between the stitches. No surgeon would care to omit the Lembert's serous suture for the purpose of securely uniting the peritoneal surfaces; but Madelung, who uses merely a simple row of sutures, is right in maintaining that the union is mainly brought about by the silk suture, which penetrates all the divided layers, and which arrests the bleeding from the edges of the wound.

The preparatory and after treatment of the patient has an important influence on the result. Here two points stand out prominently: the feeding of the patient, and the prevention of decomposition of the gastro-intestinal contents. The nutrition

of the patient, which is often at a very low ebb, cannot be secured without considera tion of the latter point. A patient with decomposing stomach contents and chronic intoxication cannot be nourished. The stomach before, and, when necessary, after the operation, and indeed on the day of the operation, should be emptied as soon as decomposition of its contents sets in. We have already stated in connection with gastroenterostomy that this may be done in so dangerous a manner that the patient may be brought to the operating table in a very collapsed condition. This happens if inexperienced assistants, or nurses, work at a patient for a half to one hour with ordinary water at any temperature, or, what is still worse, with antiseptic solutions, in order to get the washings to return clear.

This must certainly be avoided. A short washing out with physiological salt solution at the temperature of the body, with the patient in a suitable position, without using any pressure, and without completely emptying the stomach, has no bad results.

The patient must, of course, be nourished, and it is in these cases that the introduction of fluids before and after the operation is of such great importance. Our method consists in the introduction, subcutaneously, several times a day, of 35 oz. of warm salt solution, and in the repeated administration per rectum of 3½ pints of sterilised milk. By the mouth, concentrated food in the form of strong jelly (from 2½ lbs. of meat boiled for seven to eight hours in a flask), with somatose, or similar nutritious preparations, is often the only nourishment which can be taken in stricture of the pylorus without harm. In decomposition of the stomach contents the simultaneous administration of a slight antiseptic (bismuth) may be beneficial. In nourishing the patient after the operation no surgeon has gone so far as Roux, who allows the patient to have whatever food he fancies.

It is scarcely necessary to mention that patients who are reduced to a weak state must be kept warm (heated operating table) during and after the operation, and that the anæsthetic is to be administered in its lightest form (ether diluted with air in Braun's flask), and is to be limited to painful parts of the operation, such as cutting and pulling on the peritoneum.

130. Gastrectomy with Gastroduodenostomy. A mesial incision is made from the apex of the ensiform cartilage to the umbilicus, and, when more room is required, a transverse incision is added, extending as far as the outer border of the rectus abdominis (Hartmann). The tumour is seen and lifted out. Slight adhesions may often be separated by introducing the hand. If the tumour cannot be lifted out strong adhesions will be found to exist, either in the neighbourhood of the pancreas, of the transverse mesocolon, or with a retroperitoneal bunch of glands towards the posterior abdominal wall, or, where the disease is widespread, with the spleen and the diaphragm. The suspicion then already exists that a radical operation is out of the question.

After ascertaining exactly the limits of the tumour, and the mobility and possibility of separating glands, the lesser omentum and the gastrocolic ligament are perforated at the margin of the new growth towards the fundus of the stomach, and two large pressure-forceps are applied quite close to each other, and closed as firmly as possible. After gauze pads have been placed beneath the forceps (the aseptic protecting pads have previously been placed round the parts outside the abdomen) the stomach is cut across between the two clamps, close up to the one to the right. According to Hartmann's rule, and on the grounds of Cuneo's observations, the clamps must be applied to the lesser curvature as high up and as much to the left as possible; and in order that the glands that accompany the coronary vessels may at the same time be removed, it appears to us advisable to double ligature and cut across the coronary artery above the point where the section is to be made (Fig. 95). By dividing bloodlessly the small omentum above the glands, the divided stomach is rendered so movable that it can be turned over to the right side (Fig. 96).

Hartmann places value on the last procedure, because the fatty tissue and glands can then be followed up along the lesser curvature, and can be included

in the removal as far as the origin of the pyloric and the gastroduodenal branches of the hepatic artery. The latter vessel is carefully avoided, while the two first named are ligatured. After throwing the stomach over towards the right margin of the wound, one sees quite well the gastroduodenal artery running downwards in the groove between the duodenum and pancreas (Fig. 96). In this way no bleeding should occur in detaching the chain of glands which accompany this

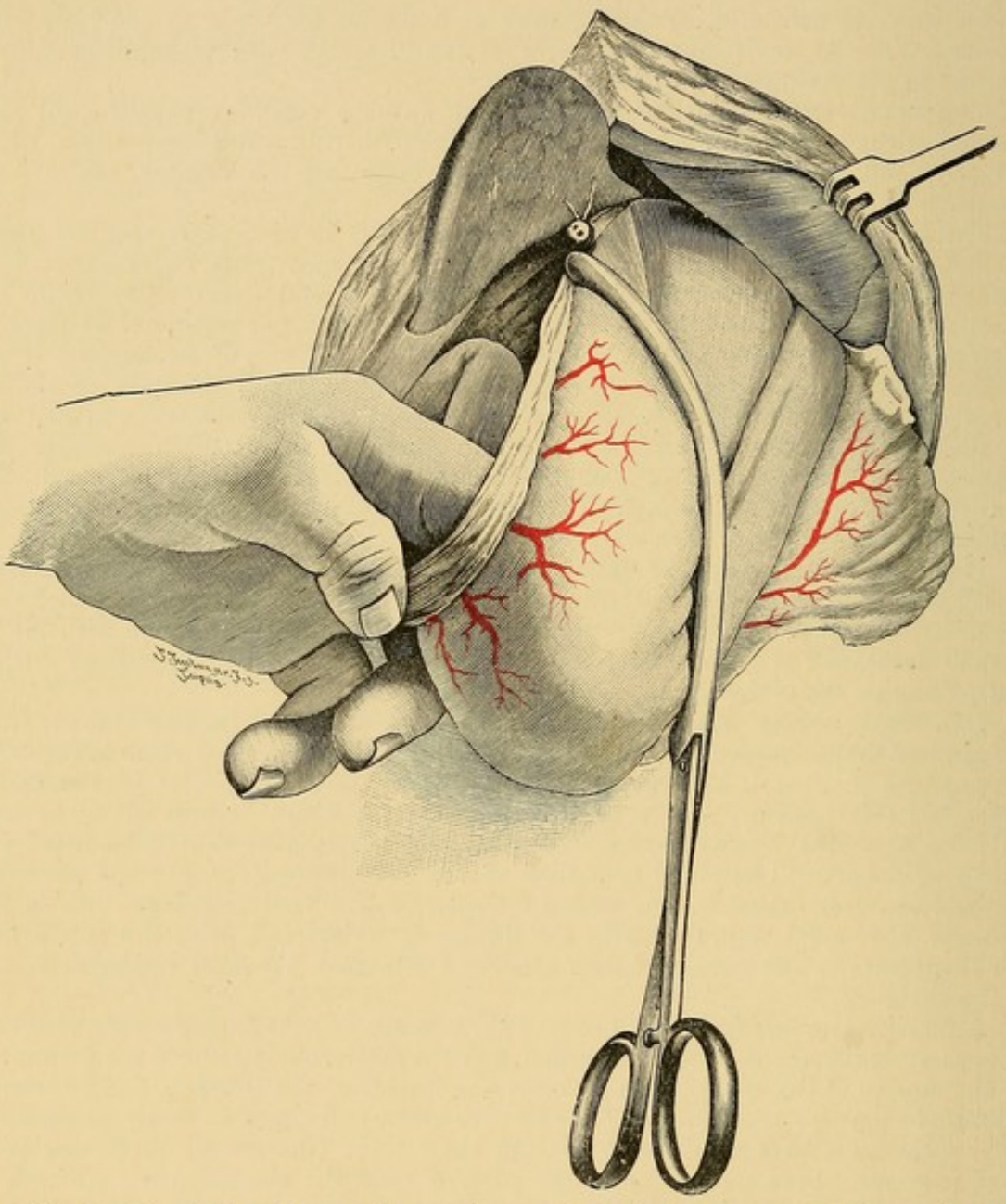


FIG. 95.—Resection of the pylorus, with extensive removal of the lesser curvature (Hartmann's modification of our method). The coronary artery is ligatured, the small omentum is torn through with the finger and left attached to the lesser curvature. The forceps are applied so as to include the greater part of the lesser curvature. Above the pyloric portion of the stomach is seen the left lobe of the liver, which is turned upwards.

artery along the above-mentioned groove. We can manage quite well without ligaturing the artery. Throwing the stomach over to the right edge of the wound has the advantage that by drawing upon it the duodenum is rendered quite accessible from behind, so that the limits of the new growth can be ascertained with

certainty, and one can determine if the duodenum be long enough and movable enough to enable one to perform gastroduodenostomy. When this is the case two small pressure-forceps are now applied to the duodenum, which is cut across between them with the knife close up to the pair farther removed from the stomach, a small pad of gauze having previously been placed under the part. The cut edges are then carefully and thoroughly cleansed.

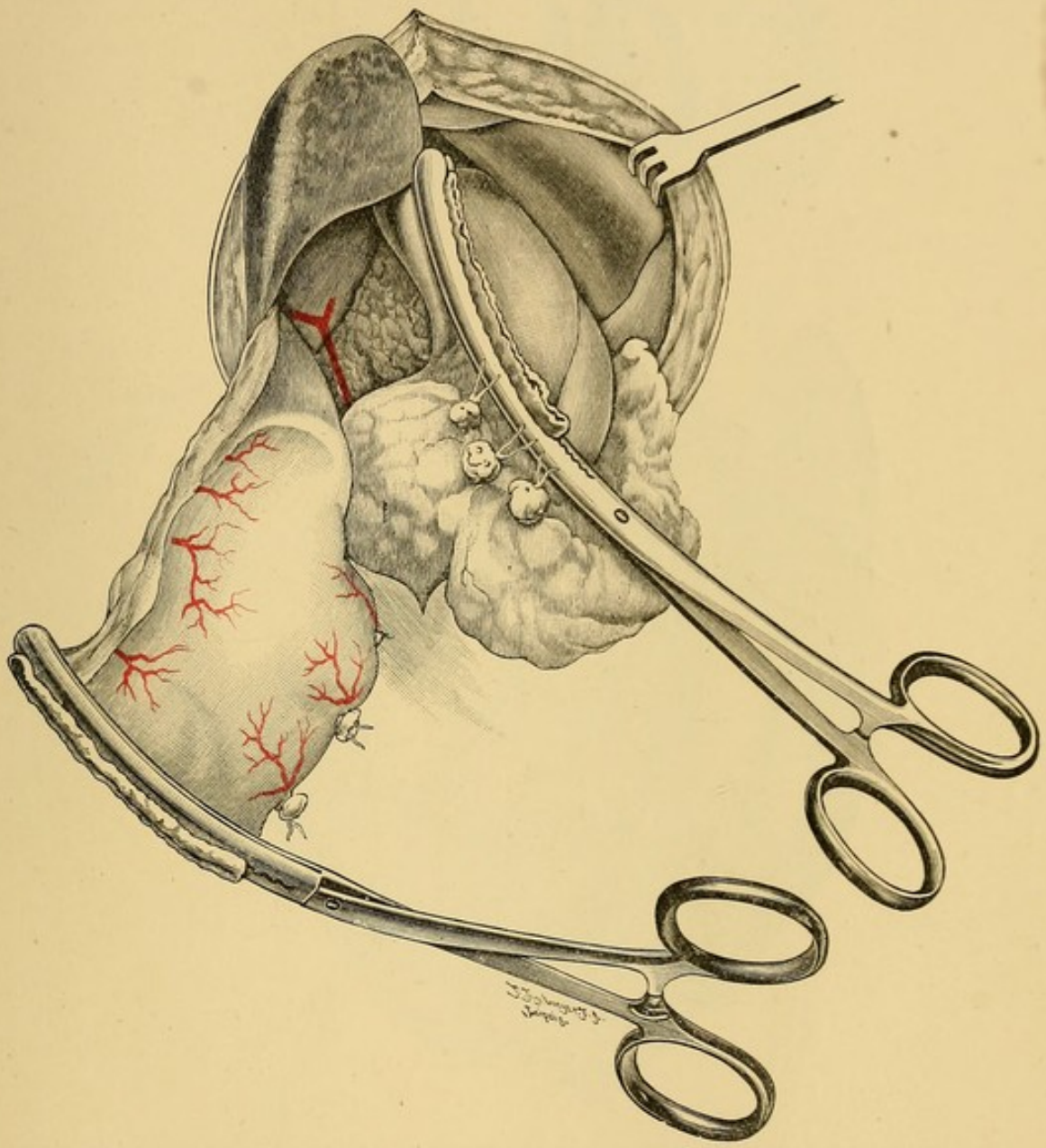


FIG. 96.—Resection of the pylorus, with extensive removal of the lesser curvature and small omentum. The divided stomach has been folded over the right margin of the wound, exposing the posterior surface of the duodenum and the gastroduodenal artery (the hepatic artery has been ligatured above it). The gastrocolic ligament has been ligatured and divided in several places. The pancreas is seen deep down in the wound.

The opening can now be made into the stomach (Fig. 97) before closing it with sutures, because the forceps in position afford a very good support. A pair of clamp-forceps is applied to the duodenum and the accompanying vessels, and the crushing-forceps are removed. The fingers of the assistant can now grasp the

stomach so that the anterior wall is pressed against the posterior wall at the place where the incision has been made; or a pair of clamp-forceps may be applied to the stomach after it has been closed by suturing and before the incision is made for anastomosis with the duodenum.

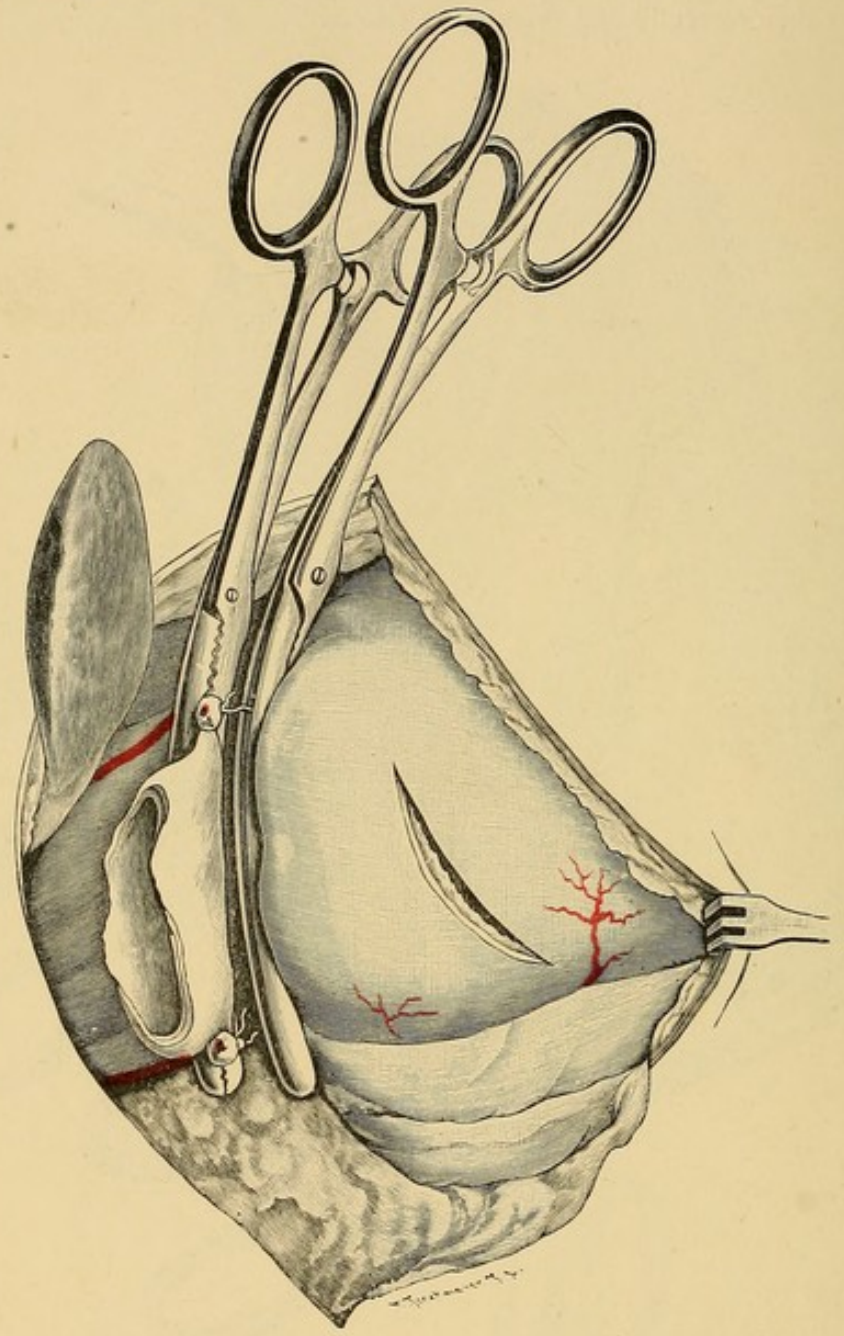


FIG. 97 illustrates the use of the clamp-forceps in resection of the pylorus; they simplify the operation, but if improperly used they may interfere with the nutrition of the edges of the wound. After the tumour is excised the clamp-forceps are applied to the stomach and duodenum to prevent escape of contents and to temporarily control the vessels. The divided vessels at the upper and lower surfaces of the duodenum are wrongly drawn; they ought to appear as if divided in the same plane as the duodenum.

The manner in which the suturing is done so as to securely close the stomach and at the same time insure against contamination by the escape of any of its contents is well shown in Figs. 98 to 101. As will be seen, a continuous mattress suture, after the manner of a half Gely's suture, is carried close behind the crushing-forceps

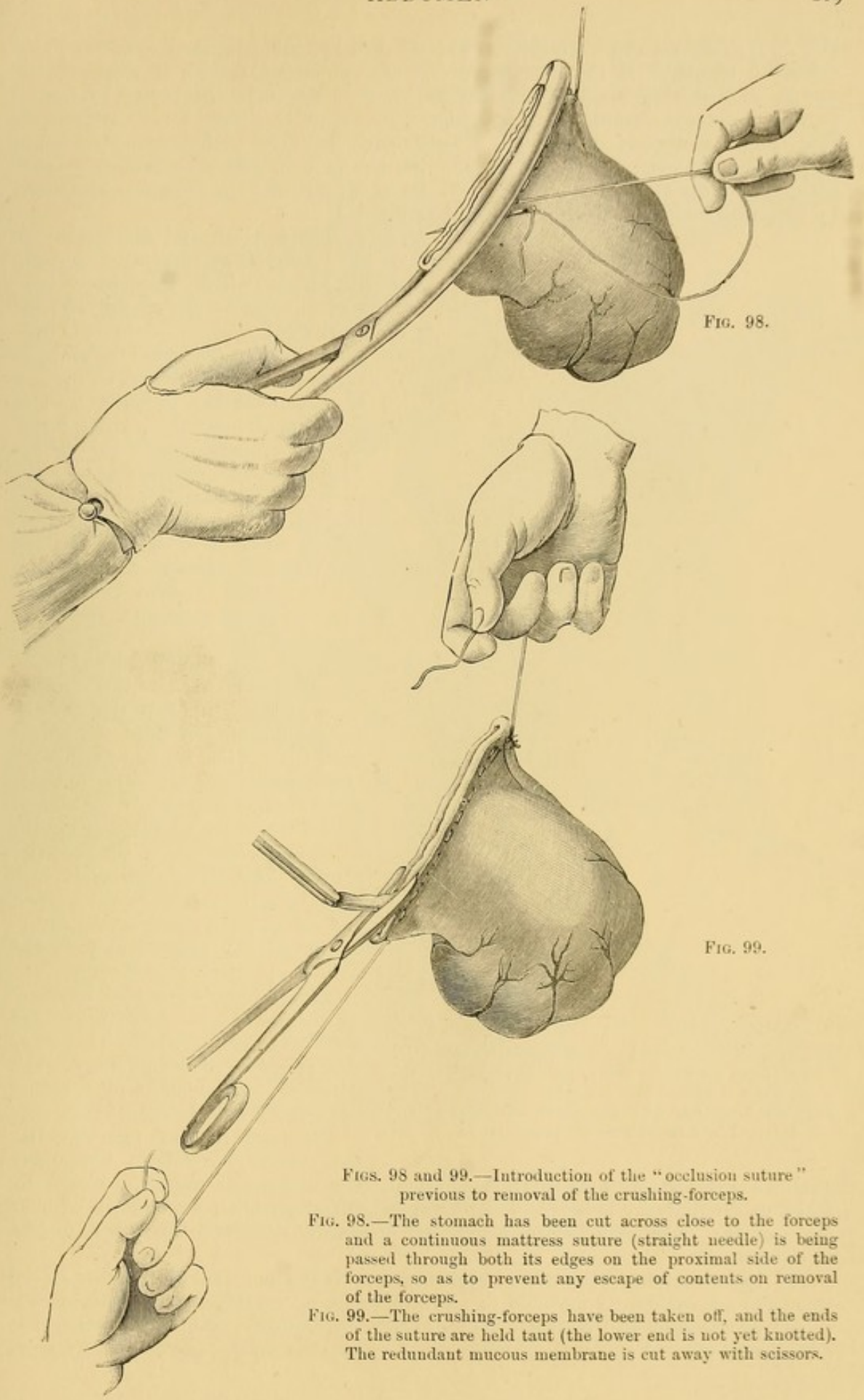


Fig. 98.

Fig. 99.

Figs. 98 and 99.—Introduction of the "occlusion suture" previous to removal of the crushing-forceps.

Fig. 98.—The stomach has been cut across close to the 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. 99.—The crushing-forceps have been taken off, and the ends of the suture are held taut (the lower end is not yet knotted). The redundant mucous membrane is cut away with scissors.

(Fig. 98); only the commencement is knotted, and by pulling on the two ends reliable closure is effected. If the crushing-forceps are not strong enough to compress the tissues so that they are like thin dry paper, it is desirable that every projecting portion of mucous membrane and muscular pulp should be clipped away with scissors (Fig. 99), but this is unnecessary if sufficiently powerful compression (crushing) forceps are employed. With the ends of the suture held taut, a continuous glover's suture is rapidly applied over it so as to fix each loop, and the closure is completed by inverting both by a continuous serous suture.

Fig. 100.

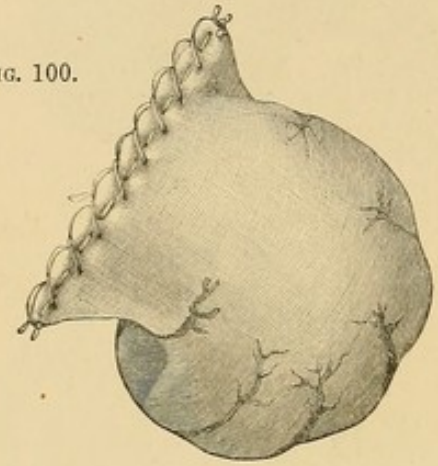
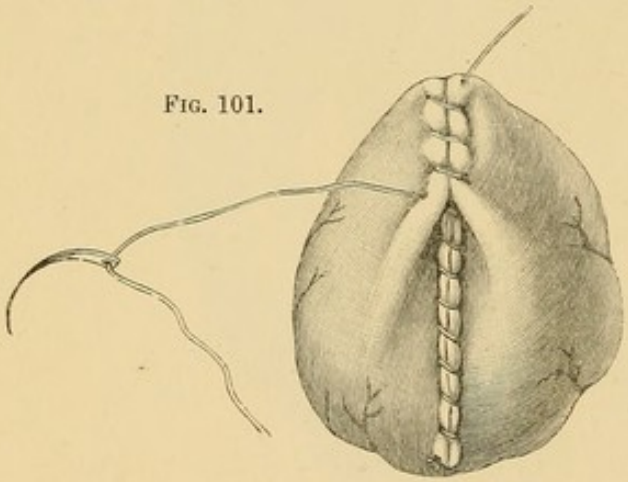


Fig. 101.



Figs. 100 and 101.—"Occlusion" of the stomach.

Fig. 100.—The stomach has been completely closed by a second continuous suture passing through all the coats and applied over the first.

Fig. 101 illustrates how the above two sutures are inverted by a continuous serous suture.

The stomach and duodenum are now clamped at some distance from the place where they have been opened, or are to be opened, and the crushing-forceps are removed from the duodenum. Escape of the contents being carefully prevented, an incision is made into the posterior wall of the stomach near the greater curvature at a distance of 3 cm. (about $1\frac{1}{4}$ in.) from, and parallel to, the sutures which close it, at first merely through the serosa, for a length equal to the breadth of the duodenum. The posterior segment of the circular suture is now applied (Fig. 102). The wall of the stomach is then completely cut through and a continuous suture, passing through all the coats, is applied so as to unite the posterior edges of the opening in the stomach and duodenum. A third continuous suture is applied so as to unite the two mucous edges. The anterior edges are now united by a continuous suture which passes through all the coats, and is knotted to the posterior suture. The clamp-forceps, if such have been employed, are removed, and lastly, the anterior serous suture is applied and knotted at each end with the posterior serous suture.

Fig. 102 shows how the duodenum and stomach are held when the fingers are employed for temporary closure instead of clamp-forceps. The posterior continuous serous suture has already been introduced.

The gauze pads are removed after the sutures have been thoroughly swabbed with warm sterilised salt solution. The abdominal wound is closed by suturing the different layers, and xeroform gauze and collodion are applied without any bandage. The skin suture is removed after three days, and bismuth is applied to the wound.

131. Gastrectomy with Gastrojejunostomy. If the duodenum is found to be too short and not sufficiently movable to allow of its being employed for anastomosis, it should be closed by an "occlusion suture." But here, instead of using the somewhat complicated method of closure which is necessary for the stomach, one can, after remov-

ing the crushing-forceps from the duodenum, and before dividing it, simply tie a silk thread tightly round the part which has been compressed, cut above it, and close the duodenum by a purse-string suture, such as is shown in gastrostomy (Fig. 88).

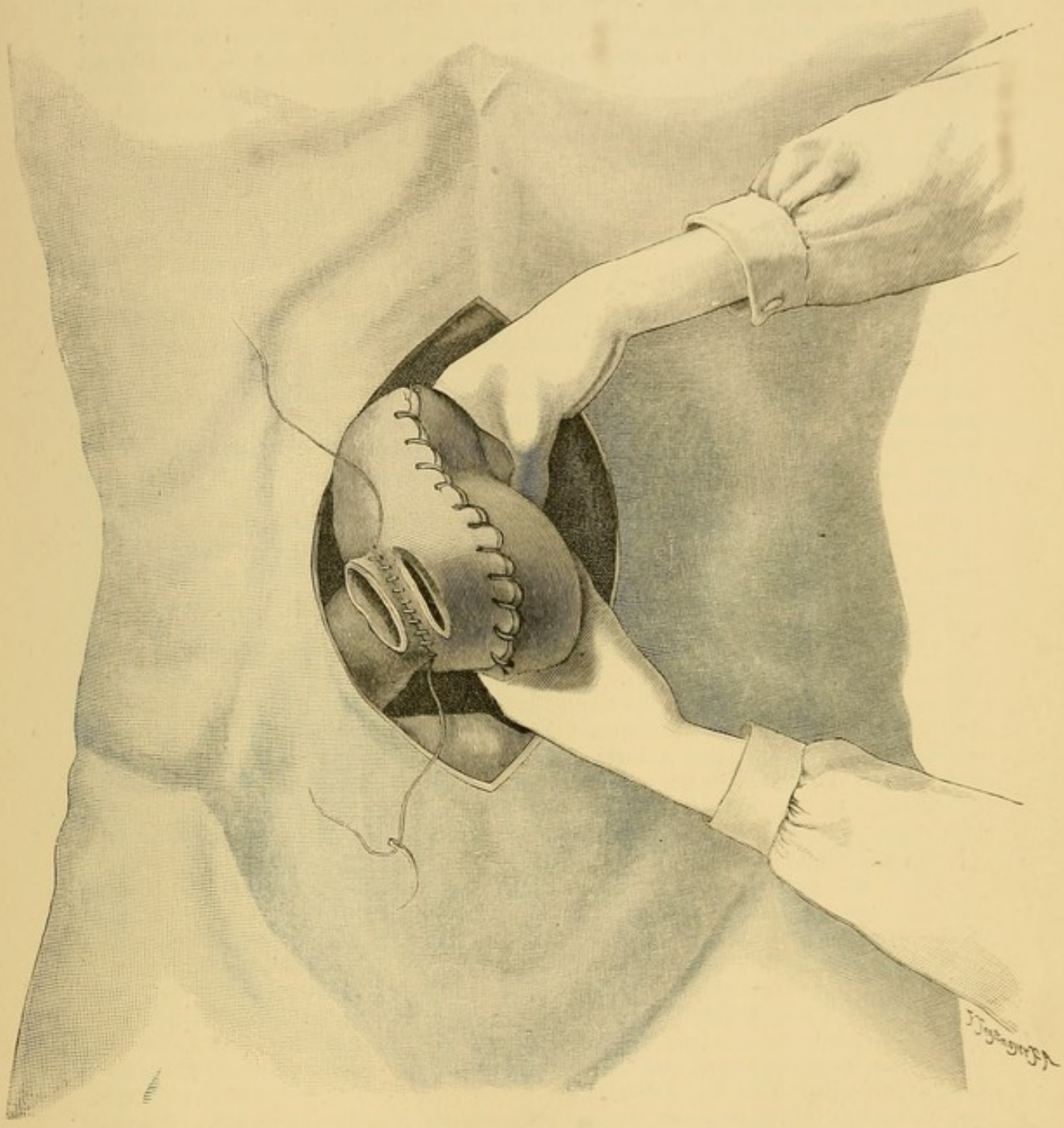


Fig. 102.—Resection of the pylorus. The stomach has been closed, and the duodenum is applied to its posterior wall. The posterior continuous serous suture has been inserted, and an incision corresponding to the lumen of the duodenum has been made in the stomach.

The stomach is closed and gastrojejunostomy is then performed according to the method already described.

132. Gastrectomy. The Rydygier-Billroth and Henle-Mikulicz methods.

If the lower part of the incision in the stomach is used for implantation of the

duodenum or jejunum, a powerful pair of compression-forceps (crushing-forceps) should be applied to the stomach from above, and only as far down as the part to be left for the anastomosis. It is specially desirable to use an angiotribe (crushing-forceps) here so as to compress the wall of the stomach into a thin sheet and facilitate the closure of the point of junction ("the critical Y-point") of the occluding and anastomosing sutures. The point at which the anastomosis is to be made may be quite well clamped with an ordinary pair of intestinal clamp-forceps if one does not want to wait before dividing it until the occluding suture has been inserted.

The stomach is then sutured as far down as the anastomotic opening, and a pair of clamp-forceps is used to close the part of the stomach in which the opening lies. The divided duodenum is now sutured to the opening left in the stomach.

The treatment of the duodenum is neither easier nor more difficult than in gastro-duodenostomy, but the latter avoids the difficulties and dangers of the Y-shaped suturing. The Rydygier-Billroth, or so-called Billroth's first method, has therefore the same limits as gastroduodenostomy. Where the duodenum is not sufficiently long or movable to allow it to be easily inserted into the stomach, it should be closed in the manner just described, and the Henle-Mikulicz operation performed by anastomosing a loop of small intestine with the lowest part of the divided stomach.

133. Complete Gastrectomy. Schlatter's operation of complete excision of the stomach is very rarely indicated, as there are very few cases in which an infiltrating carcinoma affects the greater part of the stomach without giving rise to such extensive adhesions and glandular enlargement as to make a radical operation impossible. From our experience of two patients on whom we performed the operation, the indications appear to be still further limited, because there must be sufficiently healthy œsophagus and cardiac end of stomach available to admit of compression forceps being firmly applied to the latter and a clamp to the former. If the parts cannot be satisfactorily clamped before being divided, there is a great risk of the peritoneum becoming soiled by having to work in such an inaccessible region as the œsophageal opening of the diaphragm.

We once performed the operation under these unfavourable conditions, which we now regard as contraindications. In this case, moreover, a small piece of the œsophagus was removed, with the result that the patient died of peritonitis set up by contamination with the gastric contents. In another case, which we published, forceps could be applied, and the sutures uniting the œsophagus and duodenum held excellently. The fatal issue, which was due to necrosis of the gut, was entirely accidental. In the first of these two cases we were obliged at the same time to excise the transverse colon, while in the second case we had to deal with firm adhesions to the pancreas and spleen.

There are two methods of restoring the continuity of the alimentary canal. Either a loop of the jejunum may be inserted into the œsophagus, according to Schlatter's proposal, or the junction may be made between the duodenum and œsophagus, the latter being the method we employed; Schuchardt, Brooks-Brigham, and Schopf have also adopted it. We have not seen the account of Richardson's successful case, or of Tricomi's case. Of the seven cases we know of, five were successful and two fatal (our own cases). But we are convinced that more than seven cases have been done, and that surgeons have not published those which have been unsuccessful. We know of at least two others which have not been published, one of which died on the table and the other shortly after the operation. We shall give a description of Schlatter's œsophago-jejunostomy, and of the method of œsophago-duodenostomy according to Brooks.

We give here the description of our first case where the anastomosis was successfully made between the duodenum and œsophagus.

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 see 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 get 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 ins. 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 parts 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 were united; 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 (1½ pint), as well as a coffee enema, was given in this case.

In a suitable case total excision is not more difficult than resection. The conditions which complicate the operation are adhesions to the neighbouring structures, the pancreas, the spleen, and, most important of all, the diaphragm. The question as to whether the operation can be performed or not depends upon the condition of the abdominal part of the œsophagus. If it cannot be pulled out of the foramen in the diaphragm without the diaphragm and pleura being dragged down also, its division may involve opening into the pleural cavity (which caused immediate death in one case we know of). Operation should only be undertaken when it is possible to retain a piece of the œsophagus below the diaphragm (or a piece of the cardiac end of the stomach) of sufficient length to enable it to be accurately sutured to the duodenum, the œsophagus being securely clamped about an inch higher up. The free end of the œsophagus which projects from the forceps must also be long enough to admit, and firmly grip, the one-half of a Murphy's button, as in Brooks' case.

Brooks found Murphy's button a great aid, and he did not consider it necessary to apply sutures over it. This may well be a case where the button is to be preferred to a suture which is not quite secure, because, for reliable suturing, the peritoneal coat

must not be tightly stretched. But one runs the risk here that the peritoneum of the œsophagus, which has been drawn in from the sides, may retract, or may be cut through, owing to being too tightly stretched. In such a case the pressure exerted by the button is more reliable. In Brooks' case the button remained in position without doing any harm, which, however, might not always occur.

It is essential that the duodenum should project at least 3 cm. (about $1\frac{1}{4}$ in.) beyond the clamp, as the intestine can be more easily brought up to the œsophagus, whether it be for suturing or for the insertion of a Murphy's button. If this is not possible, if the duodenum cannot be drawn upwards so as to come in contact with the œsophagus, then, as in resection of the pylorus, the duodenum should be closed and a loop of jejunum substituted, though in this case the functional result is less certain. Both limbs should be in the vertical position as in our method of gastro-enterostomy. The Y-method of Roux is here scarcely to be considered. Murphy's button enables the operation to be performed with the greatest speed.

The after treatment is the same as in resection of the pylorus, except that the nourishment must be at first absolutely fluid, especially if a Murphy's button has been employed, and it should be given in very small quantities. Schlatter has proved that a person can not only be sufficiently nourished without a stomach, but that he also absorbs as much albumen and fat as normally, and that the absence of hydrochloric acid has no effect on intestinal fermentation. Schlatter's patient, who died fourteen months after the operation, had secondary growths in the mesenteric glands, in the lungs and pleura, and local recurrence in the œsophagus. The œsophagus below the diaphragm had increased 3 ins., in length, and was somewhat wider than normal. In Schuchardt's case, where three finger-breadths of the cardiac end of the stomach was retained, after $2\frac{1}{2}$ years a sac had formed which held 17 oz., and part of the duodenum had become dilated.

Brooks' patient still enjoys good health after two years and eight months; she is able to do her work and to eat anything, like an ordinary person; but she has to take small meals at frequent intervals. The experiments of Kaiser and Gomry, and more recently those of Pachon and Cavallo, have shown that some precautions have to be taken shortly after operation in regard to the diet. Dogs, whose stomachs had been excised, could not at first digest even milk completely, and solid food not at all: the stools were very loose, and food in large quantities produced vomiting. Not until two months after was cooked meat completely digested. Raw meat and connective tissue were not digested well even then.

134. Partial Excision of the Cardiac End of the Stomach. Excision of the cardiac end of the stomach for disease was unsuccessfully performed by Mikulicz and Bernays, and Hartmann condemns it as a bad operation. *A priori* it is difficult to understand why the cardiac end cannot be excised as well as the entire stomach. For if the œsophagus can be sutured or joined by a Murphy's button to the duodenum and jejunum, it should also be possible to unite it to the stomach. Owing to the difficulty of suturing, one can hardly recommend closing the stomach partially and uniting the œsophagus into the rest of the lumen, as there is the same danger at the Y-point as in the Rydygier-Billroth operation of pylorectomy. We prefer a method analogous to that suggested by us, viz. to close the stomach entirely and to insert the end of the œsophagus into it through a special opening, either by suturing or by the aid of Murphy's button.

The difficulty of the operation compared with complete excision is due to the disease having spread too far along the œsophagus. Many cases of carcinoma of the cardiac end of the stomach present the same symptoms as stricture of the œsophagus, and, like it, they may exist for a long time without giving rise to any symptoms. By the time the diagnosis is made it will be found that the disease has spread farther up the œsophagus than in the case of diffuse carcinoma of the stomach, even though this, as a rule, spreads upwards towards the cardiac end.

In carcinoma of the cardiac orifice we have reached the limit which is usually accepted for the total excision, if we are unable to isolate a sufficient length of the œsophagus above the disease to be of use for forming a connection.

W. Levy has subjected the question of resection of the cardiac part of the stomach to very thorough examination. He has determined that the vagus nerves in front of and behind the cardiac orifice can be divided without danger, as Krehl's researches have shown. Following Hartmann, he performs a preliminary ligature of the coronary vessels, and, according to the amount resected, sutures the œsophagus direct to the stomach as he divides it. Levy has also divided the œsophagus in the neck and drawn the lower end out through a fistula in the stomach. Biondi and Krukenberg have made further experiments. The latter dissected with a blunt instrument from the abdominal cavity through the opening in the diaphragm, freed the cardiac part from the diaphragm, and drew as much as 3 ins. of œsophagus down into the abdomen. He sutured the œsophagus and stomach, whereas Levy used a Murphy's button. Krukenberg makes an incision along the costal margin, more to the left than to the right, cuts down longitudinally on to the cardiac orifice, and works in the connective tissue outside the muscular coat, thereby raising up the vagi, sympathetic twigs, and coronary vessels until the finger can be passed round the cardia. The finger is then passed in the same stratum through the diaphragmatic opening upwards along the œsophagus, so as to allow of its being pulled downwards. The next step is removal of the disease, followed by suturing.

It will be noticed that Krukenberg's experiments apply to cancer of the lower end of the œsophagus rather than to disease of the cardiac region.

135. 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 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.

Hypochondrium

136. Surgery of the Bile Passages. There is a great diversity of opinion on the indications justifying operation on the gall-bladder. The principal indication is cholelithiasis, and surgeons who consider that operation is imperative in every case of cholelithiasis have by far the most satisfactory results, which prove that stones in the gall-bladder, as in any other organ, can only be removed rapidly and safely by this method. We do not, however, go the length of saying that gall-stones "belong" to the surgeon. They belong in the first place to the patient, and if he prefers to retain them and to drink Carlsbad waters as well, he is quite within his rights to adopt this method, a line of treatment which, as is well known, is followed even by many surgeons when they themselves have gall-stones. In the same way, if a patient prefers to wait in suffering and pain for a

stone to work its way down *per vias naturales*, he is but enjoying his personal privileges. But at the present day the surgeon is certainly justified in telling a patient with gall-stones that by an operation he can be quickly and safely cured of his trouble, and be saved from eventual danger, more rapidly and more easily than by any other treatment.

As in operations on the vermiform appendix, so in those on the gall-bladder it is preferable not to operate during the acute stage of the spasms, or during acute inflammation, unless some urgent indication is present. It must be admitted that such an indication often exists, and in such cases operative interference should be undertaken without delay. When delay is possible, or necessary, it is specially important—and here the analogy with the operation for perityphlitis is complete—that the operation should not be performed in the intermediate stage, but that every sign of inflammation should be first allowed to disappear, because the adhesions in the intermediate stage are firmer than in the acute stage, and yet the walls are relatively friable, thickened, and unsuited for the application of sutures or ligatures. Therefore the operation must either be performed at once in the early stage or else after the inflammatory processes have entirely resolved.

The incision to be made to expose the gall-bladder and biliary passages must vary in size according to the difficulties in each particular case. To expose the gall-bladder in an ordinary case, Mayo Robson prefers the longitudinal incision at the border of the rectus, because it causes less injury to nerves and vessels than an oblique incision below, and parallel to, the costal margin. The last-named incision, which we always employ, gives much better access, and as it is not always possible to tell beforehand what difficulties may be met with in any particular case, and as it is often desirable to be able to explore the bile passages very carefully, we prefer the oblique incision, in spite of the fact that it does not correspond to the normal lines for incision. It is, as a rule, desirable to incise the border of the rectus abdominis fairly deeply as well. But as it is possible, by taking pains, to avoid nerves and draw them on one side, the only result is that a new tendinous insertion is formed without interfering with the function of the muscle.

137. Cholecystotomy (Fig. 103). What Bernays calls ideal cholecystotomy and Courvoisier cholecystendysis is a very simple and safe operation. 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. A relatively small incision in the abdominal wall is all that is required. When catarrh or inflammation coexist simple cholecystotomy should not be performed. One must also be sure that the bile ducts are patent.

An oblique incision is made 10 cm. (4 in.) long and 4 to 6 cm. below the costal margin. 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 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 transversalis fascia, on dividing which the peritoneum is exposed.

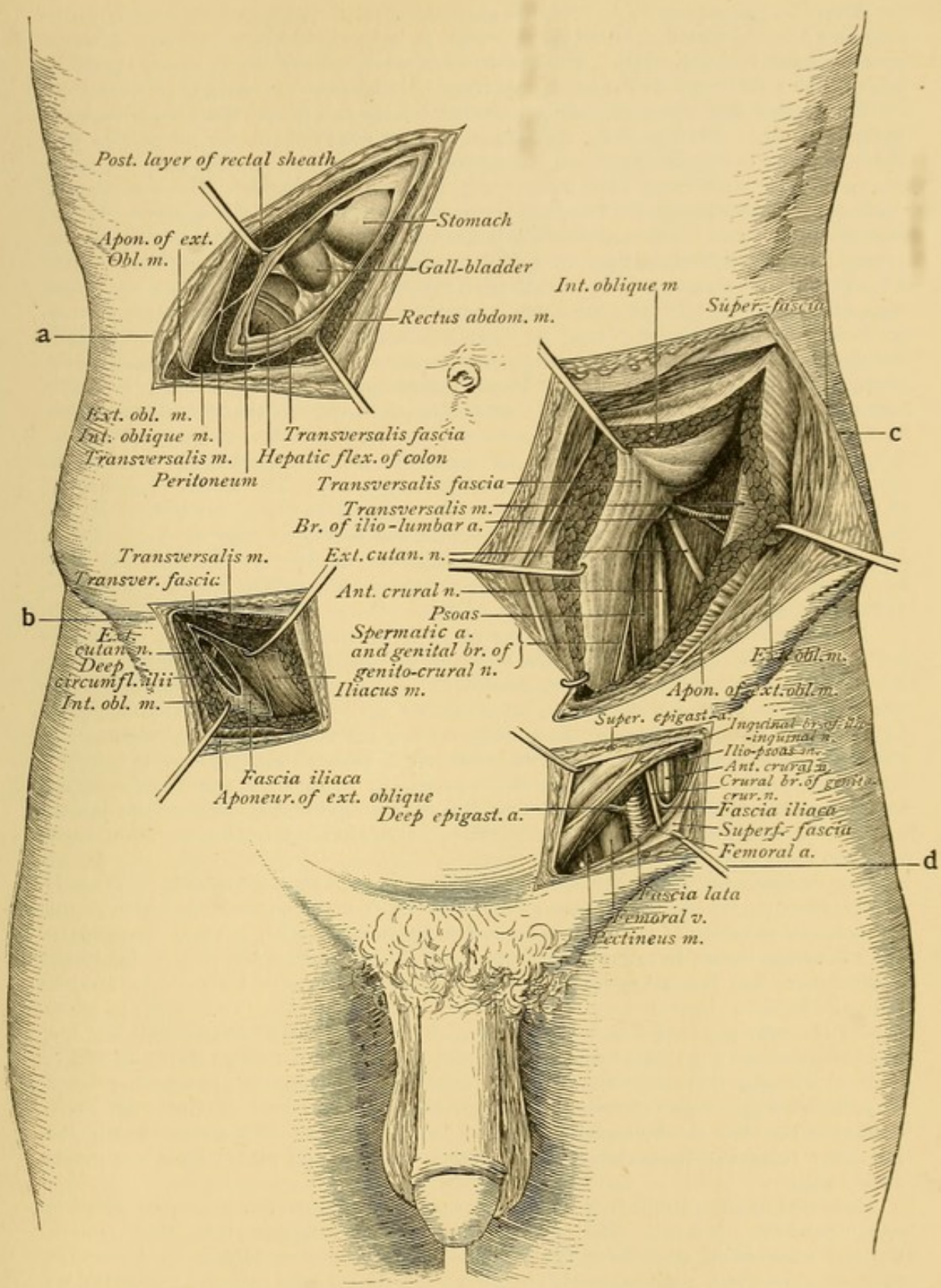


FIG. 103.—(*a*) Cholecystotomy.[1] (*b*) Ligature of the deep circumflex iliac artery. (*c*) Ligature of the common iliac artery. (*d*) Ligature of the common femoral artery.

[1] The incision here is for a difficult case. For a simple case, an incision is employed of half this length, the centre being over the edge of the rectus.

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 further procedure depends on the indications and on the conditions disclosed by the operation. If the walls of the gall-bladder are found to be normal, so that the indication is merely to remove the contents, especially stones, the gall-bladder is drawn into the wound and fixed there firmly by means of forceps. The surrounding parts are packed with gauze tampons to prevent infection and the entrance of bile into the peritoneum. 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 evacuated, and then the calculi removed by means of a scoop and forceps. In doing this, particular care must be taken 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, right-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 includes the whole thickness of the wall, whereas the superficial row 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. 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 $5\frac{1}{2}$ ins.

138. Cholecystectomy. At the present time Langenbuch's operation should be performed only in cases in which the walls of the gall-bladder are diseased, and in which, as a result of this, we may expect the lumen to become obliterated if the affection takes a favourable course, or, if things go badly, may lead to dangerous inflammatory changes owing to the production and retention of pus and mucus. In the latter case, however, we recommend excision of the gall-bladder also, but only if the cystic duct is easily palpable and not materially changed, so that there is reason to hope that a ligature applied to it may not cut through it, but may occlude it with safety. In new growths of the gall-bladder cholecystectomy is the operation to be chosen.

For excision, the serous membrane is incised over the most prominent part of the gall-bladder, parallel to the margin of the liver, and the serous covering between this incision and the edge of the liver is separated by working with a blunt dissector in the sub-serous tissue, in order to separate the gall-bladder from the liver as far as the cystic duct. The larger vessels met with in the dissection are tied. The artery to the gall-bladder is ligatured separately when dissecting out the cystic duct, to which a pair of pressure forceps is then applied. A double ligature is tied round the duct in case its walls are very tough, and the duct is cut across. The stump should be touched with the thermo-cautery when an infectious inflammation has been present. The hæmorrhage which results from separating the gall-bladder from the under surface of the liver can be easily stopped by gauze tampons. The serous sac which is left after removing the gall-bladder is folded together and closed by a continuous serous suture.

Removal of the gall-bladder has never produced any bad results in the cases on which we have operated. The patients remained perfectly free from their trouble. On the other hand, removal of the gall-bladder has the disadvantage that in those rare cases in which gall-stones still continue to form and obstruct the common duct, or in which the latter is narrowed from inflammation, further operation to procure a free channel for the bile is rendered very difficult.

139. Cholecystostomy. If, as opposed to the cases above described, the duct cannot be clearly felt, or if it be dilated, thickened, or otherwise markedly changed,

the application of a ligature to it is unsafe, because it may cut through at once or too soon after the operation, and because it cannot be applied sufficiently far back to obviate the risk of leaving a pouch in which stones may reform. In such cases cholecystostomy is the correct procedure. It is also indicated when there is uncertainty as to the free flow of the bile into the intestine, and also when septic contents have to be evacuated not only from the gall-bladder, but from the bile duct as well. Many surgeons make extensive use of this operation because they lay great weight on drainage of the bile passages.

The gall-bladder is secured to the wound with four to six sutures, which include, on the one hand, the fascia with parietal peritoneum, and, on the other hand, the serous membrane and the muscular coat of the gall-bladder. The remaining part of the wound is closed in its deeper parts by means of a suture which includes the fascia and peritoneum. The rest of it, or the part immediately surrounding the bladder, is left open. A glass tube with iodoform gauze packed round it is inserted into this part. The advantage of suturing the edges of the wound in the gall-bladder to the fascia only, instead of to the skin, should be specially noticed, because by this means fistula formation is more easily avoided. Block operates in two stages. This is only required in exceptional cases.

Cholecystostomy is the safest and most simple of all operations for the cure of gall-stones. One of the drawbacks, however, is a considerable increase in the time required for the wound to heal (six weeks as compared with eight days for cholecystotomy and cholecystectomy as described above). It causes also greater inconvenience after the operation on account of the drag upon the liver, and generally leads to obliteration of the gall-bladder if the latter was inflamed at the time of operation. Permanent fistulæ not infrequently result, as happened in 14 out of Mayo Robson's 189 cases.

140. Choledocholithotripsy. When gall-stones have become impacted in the ductus choledochus, the surgeon is confronted with a new set of indications for treatment. The prognosis of an operation is then more unfavourable because the patient is the subject of jaundice, and an old-standing icterus produces an exceedingly dangerous hæmorrhagic diathesis. In all cases of protracted icterus special stress must be laid upon the most careful arrest of hæmorrhage, owing to the possibility of a fatal reactionary hæmorrhage occurring from a small vessel. Mayo Robson, following Wright, recommends, as a preventive measure, the use of chloride of calcium, 20 grains every four hours for several days before operation. In such cases we have the choice of several different surgical methods of treatment of varying value. The handiest method is removal of the stone through an incision, or by breaking it up without an incision. Choledocholithotripsy with the fingers or with forceps is an excellent method with which we, amongst the very first, obtained complete success, but it can only be performed safely if the stone is especially soft and can easily be caught hold of.

141. Choledocholithotomy. Choledochotomy, recommended by Langenbuch in 1884, and first carried out by Kümmel, consists in opening up the duct with the knife and suturing it subsequently. This method should only be employed in those cases where exactitude in the insertion of the sutures can be relied upon—that is, when free access can be got to the ductus choledochus, so that it can be compressed above and below, while fine continuous serous sutures are being introduced which will leave no room for doubt as to the complete closure of the wound in the duct. Elliot puts in his sutures before removing the stone. In doubtful cases it is wise not to rely too much on the suture, but to put in a xeroform tampon down to the point of suture and to introduce a drain alongside of this (Mayo Robson introduces the drain through a special opening in the lumbar region), and not to close the abdominal wound completely.

Access to the common bile duct is made materially easier, in Mayo Robson's opinion, if the upper lumbar region be raised upon a pillow, so as to cause a lordosis of the spinal column. Langenbuch introduces a finger along the gall-bladder into

the foramen of Winslow, raises up the hepatico-duodenal ligament, and incises the peritoneum. He prefers, however, to use traction on the pylorus in order to free the horizontal part of the duodenum, and then to raise up the descending part of the duodenum, together with the pancreas, into the abdominal wound by introducing his finger behind it. By this means it is said to be possible to excise stones situated in the common duct, even as low down as the part situated in the posterior wall of the duodenum.

In this operation Mayo Robson acknowledges the advantages of the oblique incision which we employ. It should be very free, *i.e.* right up to the middle line, through the whole thickness of the rectus muscle.

142. Cholecystenterostomy. In the numerous cases in which the stones are situated so that they can only be felt with difficulty, and where the bile duct is not sufficiently dilated to allow of its being well stitched after opening, it is better to refrain from choledochotomy and to form a new channel for the bile. This is, of course, only possible when the gall-bladder is still present, and when it is not contracted and obliterated as the result of prolonged obstruction (Courvoisier), and also when the cystic duct is still patent. Now it is just in these cases in which the stone is in the common duct that the gall-bladder is atrophied. This is so much the rule that Mayo Robson and Courvoisier both consider that jaundice with distension of the gall-bladder is a sign that the obstruction of the common duct is of malignant origin.

The bile is drained from the hepatic duct through the cystic duct and the gall-bladder by performing cholecystostomy as above described, and establishing an external fistula until the stones pass out of the common duct into the intestine, or by forming an internal fistula by a cholecystenterostomy. The operation was first introduced by Winiwarter, and has been successfully performed by him and Kappeler. Cholecystoduodenostomy is performed by choice, cholecystojejunostomy if the former is not possible, and only when it is absolutely unavoidable should cholecystocolostomy be performed. The best method of performing the operation is by the aid of a Murphy's button of small calibre. The latter has been shown to be well adapted to this operation, because of the rapidity and ease with which it can be adjusted, and the certainty of rapid union which it offers. The wall of the gall-bladder is relatively thin, and is therefore adapted to the mechanism of the button.

Cholecystenterostomy is a much better procedure than cholecystostomy, because it allows of immediate closure of the outer wound and saves the patients from the unpleasantness of an external fistula, and more especially because it prevents the extreme loss of bile which attends the latter. For this reason cholecystenterostomy is to be preferred whenever it is possible to perform it. Connection with the jejunum is more easily established than the more rational connection with the duodenum. It is seldom necessary to perform a choledochenterostomy.

Duodenocholedochotomy

We owe to Pantaloni an excellent exposition of the different operations by which access can be got to the common duct by opening the duodenum.

143. Transduodenal Lithotomy. The first operation was performed 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 below and to the left, with a median vertical limb, and lower transverse limb passing through the right rectus abdominis.

The forefinger is passed in below and the duodenum is raised up, if possible 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 trans-

versely, because we consider an incision parallel to the vessels to be more rational.[1] 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.

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, 3 cm. 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; occasionally it is well to put in a drain, such as a strip of xeroform gauze.

144. Transduodenal Choledochotomy. 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 and Mayo Robson 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, an incision is made down on to the stone. Whether the incision should be transverse or longitudinal will be determined by the position and shape of 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. In this case also 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. Whether the opening is now closed in the ideal way (by a suture through the whole thickness of the wound, with a secondary suture to approximate the mucous edges) or not, must depend upon whether the opening in the papilla is stenosed or not. As a general rule it will be found advantageous to make sure of a considerable opening where there is a danger of the formation of new stones. If the opening is not required it will contract of its own accord. A suture should therefore be put in all round the opening through the whole thickness of both canals. In Kocher's and Kehr's case, in which this method was adopted, no bad consequences resulted from chance regurgitation of intestinal contents.

To insert no sutures, as Mayo Robson does, 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.

If the posterior and anterior sutures are put in carefully there is no need for drainage, except under the circumstances detailed above.

[1] A longitudinal incision is, of course, also permissible.

145. Hepatotomy and Resection of the Liver. An incision into the liver tissue is usually made in cases of hepatic abscess. The method of performing this when the abscesses are situated on the convexity of the liver has been described and illustrated in discussing transpleural hepatotomy. For abscesses in the under part of the liver, or in the left lobe, the incision should be made along the costal margin, either in front or behind. Parahepatic and subphrenic abscesses are also opened here.

A mesial incision may be most suitable for abscesses in the left lobe of the liver. We have published a case of obstruction of the bile passages where a very large "bile abscess" developed in the left lobe of the liver, which contained pure bile. After it had been evacuated a biliary fistula formed, which healed spontaneously after a course of Carlsbad waters, which probably induced the passage of a stone.

As regards the treatment of echinococcus of the liver, the reader must refer to the works on regional surgery, as the subject would take us beyond the limit of the present work. The method known as marsupialisation, and also excision combined with resection of the liver tissue, have been employed.

Keen, who has three times successfully excised liver tumours, 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 satisfactorily 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; they have the great disadvantage, however, that if left *in situ* it is very difficult to approximate the edges of the wound 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 (see Fig. 98), and, if necessary, a continuous suture over all. If, in using 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.

Umbilical Region

In the absence of any special indication the abdomen is opened by a mesial incision, situated somewhere along the line which extends from the ensiform cartilage to the symphysis pubis, because, after dividing the skin and subcutaneous tissue, the aponeuroses of the abdominal muscles fuse into a single layer (the linea alba), under which the fascia transversalis remains distinct, and because if they are carefully approximated afterwards by a special suture they prevent the formation of a hernia. When possible it is desirable to keep the incision away from the immediate region of the umbilicus. We may get rid, however, of the furrows and dimples of the umbilicus by excising it (omphalectomy), but this is unnecessary if the part be thoroughly purified. It is preferable to make a longitudinal incision round the navel, to the left, or, *e.g.* in umbilical hernia, a transverse incision may be made above or below the umbilicus, over the tumour.

146. The Radical Cure of Umbilical Hernia. The radical cure of small herniæ in young subjects is a very simple operation. In elderly people, on the other hand, where a large umbilical hernia—especially in women—has become irreducible owing to adhesions and thickening of the great omentum, which is consequently giving discomfort, and also in a large strangulated umbilical hernia, one must be prepared for difficulties, and must endeavour to overcome them by proceeding cautiously, at the same time taking care to get a clear idea of the conditions present. 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. Eiselberg'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 period.

When the contents have been successfully replaced, it is most desirable, in the 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.

Hypogastric and Iliac Regions

147. Puncture of the Abdomen. When the withdrawal of an accumulation of fluid in the abdominal cavity is indicated, the puncture is made in the lower part of the abdomen, midway between the umbilicus and the mid point of Poupart's ligament. The advantage of this situation is—as in the case of the incision for exposing the vermiform appendix—that the puncture is made external to the edge of the rectus, and therefore external also to the deep epigastric artery, and that it at the same time avoids the muscular portions of the broad abdominal muscles. In using a large trocar it is desirable to make a small preliminary skin incision, and to use, as in ovariotomy, a trocar, the inner canula of which should have a blunt edge, which may be pushed forwards.

148. Incisions in the Region of the Hypogastrium. We shall not repeat the remarks we made when dealing with the positions of incisions in general for laparotomy. For the endless gynæcological operations which are performed in the hypogastrium the median incision will always be the simplest. The methods of modifying it have been discussed. If we consider Langer's figure of the lines of incision we shall see that, for lateral incisions, the oblique incision passing towards the middle line as it descends conforms to his indications in that the closer to the middle line the incisions are made the more they must approach the perpendicular. For example, if the radical operation for appendicitis be performed at the outer border of the rectus, only the fascia being divided, an incision must be made which is much more nearly vertical than if the operation were being performed more to the lateral aspect through the muscular layers; in the latter case the incision approaches to the horizontal, and the more nearly it approaches to the costal margin the more nearly does it lie in the line of the muscular fibres.

It is evident that the incision which corresponds to these lines, as Brunn has

emphasised, also corresponds with the lines of the superficial muscles, nerves, and vessels, a point which we have put forward as one of the chief advantages of our normal incisions. A second point which is important as regards its relationship to the choice of incision is the question whether one desires to operate trans- or sub-peritoneally. The difference in procedure may be seen from a comparison of the incisions which we shall recommend for ligature of the common and external iliac arteries.

In the former the abdominal wall is divided down to the peritoneum by cutting through the muscles and the fascia transversalis two finger-breadths above Poupart's ligament. In the latter the peritoneum is altogether avoided by keeping close to Poupart's ligament, and dividing only the transversalis fascia, which is attached to it, the peritoneum being reflected on to the fascia iliaca half a centimetre higher up.

Abscesses in the iliac fossa can, in like manner, be opened extra-peritoneally by passing in front of or behind the iliac fascia; or the peritoneum may be opened, if one wishes to open perityphlitic abscesses, to remove tumours of the cæcum, to make an artificial anus in the sigmoid flexure, or to remove a tumour of the sigmoid. A transverse incision from the right external abdominal ring across to the left external ring is indicated when the bladder is to be opened, in the removal of tumours of the female genital organs, and of the upper part of the rectum or the lower part of the sigmoid flexure.

A third point which we would emphasise is the value of making the incision above and parallel to the inner half of Poupart's ligament for all intrascrotal affections. We consider the inguinal incision for the majority of tumours inside the scrotum greatly superior to the older incision through the scrotum, because hæmorrhage is less, the wound can be sutured with greater ease and accuracy, and is more easily kept aseptic. We have invariably employed it for many years in the treatment of hydroceles, varicoceles, and spermatoceles, and of all tumours and inflammatory and tubercular conditions of the testicle. Its use is, however, contraindicated in very large swellings whose size cannot be diminished, and where adhesions exist with the skin of the scrotum, as in inflammatory and tubercular affections.

For all other conditions the inguinal incision should be employed, the testicle being drawn out of the scrotum, and subsequently replaced if its removal is not indicated. In this way the treatment of the wound is greatly simplified.

149. 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.

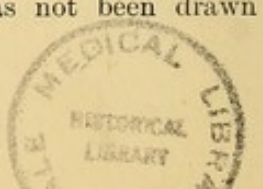
150. Exposure of the Spermatic Cord. Castration. A transverse incision is carried downwards and inwards over the inguinal canal a finger-breadth above and parallel to the inner half of Poupart's ligament. This incision corresponds exactly to the line of cleavage of the skin, and therefore comes together 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 lies 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) 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.

When the skin is adherent, or when the tumour of the testicle is very large, *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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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 has only 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 when 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 compressing it with pressure-forceps, rather than to tear it, a process which is always 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. Ligatures should be avoided.

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.

151. 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 now appear; these are divided, together with the tunica vaginalis communis (infundibuliform fascia), which lies below it. The cord is drawn out 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.

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 injecting 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.

152. 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.

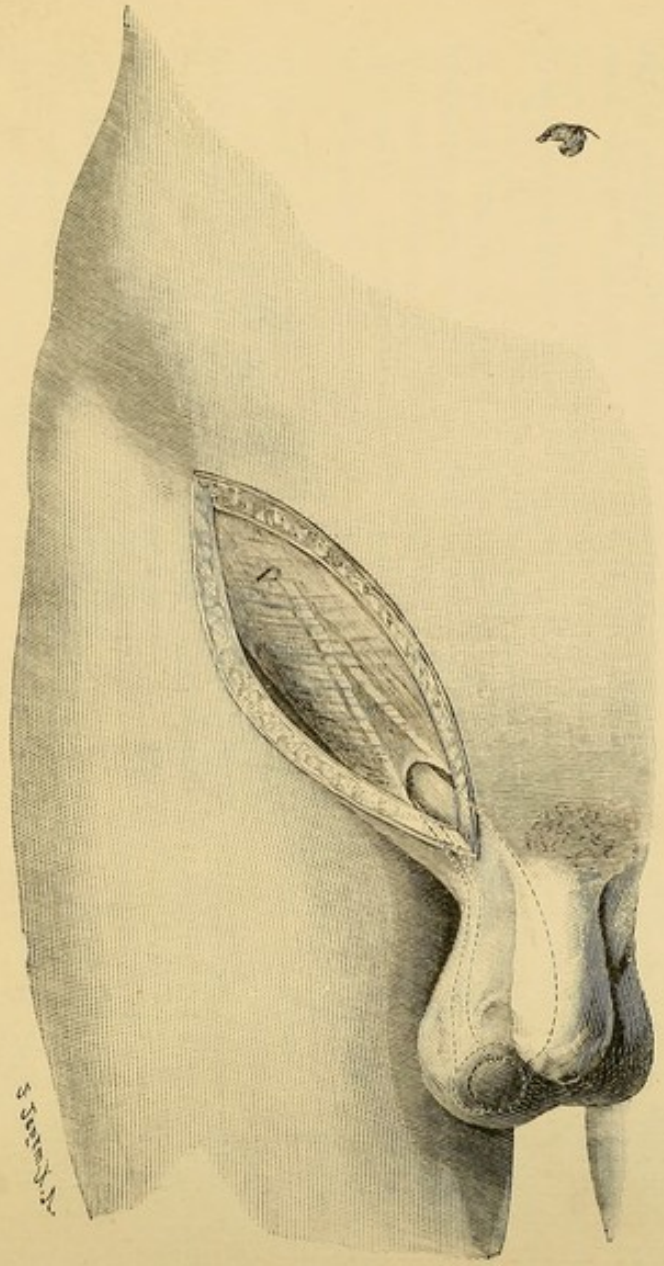
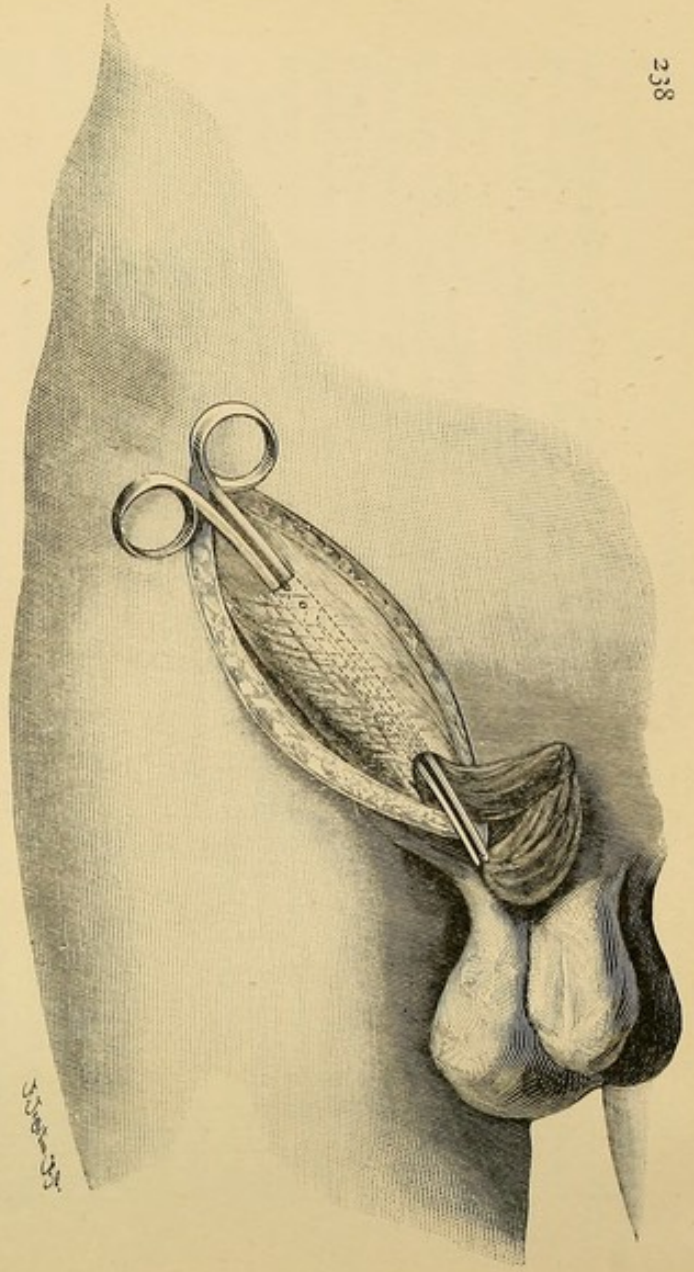


FIG. 104.—Radical operation for inguinal hernia. First step: exposure of the aponeurosis of the external oblique and of the sac.

FIG. 105.—Radical operation for inguinal hernia. Second step: the drawing of the isolated sac through the inguinal canal by means of curved forceps.



153. Herniotomy and the Radical Operation for Inguinal and Femoral Hernia. The incision for inguinal herniotomy is the same as that just described for exposing the spermatic cord, except that it is somewhat longer. The skin and subcutaneous tissues are divided a finger-breadth above the inner two-thirds of Poupart's ligament. The superficial epigastric artery, and a vein (vena pubica) which descends farther inwards towards the middle line, are ligatured. The external spermatic fascia of Cooper (prolonged down upon the cord from the margins of the external abdominal ring) is divided. After further division of the cremaster muscle, and especially the infundibuliform fascia, the sac can be easily isolated, at least at its upper part, from the structures of the spermatic cord, and its fundus can be pulled out of the scrotum. By stretching out the structures of the cord and holding it up to the light, the outline of a thin hernial sac can be see shining through it.

(a) Old Method. This method is suitable when the sac is thickened, as in old-standing herniæ, in very large herniæ, or in cases where there has been inflammation of the sac. It is likewise suitable when there is much matting of the contents, specially of the omentum. In this method of performing the radical cure the sac is carefully isolated, and then drawn forcibly downwards until the part of it which lies in the internal abdominal ring can be seized, transfixed with silk, and each half ligatured. If it is not possible to get high enough up, the anterior wall of the inguinal canal, *i.e.* the aponeurosis of the external oblique, must be slit up in its whole length, as in Bassini's operation. After the sac is divided below the ligature the stump retracts quite up into the abdomen. A row of deep sutures, including the aponeurosis of the external oblique muscle and the muscular fibres of the internal oblique, is then inserted in order to strengthen and narrow the inguinal canal in its whole length.

We have for years employed this simple method of performing a radical operation, and with very good results. It corresponds essentially to that of Lucas-Championnière.

(b) Lateral Transposition Method. The incision is the same as that above described, viz. above and parallel to the inner two-thirds of Poupart's ligament. The fibres of the aponeurosis of the external oblique are exposed (Fig. 104), and the hernial sac is completely isolated in the way already described. Now comes the characteristic and essential step of our method. A small opening is made in the strong portion of the external oblique above and external to the middle of Poupart's ligament (above and external to the region of the internal abdominal ring), and a special pair of curved dressing forceps is pushed through it, *i.e.* through the aponeurosis of the external oblique and the muscular fibres of the internal oblique, and along the inguinal canal in front of the spermatic cord to emerge at the external ring, where they are made to seize the fundus of the isolated hernial sac (Fig. 105), which is drawn from below upwards and outwards along the canal and through the small opening above mentioned. Traction is now made on the sac, so that, instead of running downwards and inwards along the cord, it is pulled in an outward direction from the internal abdominal ring, and the funnel-shaped opening at the neck of the sac is drawn well into the small opening in the abdominal wall. The portion of the sac which is brought through the opening is now transfixed and stitched to the adjacent part of the abdominal wall by a silk suture. The sac is cut off. It is still better to compress the sac with a narrow pair of pressure-forceps and then to ligature it. A very small stump is thus obtained, which can be cut off fairly close to the ligature. The narrow stump is pushed back through the fascia, and a needle is passed through the two sides of the opening in the fascia and through the stump, by which means the stump is stitched to the small opening in the fascia, and the latter is closed simultaneously. The peritoneum is thus stretched in a lateral direction, and the descent of a sac in the direction of the cord is rendered impossible. The operation is finished by suturing the canal in the manner above described.

We have departed from our earlier method of applying torsion to the sac and laying it along the anterior wall of the inguinal canal. The vitality of the sac is

so much lowered by these procedures that it is liable to necrose and hence to disturb the progress of the wound.

(c) **Transposition by Invagination.** Since the third edition of this book was published we have gone a step farther in simplifying the method of radical cure by transposition. An incision is made over, and parallel to, the inguinal canal, but extending beyond it above and below. The superficial epigastric artery is ligatured, the aponeurosis of the external oblique is exposed, and the intercolumnar fascia, the lower fibres of the internal oblique (cremaster), and the infundibuliform fascia are divided. The sac is then isolated at the external abdominal ring, and freed

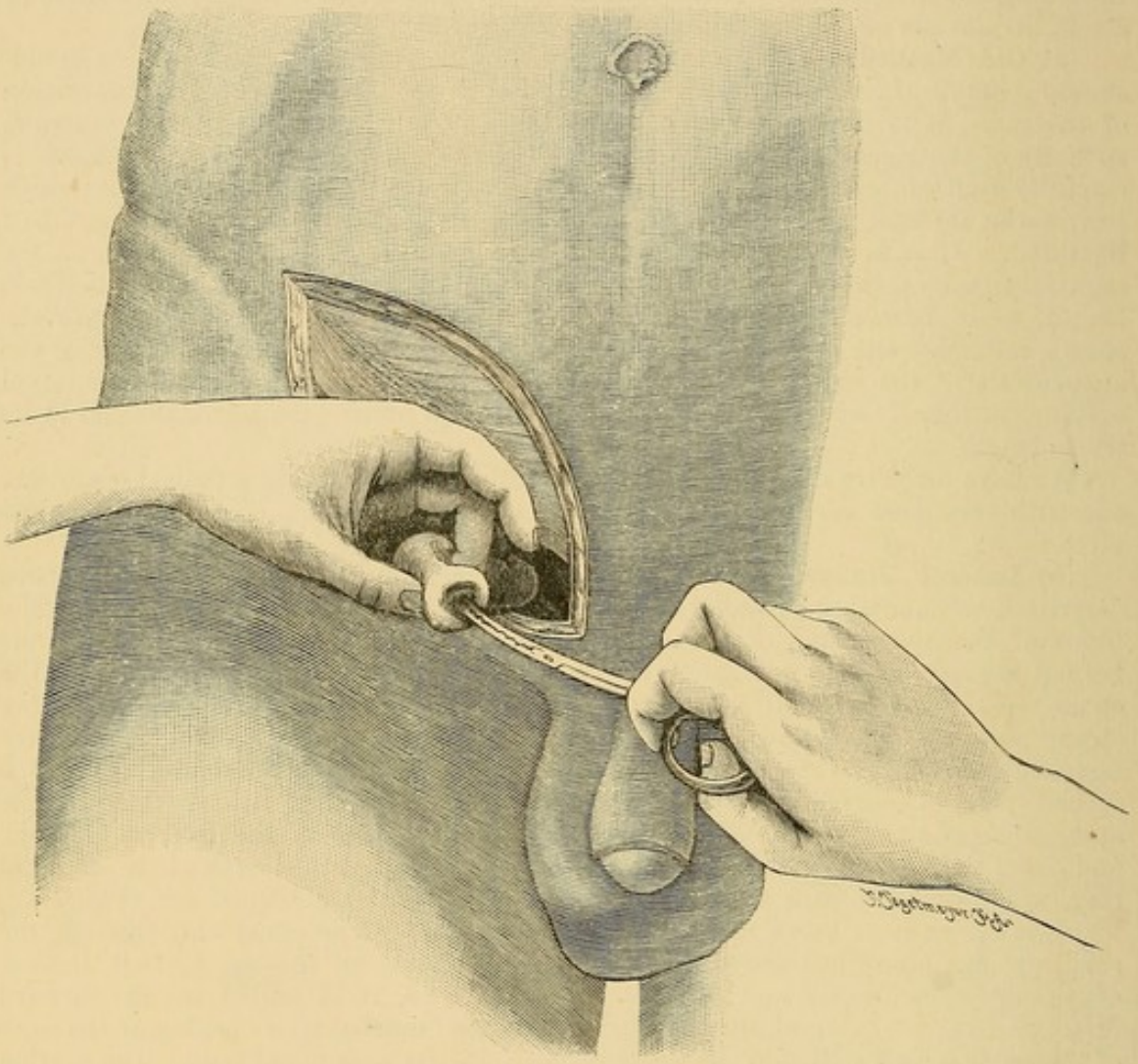


FIG. 106.—Radical operation for external inguinal hernia by invagination-transposition. The isolated hernial sac is seized at its apex with curved forceps and invaginated into itself as far as the posterior end of the inguinal canal.

as high up as possible, traction being at the same time put upon it. So far the operation is identical with the former ones.

The unopened sac is now seized at its apex with long narrow curved forceps, and invaginated backwards through the inguinal canal up into the abdominal cavity (Fig. 106). The point of the forceps is then forced against the abdominal wall, which is made to project just external to the internal abdominal ring.

An incision $\frac{1}{3}$ cm. long is made through the aponeurosis and muscles down to the parietal peritoneum, which, together with the invaginated hernial sac, is pushed

through the opening (Fig. 107). The parietal peritoneum is taken up with dissecting forceps and incised, and the edges are grasped with artery forceps to prevent them from retracting (Fig. 107*a*).

The whole length of the invaginated sac is forcibly pulled out; the empty forceps

FIG. 107. FIG. 107*a*.

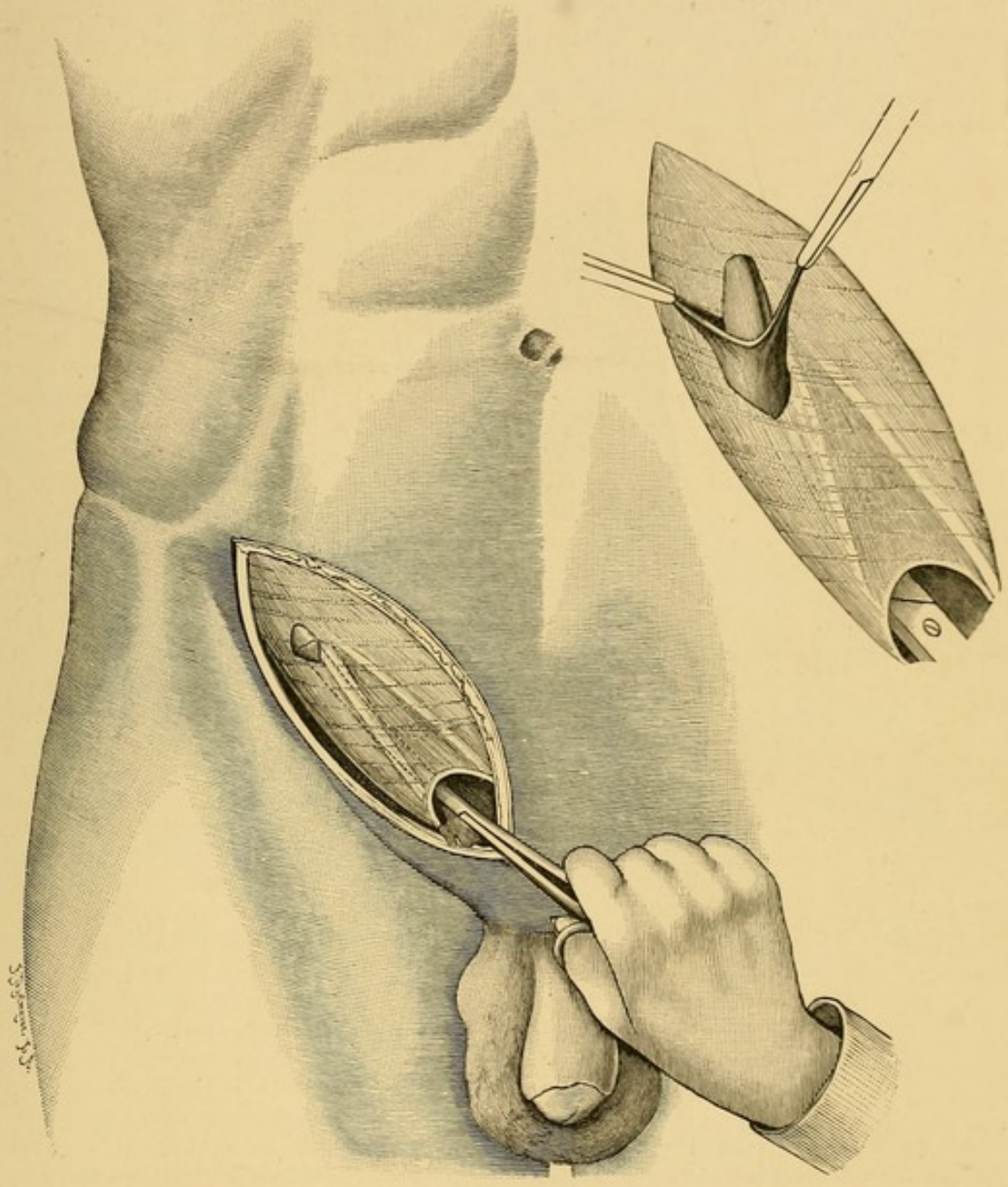


FIG. 107.—The invagination-transposition method. The point of the forceps forces the apex of the invaginated sac directly outwards from the internal inguinal ring towards the anterior abdominal wall. A small incision is made over the prominence so caused through the external oblique aponeurosis and the deep abdominal muscles.

FIG. 107*a*.—The parietal peritoneum is shown divided, its margins held apart, and the inverted hernial sac pushed through.

in the inguinal canal are taken out at the same time. The base of the sac is crushed with a pair of pressure-forceps, transfixed with a silk suture (Fig. 108), and the two

halves, together with the parietal peritoneum, are tied. The sac is cut off close to the ligatures, the stump pushed back under the fascia, and the same silk suture is used to close the opening in the aponeurosis of the external oblique.[1] Lastly, the canal is closed as above described in order to increase the resistance (Fig. 109*b*).

This extremely simple method, besides causing very little injury to the tissues, is more effective in entirely reducing the hernial protrusion than any other, because the peritoneum from the neighbourhood of the internal abdominal ring is drawn out and firmly fixed in the opposite direction to the course of the spermatic cord, *i.e.* it is maintained stretched in an outward direction.

At autopsies performed at longer or shorter intervals after the operation we have had the opportunity of seeing the results of this procedure. On the peritoneal

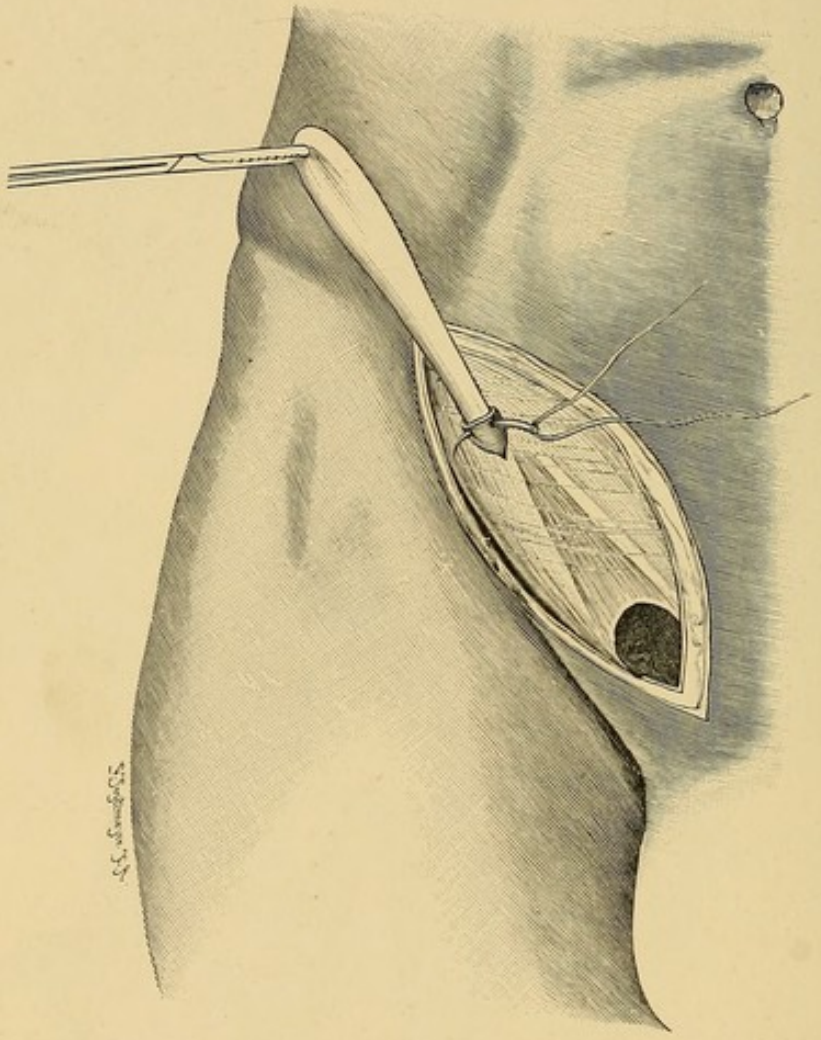


FIG. 108.—Radical operation for external inguinal hernia by the invagination-transposition method. The whole length of the inverted hernial sac is forcibly pulled through the small opening in the abdominal wall and a needle passed through its base, including the parietal peritoneum.

aspect, at the spot where the sac was drawn through, a fine circular peritoneal cicatrix is seen as a prominence, with two shallow recesses above and below it. The parietal peritoneum on the mesial aspect is raised in slight folds about 2 to 3 mm. in height. There is no sign of any invagination into the inguinal canal.

The permanent results with this method, so far as we are able to obtain com-

[1] We have often simply pushed back the stump and closed the opening in the fascia independently, as Quervain has told us that he does.

parisons from the literature on the subject, fully bear out the opinion that it is better than any other. We instituted a careful inquiry into the subject, and we were all the more pleased when we found that cases operated on by the younger assistants have given uniformly good results. Hirschkopf collected in 1899 (November) 236 hernia operations from our clinic and private practice performed by various methods. Whereas Lebensohn found four recurrences in 111 of our earlier cases operated on by simple transposition (method *b*), Hirschkopf found not a single relapse in 42 cases in which this method was used. In 83 cases operated on by the transposition-invagination method (method *c*) there was one recurrence. He compares these figures with the 659 operations by Bassini's method (Franz and Rotter), in which there were 4·4 per cent of recurrences. Our patients get up almost without exception after eight days, and they never wear a truss.

From the article by Grosse (*Deutsche Zeitsch. f. Chir.* Bd. lix.) on the results obtained by Professor Landerer, we conclude that our method of radical operation gives, in the hands of other surgeons, not only as good, but even better results than the more generally followed methods of Bassini and Macewen. Grosse states that not only was suppuration much rarer after Kocher's operation, but also that in fifteen cases operated on according to Kocher's method, inquiry elicited no case of recurrence. In three cases in which Macewen's operation was performed there was one recurrence; in eight cases of Bassini's operation three recurrences; in six of suture of the pillars two recurrences. This gives for Kocher's operation 100 per cent permanent cures; for Macewen's 66 per cent; for suture of the pillars 66 per cent; for Bassini's 37 per cent; and for Kocher's method, modified by Landerer, 80 per cent. Carle has permitted Galeazzi to report on 601 operations according to Bassini's method, and 239 according to Kocher's. The former showed 5·99 per cent recurrences, the latter 5·02 per cent.

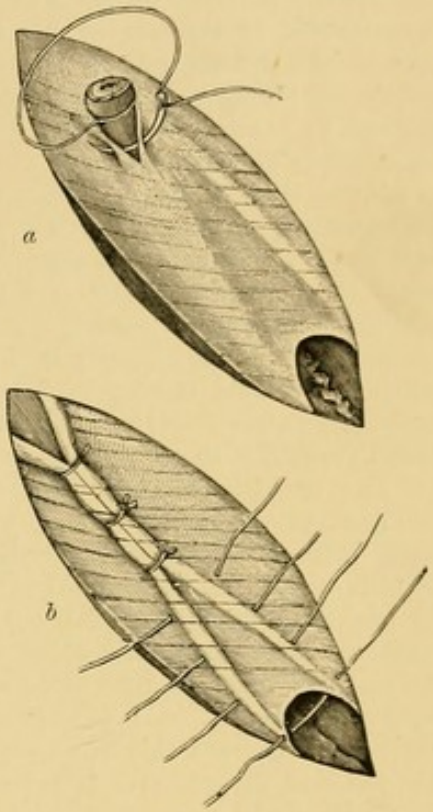


FIG. 109*a*, *b*. — The upper figure shows the sac cut off, and also how the same suture which is tied round the stump is employed to close the small opening after replacing the stump. The lower figure shows the strengthening sutures for the anterior wall of the canal, in position and partly tied.

Madelung has also communicated his results through P. Bernhardt. These results are less successful as regards permanent cure, because Madelung does not subject all cases of hernia to radical operation, but only such as cannot be treated by trusses. For this reason he has in many cases to reckon with complications, such as difficulty in separating up the sac. In consequence of this the process of healing is disturbed in about one-third of the cases, and it is a recognised fact that nothing predisposes to recurrence more than suppuration of the wound.

Trzebicky has noted better results in fifty-three cases. In spite of suppuration in ten cases there were only very few recurrences.

The transplantation methods have the great advantage that, unlike Bassini's much praised method, they do not open up the inguinal canal. If suppuration should occur, and the sutures give way, Bassini's method is productive of bad results. By our own method success is attained in spite of this. Bassini's method is more complicated, causes more injury to the tissues, and so predisposes much more to trouble in the wound.

Our method is incomparably simpler and speedier, and, as regards accurate closure of the internal abdominal ring, it is at least as satisfactory as Bassini's. V. Angerer, of Munich, confirms this view. Whereas, in the last-mentioned operation, the spermatic cord is displaced from its natural position in order to be able to close the canal by sutures, we displace the neck of the hernial sac from the neighbourhood of the cord in order to close it completely by a deep stitch.

We are not prepared to give up this advantage of displacing the sac, as it solves, in a very simple manner, the problem of preventing the exit of a hernia by making use of an opening which is normally present.

As regards the indications and contraindications to our method, it should be noticed that certain disadvantages, which existed in the older form of the operation, are entirely removed by the latest modification. Link is dissatisfied with the method, because out of thirteen of his cases necrosis of the hernial sac occurred in three, and of the aponeurosis of the external oblique in two. Such an occurrence is now impossible if the sac is first treated with compression-forceps so as to reduce the pedicle to a minimum, and if the latter is replaced and the small opening in the aponeurosis stitched up.

It is clear, however, that every hernia is not suited for the invagination-transposition method. Herniæ with much thickened and only slightly elastic sacs, and those whose contents are much matted, are not suited to this method. In such cases it is decidedly better to open up the inguinal canal according to Bassini's method, to free the neck of the sac high up, and to ligature it. If there is much matting the sac may simply be left alone as Wölfler recommends. This is the more justifiable as this matting often occurs in large herniæ in old people, in whom it is especially desirable not to increase the danger by extensive injury and infiltration of blood (to which the cord is especially liable), or by prolonging the operation.

The operation in very adherent herniæ is greatly simplified by merely ligaturing the neck of the hernial sac at the highest point. Another method of dealing with these difficult cases where the hernia is closely adherent to the tissues of the cord is to remove the testicle and cord after opening up the inguinal canal—that is to say, to perform a simultaneous castration. Bernhardt, in Samaden, has recommended a remarkable procedure in place of the above, viz. a transposition of the testicle and hernial sac together into the abdominal cavity. The adhesions in congenital hernia offer no difficulty in the application of our method. Where the peripheral end of the sac is adherent this is simply cut off; a blind end is then formed by ligaturing the sac, and invagination is performed as usual.

It is only in cases of large old-standing herniæ with thickened sac and abnormally wide ring that there can be any question of performing one of the complicated plastic operations, whether in the form of a myo-, periosteo-, or osteoplastic flap which is sutured to the ring. According to Brenner (Salzer's method), Schwartz, Bakunin, and others, relatively good results can be obtained in difficult cases by this procedure.

In discussing radical operations for hernia we must further consider those cases in which risk to life must be avoided, viz. cases with heart failure, disease of the lungs, or affection of the kidneys, specially in old and weakly patients. In such cases when, on the ground of local discomfort and danger of strangulation, there are clear indications for operation, general anæsthesia should, if possible, be avoided. It is to Cushing's very thorough studies of the course of the nerves that we owe, in using local anæsthesia, our knowledge of the method of avoiding the intense pain caused by injury to the parietal peritoneum by means of local anæsthesia. The nerves involved in the operation, exclusive of those in the skin, are, the hypogastric branch of the ilio-hypogastric, lying close to the lower border of the internal oblique, and the united trunk of the ilio-inguinal and the genital branch of the genito-crural running in the inguinal canal on the infundibuliform fascia and the cremaster muscle. The intrascrotal organs, together with the hernial sac, can be rendered anæsthetic by an injection of cocaine under the aponeurosis of the external oblique, in the region of the

upper part of the inguinal canal. The scrotal skin remains sensitive. The above-mentioned nerves supply the cremaster, and should therefore not be divided.

154. Radical Operation for Femoral Hernia (Fig. 110). An incision is carried

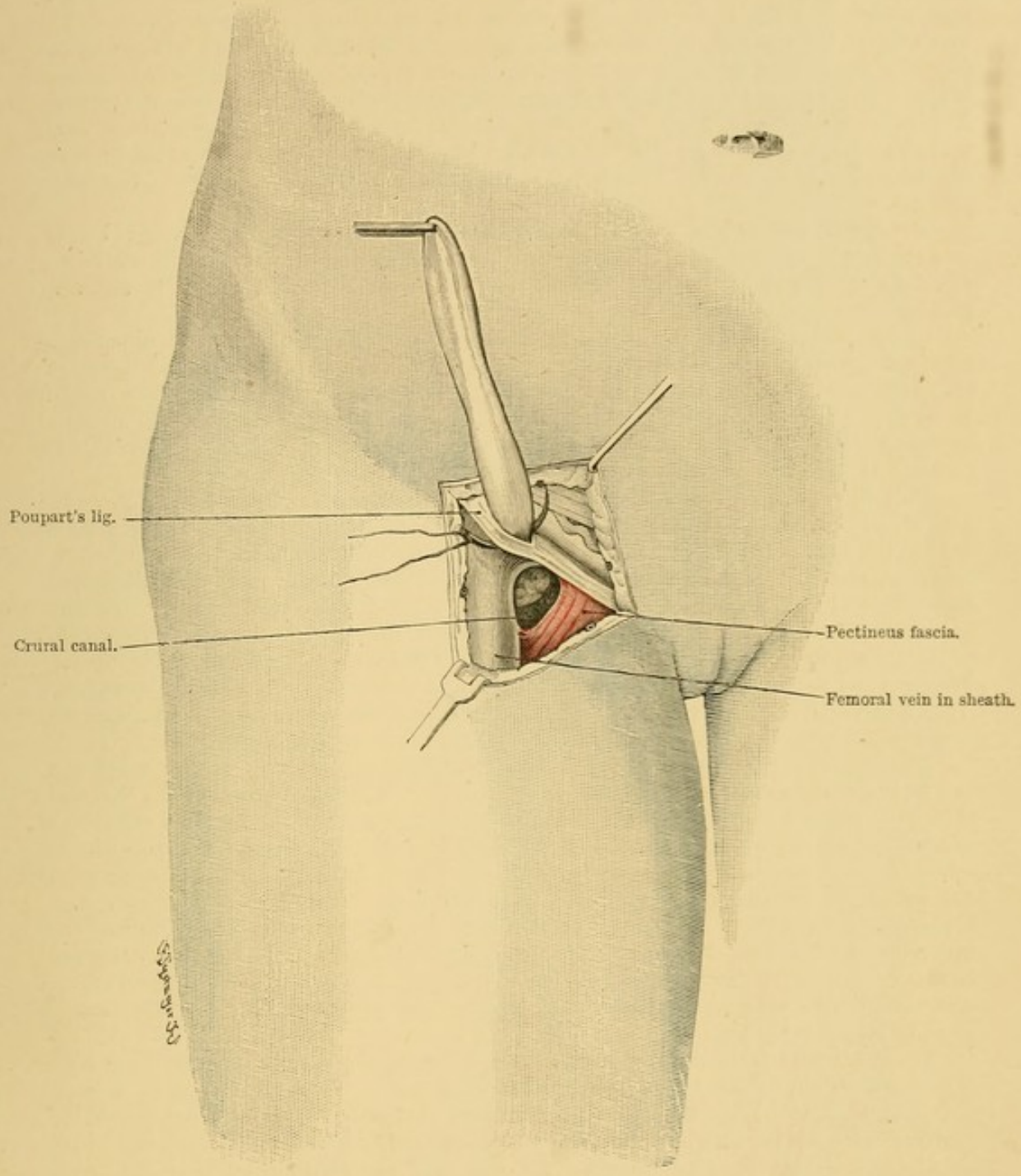


FIG. 110.—Transposition method in radical cure of femoral hernia. The sac is pulled upwards and outwards through the outer pillar of the external abdominal ring. The needle is incorrectly represented passing through Poupart's ligament. This may be seen more correctly by referring to Figs. 108 and 109*a*, representing inguinal hernia.

along the inner third of Poupart's ligament through the skin, superficial fascia, and cribriform fascia, until the hernia, which is generally surrounded with fat, is exposed.

The sac is completely isolated with a blunt instrument up to the crural ring. The fundus of the sac is now seized with forceps and invaginated into itself; the forceps, together with the invaginated sac, are then passed through the femoral ring and forced above Poupart's ligament against the tense outer pillar of the external abdominal ring. A small opening is made, the inverted sac is pushed through, its apex seized, and the same procedure carried out as in inguinal hernia (page 242). The ring is then closed by sutures passing deeply through Poupart's ligament, the pectineal fascia, and the deep crural arch (ligament of Cooper). Two or three stitches are put in so as to attach Poupart's ligament to the pectineal fascia, thus converting it into a support and a prolongation of Gimbernat's ligament. The stitches pass up to the femoral vein, but the ring cannot be closed any farther than this because of the danger of thrombosis. Damage to the vein from the needle must be carefully avoided.

In femoral herniæ with a broad base, just as in direct inguinal herniæ, it is better to remove the sac high up, according to the method first described. There is no difficulty in completely closing the opening in direct inguinal hernia by sutures, because the spermatic cord is very little in the way.

In operating for inguinal hernia in the female the closure of the inguinal canal is a very simple matter, as we have no spermatic cord to deal with. The round ligament (with its accompanying vessels) lies closely approximated to the sac, and may indeed be drawn outwards through the opening in the aponeurosis of the external oblique muscle together with the sac, and there fixed with sutures. The mere cutting it across may give rise to displacement of the uterus.

155. Shortening of the Round Ligament. Alexander's Operation (Fig. 111). The round ligament in the female is isolated in exactly the same way as the spermatic cord in the male. It is much more easily done, however, because there is no cremasteric covering, and no well-developed infundibuliform fascia, but it is more difficult to find because the ligament is often thin. It is accompanied by a small artery. The line of incision will depend upon how the ligament is to be advanced and stitched, in order to counteract respectively *retroversion*, *retroflexion*, and *prolapse of the uterus*. We have had very good results from the following *modification of Alexander's operation*.

An incision is made through skin and superficial fascia parallel to, and a quarter of an inch above, the lower edge of the inner two-thirds of Poupart's ligament.

The superficial epigastric artery and vein, together with a vein at the inner and one at the outer angle of the wound, are ligatured. The aponeurosis of the external oblique is divided in the inner half of the wound—that is, over the inguinal canal, but not as far as the external abdominal ring. The round ligament, together with its accompanying vessels, can now be isolated and raised up by a blunt dissector from the groove of Poupart's ligament and from the fibres of the internal oblique and transversalis muscles. The central portion of the round ligament is now pulled well upwards and outwards towards the anterior superior spine. By this means, as can be easily shown on the cadaver, the uterus is fully raised up and bent forwards, and, when both sides are operated on, it is so stretched laterally that it remains fixed in its new position.

When traction is made on the ligament a cone of peritoneum about an inch long is also pulled out external to the deep epigastric artery. This can be pushed back if it is first separated from the ligament by means of a gauze swab. In doing this the peritoneum may be torn and require to be sutured. When one is satisfied that no abdominal contents have forced their way into the peritoneal process and that the uterus is fully raised up, the loop of the ligament is sutured above the outer half of Poupart's ligament by three or four silk sutures. The inguinal canal is then closed by deep sutures uniting Poupart's ligament to the upper edge of the incision in the external oblique and to the subjacent internal oblique and transversalis muscles. As appears from the description, we no longer sever the round ligament from its attachment to the symphysis, but leave the part in the peripheral end of the canal quite untouched. We merely pull out the end which passes into the peritoneal

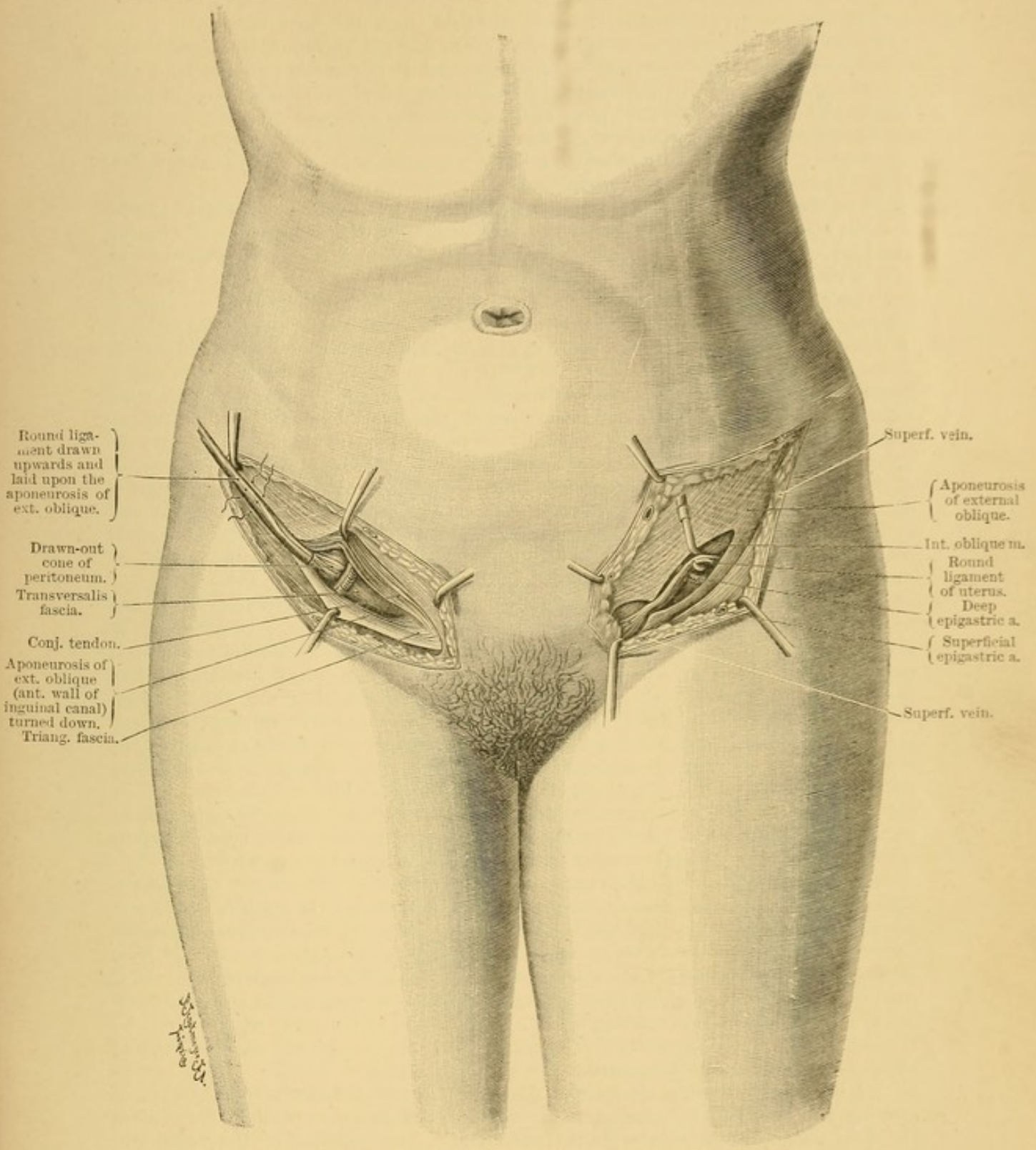


FIG. 111.—Alexander's operation for retroflexion of the uterus, modified by Kocher. On the right-hand side the inguinal canal is opened. We now no longer divide it farther than the external abdominal ring. On the other hand, it shows very well where the ligament can be isolated most successfully.

On the left side of the figure the ligament is shown cut through, whereas we now neither divide it nor do we separate it from its lower attachment, but stitch it up to the aponeurosis as a drawn-up loop. The cone of peritoneum which is drawn upwards to one side of the deep epigastric vessels is well reproduced.

cavity, and fix this externally, without dividing it, in the form of a loop to the aponeurosis of the external oblique. By this means the operation is simplified and equally effective. The operation is so simple that it is difficult to understand why gynæcologists continue for months to treat with pessaries uncomplicated cases of retroflexion and retroversion of the uterus which are causing inconvenience.

156. Operations for Disease of the Appendix. 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.

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, whose results 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, 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.

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 the least hesitation. The mortality in such cases with a surgeon of the aseptic school is nil. This radical operation 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 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 would certainly take to heart the advice given by Roux and other specialists on the appendix, and always operate in the stage at which all symptoms of inflammation have entirely disappeared.

(a) Radical Operation where the Appendix is not Inflamed. The 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.

The incision is purposely made over the fleshy region of the abdominal muscles,

three fingers' breadth above and parallel to Poupart's ligament—that is, rather more horizontal and somewhat more externally than the incision shown in Fig. 112, which is planned to avoid the muscle. Divide skin, subcutaneous tissue, and the aponeurosis of the external oblique, 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 (Fig. 113), the base of the processus vermiformis can be located with certainty, and is the first thing to look for. The appendix is then freed and brought up to the abdominal wound. A small pair of compression-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.

In such simple cases, when the appendix shows no material macroscopic changes, the peritoneum and fascia transversalis are stitched up without a drain (Quervain uses the tobacco-pouch stitch), and one or two stitches may be introduced to close the split edges of the muscle, but this is generally unnecessary. A continuous suture is put into the divided external oblique, and the skin incision is closed.

(b) Radical Operation in Cases with Inflammation. The other extreme to the radical operation above described is when removal of the vermiform process is undertaken while acute inflammatory processes are in progress—*i.e.* quite at the beginning of an attack. The principal advocates of this treatment are Rehn, Bernays, and others, and formerly Sonnenburg. Bernays is probably the surgeon who has been best able to carry out the radical operation in every case of appendicitis at the outset of the acute disease. He removes the appendix on principle in every case during the acute stage, and if this stage is past he waits before operating till a second attack occurs. The operation is then carried out in the very midst of foci of infection and of inflammatory changes.

It is obvious that the difficulties in this case are incomparably greater than they are when the operation is performed during the period of quiescence. No wonder, then, that so many surgeons are strongly opposed to this procedure. Bernays' results, however, show that this is nevertheless the ideal treatment. He had seventy-one consecutive recoveries in cases of acute purulent or gangrenous appendicitis, some with acute peritonitis. No doubt the majority of cases of appendicitis would recover without this treatment, and could be operated on without any risk at a later date; but it is no less certain that a very large percentage of cases have been irretrievably lost by the semi-expectant and semi-operative treatment adopted.

The Hospital records and tables of the causes of death in every country refer a serious mortality to "acute peritonitis," of which by far the largest proportion can be traced back to appendicitis.[1] During the acute stage the operation must provide much freer access than is required for the radical operation during a period of quiescence. A point is, therefore, chosen where either the minimum of muscular fibre, or none at all, will be encountered, and where the thinnest and most direct route to the appendix will be found. This is M'Burney's point; here Senn, Barker, Bernays, and others make their incisions; here also we advise that the operation should be begun in every difficult case.

An incision from 3 to 4 ins. in length is made half-way between the umbilicus

[1] More than once we have heard experienced practitioners express the opinion that no one ever dies of perityphlitis. That must be admitted if all cases of secondary peritonitis and metastatic inflammation be excluded!

and the anterior superior spine of the ilium, inclining downwards and inwards along the margin of the rectus, which is uninjured (Fig. 112). The incision divides the skin, the superficial fascia, the aponeurosis of the external oblique muscle, and only the anterior muscular fibres of the deeper muscules, the greater part of the incision passing through their aponeuroses. The fascia transversalis, which is very conspicuous and often immediately covers the peritoneum, can be divided without injury to the latter. A fold of peritoneum is picked up with dissecting forceps, and an opening, at first small, is made into it, as the presence of adhesions might lead to injury of the gut. The opening is then enlarged with scissors. The peritoneum is now seized with artery forceps, the finger introduced, adhesions broken down if necessary, and the cæcum drawn out of the wound. The junction with the ileum is

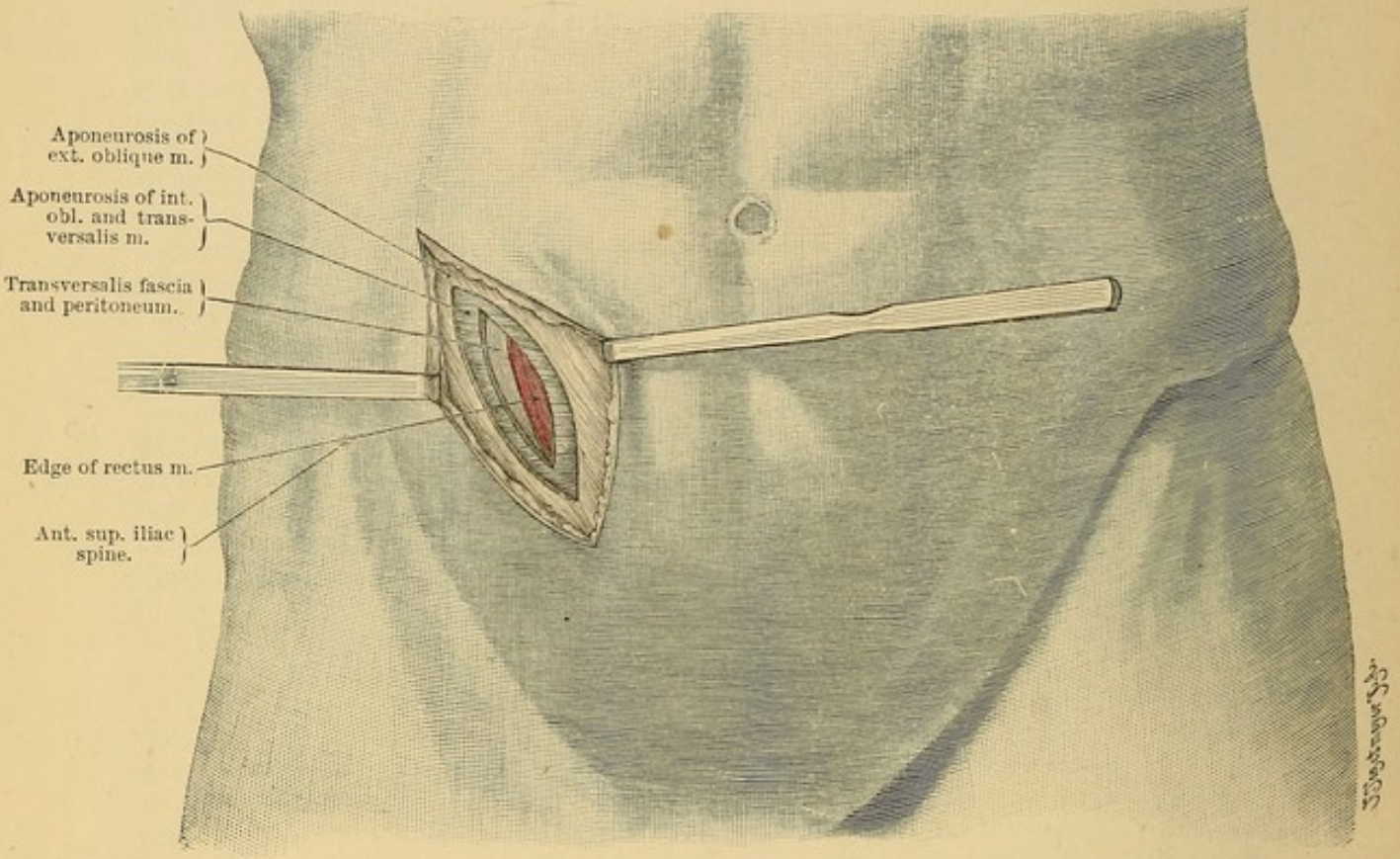


FIG. 112.—Amputation of the appendix through an incision along the edge of the rectus. An oblique incision has been made down to the fascia transversalis at a point midway between the umbilicus and anterior superior iliac spine.

then sought. The base of the vermiform process is situated in the angle between the ileum and cæcum, where the anterior longitudinal band terminates (Fig. 113). The appendix is followed up to its free end, which may be variously situated. In cases of enteroptosis in the female the finger frequently touches the transverse colon first, but this is easily recognised by its free mobility and by the fact that the great omentum is attached to it. It is not always easy to get the cæcum and ileum out of the wound. Omental adhesions are often the cause of this, and it may be necessary to separate them up and to divide the adherent omentum between double ligatures. Adhesions between coils of small intestine may be even more troublesome. It is, however, essential that these adhesions should be thoroughly divided so that *all* the adherent intestinal coils may be drawn out of the abdominal cavity. It is only after this has been done that points in the intestine which are thin or per-

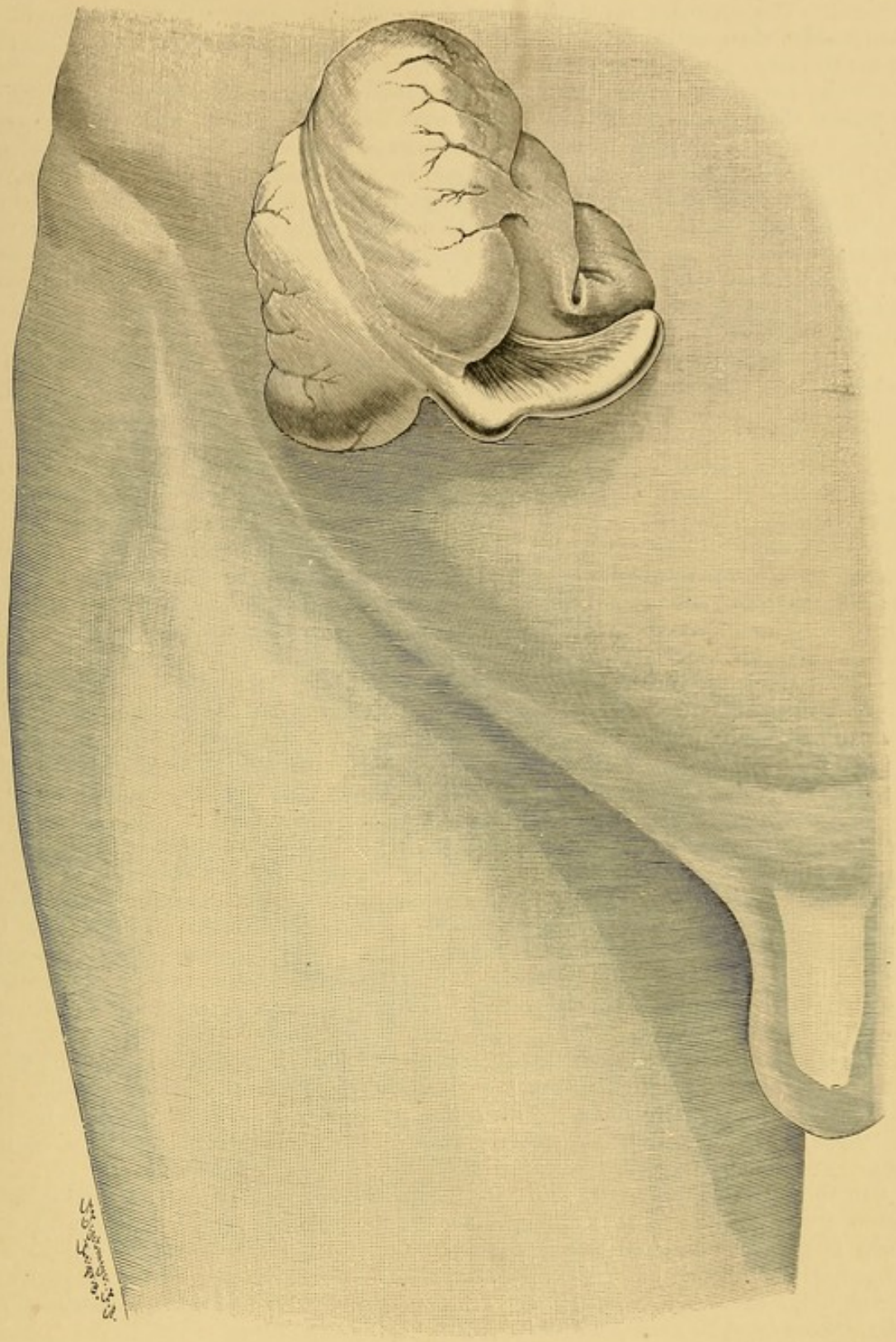


FIG. 113.—Radical operation for appendicitis. The cæcum and lower end of ileum have been drawn out of the wound. The figure shows the anterior longitudinal muscular band of the large intestine ending at the base of the appendix. The mesoappendix is well seen.

forated can be properly seen and accurately sutured, and the course of the disease arrested. The appendix is amputated as described above, except that, on account of the presence of infective material, catgut is used to ligature the appendix and for the serous suture to cover in the stump.

When the operation has been performed where inflammation is present, further treatment should never include immediate complete closure of the abdominal wound. Bernays places a strip of gauze (2 ins. broad and 6 to 8 ins. long) round the stump of the appendix, and on every piece of gut on which there is a deposit of fibrin, or any discoloration, or suppuration. Drainage is secured by means of these strips. The most important point, however, is to connect each collection of pus with the external wound by the shortest possible route with a drainage tube. In such cases the wound is closed with interrupted sutures passing merely through the peritoneum and fascia, the rest of the wound being closed a few days later with secondary sutures.

With this treatment, including cases in which general peritonitis set in early, and in which the course of the disease approached the fulminating type, Bernays estimates the cures at 98 per cent.

The radical operation may be performed in the early stages of an acute attack on one condition, viz. that the case comes under notice at a time when the seat of infection is still limited to the ileo-cæcal region, or at any rate before peritonitis has led to the formation of multiple localised abscesses scattered throughout the abdominal cavity. Unfortunately, however, few surgeons are lucky enough to have around them such a well-disciplined body of doctors and patients. With us it is the rule that the first few precious hours and days pass by when only true peri-appendicitis and perityphlitis are present, and the time is allowed to slip away, till the appearance of the symptoms of general peritonitis indicates that the patient's life is in imminent danger.

And so it happens that most surgeons get the cases of perityphlitis in the critical intermediate stage where abscess formation is going on. Roux finds that by far the most common cause of appendicitis is a phlegmonous condition of the appendix, and he considers that the differentiation into catarrhal and ulcerative appendicitis is practically useless. We consider it very important to emphasise the fact that, as opposed to the opinions of many physicians, acute appendicitis is almost always an exudative periappendicitis, generally the result of perforation, and should be treated accordingly. The resulting abscess formation may undergo spontaneous cure by perforation (generally into the small or large intestine, or externally) or by absorption, or it may lead to a fatal termination, the result of a general infection from secondary perforation followed by diffuse suppurative peritonitis. As the latter event cannot be ensured against, we must also be prepared to treat appendicitis in the intermediate stage.

(c) Operation for Perityphlitic Abscesses. In the intermediate stage the most important point is not to perform a radical cure by removal of the appendix, but to remove the pressing danger which the presence of an acute abscess in the abdominal cavity entails. The former need only be considered in so far as the removal of the appendix may be essential for the healing of the abscess.

It is important, especially from the point of view of prognosis, to distinguish between two varieties of abscess formation, viz. the isolated and the multiple. When there is only one isolated focus of suppuration (or perhaps two or three) in the immediate neighbourhood of the appendix, that is, where the case is one of purulent perityphlitis or periappendicitis, the treatment is obvious and the prognosis good. The abscess must be opened and the pus thoroughly evacuated.

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, 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 it is also advisable to use a blunt dissector after cutting through the linea alba in order to avoid injury to the bladder, which is often closely applied to the 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.

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 put in 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 such patients in a few weeks without the necessity for disturbing their minds with the prospect of a second operation for the radical cure.

(d) Treatment of Diffuse Peritonitis after Appendicitis. It is a question of the virulency 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. Roux finds that a serous or seropurulent exudation into the free peritoneal cavity is of constant occurrence. Such exudations, however, doubtless find a natural limit for themselves. Many very experienced surgeons, therefore, consider it better to wait till an abscess has formed which can be attacked through an incision which does not penetrate the free peritoneal cavity. Unfortunately, however, abscesses occur which never become accessible, and which bring about a fatal termination before they ever reached a state in which they could be so opened. 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. It is certain that a number of these abscesses arise from secondary perforation from purely perityphlitic suppurative foci, and are not the immediate consequences 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. One of the main objects of the treatment must therefore be to open the primary suppurative focus as early as possible. In spite of this, a number of patients nevertheless die after abscesses have been opened, and if death is to be avoided in such severe cases, the advice given by Bernays, Rehn, and Sonnenburg must be taken. 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.

The direct method of treatment of a true 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. 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, Cirle 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. Intravenous transfusion of salt solution is very effective as a remedy for shock. According to Cirle 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. As an accompaniment to this subcutaneous injection of strychnine is excellent. Elevation of the buttocks and lower extremities should also be employed. The near future will reveal to what extent Cirle's latest discoveries on the treatment of shock will be taken advantage of in the treatment of peritonitis.

In peritonitis it is very useful to empty the stomach and intestine by washing out, and it may be necessary to form a fæcal fistula. 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).

The present surgical treatment of appendicitis may be summarised as follows :—

1. If brilliant results are to be obtained with a maximum of success and a minimum of danger, the operation of removing the appendix should only be performed at a period when all periappendicitis has disappeared, and it should be performed in every patient who has recovered from one single attack of perityphlitis, whether the attack was severe or very mild. There should then be no operative mortality, and the patient should be convalescent in eight days.

2. When the surgeon's object is to save as many lives as possible, the radical operation should be performed and the infective foci removed in every case of acute appendicitis or perityphlitis at the *beginning* of the attack. Under these circumstances all hope of primary union and brilliant statistics must be given up. Only the surgeon who is in the happy position of being called in by the doctor in charge of the case at a time when, though there may perhaps be some circumscribed exudation round the appendix, there is yet no general peritonitis, will be able to approach this ideal treatment.

3. When the patient is not seen until a stage of the attack when abscess formation and the signs of further implication of the peritoneum have set in, the abscess should be opened as soon as its presence and position have been clearly ascertained, and as soon as possible thereafter the appendix should be resected in order to remove the source of further possible infection.

4. In patients in whom, at the time of the first visit, signs of subsidence of the inflammation and improvement have appeared, operation should not be undertaken until the attack has completely subsided.

157. Ileo-cæcal Resection. We have performed resection of the cæcum tógether with the lowest part of the ileum and sometimes more or less of the ascending colon with very good results in cases of tuberculosis and carcinoma, which occur not infrequently at the ileo-cæcal valve. Certain forms of perityphlitis demand circumscribed resection of the cæcum, *e.g.* when the infiltration of the appendix has attacked also the wall of the cæcum. In such a case, after emptying out the contents of the colon, a pair of forceps is applied to the cæcum in order to shut it off; the appendix is then removed along with the adjacent part of the cæcum; the gut is sutured in the usual manner.

In tumours—often of great size—in the region of the cæcum and ileo-cæcal valve, as well as in the case of extensive tuberculous infiltration, the principal difficulties are due to adhesions and to the existence of tumours of the lymphatic glands of the mesentery.

The incision is the same as that for removal of the vermiform appendix, except that it must be somewhat prolonged outwards and upwards when there are extensive adhesions. After opening the abdomen, the first thing to be done is to free the cæcum by separating the thick masses of omentum which are adherent to the diseased intestine, and then to separate the cæcum from its connections with the fascia over the ilio-psoas. All bleeding must be carefully arrested, and the larger strands of omentum must be firmly ligatured before division.

If by this procedure the intestine has been rendered movable, it is drawn out of the wound and resected according to the rules given for resection of the intestine. If the separation of the omentum and of the adhesions with the fascia does not suffice, then the mesentery, which may be infiltrated or thickened through infection of the glands, must also be divided after ligature of its vessels, so that the cæcum may be drawn out from the wound.

When the tumour, with the glands pertaining to it, has been freed on all sides and fully isolated, the next step, before applying the compression-forceps, is to ascertain which are the nearest healthy portions of the large and small intestines which have a perfectly free arterial blood-supply. The arteries can be seen and felt. Narrow-bladed compression-forceps are applied at these points, the gut is cut through close to them, emptied by stroking out the contents, and, if an end-to-end anastomosis of the small and large intestines is to be made, clamps are applied farther back.

There is apt to be an inequality in the width of the ileum and colon, which may, however, be equalised by hypertrophy and dilatation of the former, the result of the long-continued stenosis. In such cases we have never had any special difficulty in performing the simple end-to-end union of small and large intestines according to our method. In exceptional cases we have either divided the ileum more obliquely than usual so as to obtain a greater circumference, or, with the same object, made a small incision on the side opposite the mesentery.

If much disparity in size exists, it is much easier to apply a broad-bladed compression-forceps to the large intestine, and after removing it to apply a ligature round the bowel at this point and invert it with sutures. The small intestine is then joined to a special lateral opening in the large intestine, made where it is most convenient. Under certain circumstances it may be desirable to close both the small and large intestines as described above, and to perform a lateral anastomosis. If the patient is collapsed this may be performed quickly and without risk. A Murphy's button may be used.

Enterostomy and Colostomy

The most important reason for opening the intestine is to empty out some abnormal collection of intestinal contents. Such a collection may be caused by all forms of

intestinal obstruction, both acute and chronic. Life may often be saved in such cases by emptying the intestine. Accumulation of intestinal contents not only interferes with respiration and prevents sufficient nourishment being taken, but it also endangers the patient by the increased bacterial fermentation of the stagnant intestinal contents, and by overdistending the intestinal wall and disturbing the circulation.

Of these dangers the ulcers due to stretching of the intestinal wall deserve special consideration, because they give rise to perforation. For this reason—quite apart from the cause—marked distension of the intestine with stasis of the contents should never be allowed to persist for long, and if the condition has developed rapidly, relief should be given as soon as possible. This may be obtained by enterostomy, either by opening the gut externally, or forming an anastomosis between it and a more distal portion of the intestine. The latter procedure will be described separately under the heading "Entero-anastomosis."

Opening the gut externally is a simple and safe procedure, and may be performed without fear under cocaine on patients who are very weak. Where and how it should be done depends upon the indications, and especially on the question as to whether a temporary or permanent exit for the intestinal contents is to be formed. In the former case a very small opening (fæcal fistula) in the gut is all that is required to allow the gaseous and fluid contents to escape; in the latter case a large opening (artificial anus) is made.

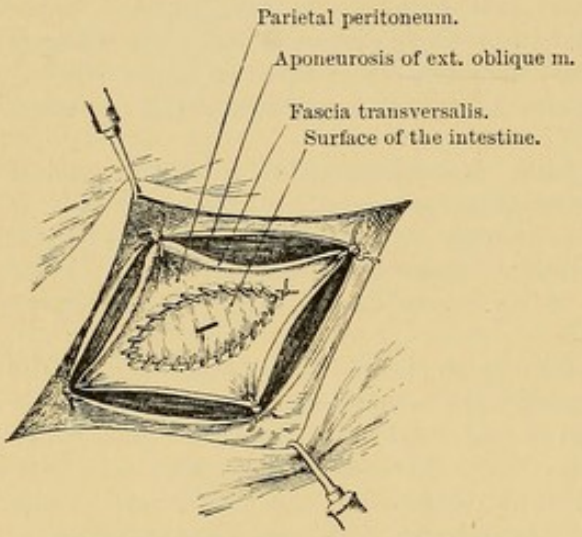


FIG. 114.—Formation of a fæcal fistula.

158. Method of establishing a Fæcal Fistula. A fæcal fistula is generally formed in acute or chronic intestinal obstruction in order to tide the patient over the immediate danger in cases where the diagnosis is uncertain, or where more serious operations are contraindicated.

The seat of election for the incision, which should be about 2 ins. long, is three fingers' breadth above and parallel to the outer third of Poupart's ligament. The skin and fascia are divided with the knife, then a blunt dissector is used to separate the muscular fibres. The distended intestine, which is generally found presenting at the wound, is to be so arranged that it fills up the wound without being allowed to project beyond it. The intestine is now fixed to the abdominal wall by means of an interrupted suture placed at each of the four corners of the wound. These sutures pass through the serous coat of the intestine and the parietal peritoneum, then through the fascia transversalis and the aponeurosis of the external oblique. The serous coat of the intestine is now stitched to the edges of the parietal peritoneal opening by means of a fine continuous silk suture, which hermetically presses together the two serous layers. The intestine is opened by rapidly plunging a fine knife into it, after which a probe is introduced to make sure that the lumen has been properly reached. Iodoform, or aristol powder, is rubbed into the wound, which is then covered with warm moist 1 : 1000 salicylic gauze, which should be frequently changed.

Such a small opening gives a free enough exit to the intestinal contents to permit of a suitable fluid diet being given by the mouth. To prevent irritation, the skin round about is coated with a thin layer of gutta-percha, which can be easily done with the aid of hot water.

159. Formation of an Artificial Anus from the Colon (Coloprocty) (Figs. 115 and 116). An artificial anus is made when a permanent exit is required, and also when it is desired to prevent the intestinal contents from passing down into the lower part of the gut, *e.g.* as a preparatory step to the operation of excision of the

rectum. The operation for the formation of an artificial anus has of late years been much restricted in favour of the operation of entero-anastomosis for all cases where the obstruction is situated above the rectum. It is now usually performed for cases of inoperable carcinoma of the rectum, and occasionally as a preliminary to excision of the rectum.

The operation now generally preferred is a colostomy, performed, if possible, so as not only to establish an artificial exit for the fæces, but also to form a true anus, in the sense that the opening has a sphincter.

In forming an artificial anus—a very simple operation in itself—much attention has been directed to endeavour to provide an opening through which there shall be no incontinence of fæces. Gersumy, Witzel, Roux, Hacker, and Lauenstein have all devised methods directed to this end. The simplest would seem to be to attempt to produce a muscular sphincter action analogous to that of the sphincter ani. But the muscles of the abdominal wall, which can easily be formed into a sort of sphincter if split in the proper direction, are nevertheless not of the same value as a true sphincter, because they do not possess the reflex mechanism which gives the true sphincter its tone, *i.e.* brings about a reflex closure at the proper time, as the result of a sensory stimulus.

For this reason the muscular sphincters, including those formed through the rectus abdominis (Witzel and Hacker), act really as elastic bands, and it is mainly a question of establishing an opening which will not gape, and which can be kept closed by a suitable pad as easily and as securely as possible. The establishment of an opening into the colon, as understood by the term colostomy, is not altogether comparable to the establishment of an opening into the stomach. In the case of the stomach, a true mouth is required, *i.e.* an opening through which food can be introduced, but from which nothing shall be able to escape. In the case of the colon the requirement is reversed, a painless evacuation of the bowel being the object to be attained, for which reason it would be better to speak of a "colon-anus." After consulting with our philological colleague, Prächter, we venture to propose the name "coloprocty."

If the patient has voluntary control over the artificial anus, it is obviously important that he should be able to hold a vessel comfortably so as to receive the fæces. Roux, as a solution to the problem, constructs a "symphysis anus." We have no experience of this method. Our patients have always been perfectly satisfied with an iliac anus. We perform the operation as follows :—

An incision is made two fingers' breadth above the outer third of the left Poupart's ligament, dividing skin and fascia. The muscular fibres of the internal oblique and transversalis are split with a blunt dissector and the fascia transversalis divided. Fig. 115 shows how, after dividing the fascia transversalis and opening the parietal peritoneum, the edges of the latter can be drawn out between the muscular fibres which tend to close spontaneously. After dividing the fascia transversalis the peritoneum is opened to a more limited extent, and a complete loop of the pelvic colon (in inoperable carcinoma of the rectum) is drawn out of the wound. It is most important to satisfy oneself as to which is the proximal and which the distal portion of the loop. The serous layer of the loop is now stitched to the edges of the opening in the parietal peritoneum with a continuous silk suture in such a way that plenty of room is given for the proximal part of the loop, which in its turn is made to compress the distal portion (this condition is not represented in the illustration, Fig. 116).

As an artificial anus, unlike a fæcal fistula, is generally constructed under circumstances when there is no special hurry, it is best not to open the bowel at once, but, after suturing it in position in the wound, to allow the latter to granulate for forty-eight to seventy-two hours. After this delay the bowel is to be opened transversely to its long axis with the thermo-cautery, so that the upper end shall evacuate its contents externally directly through the opening.

Some surgeons, as Hartmann, do not suture it at all, but merely pull out the gut, push a piece of iodoform gauze under it and round both ends, and leave it for eight days.

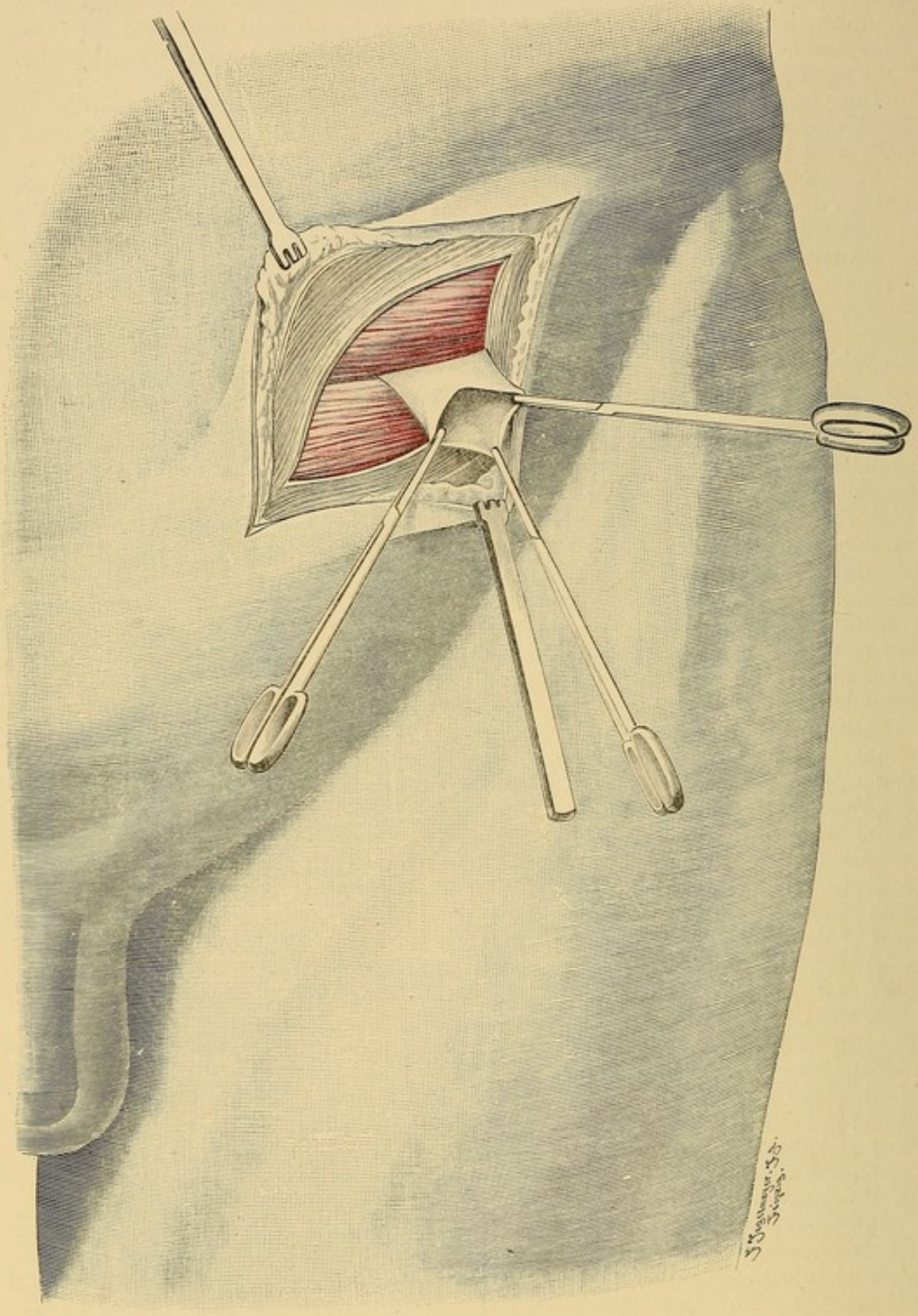


FIG. 115.—Formation of a temporary artificial anus in the left iliac region ; the parietal peritoneum has been drawn out between the deeper abdominal muscles and opened.

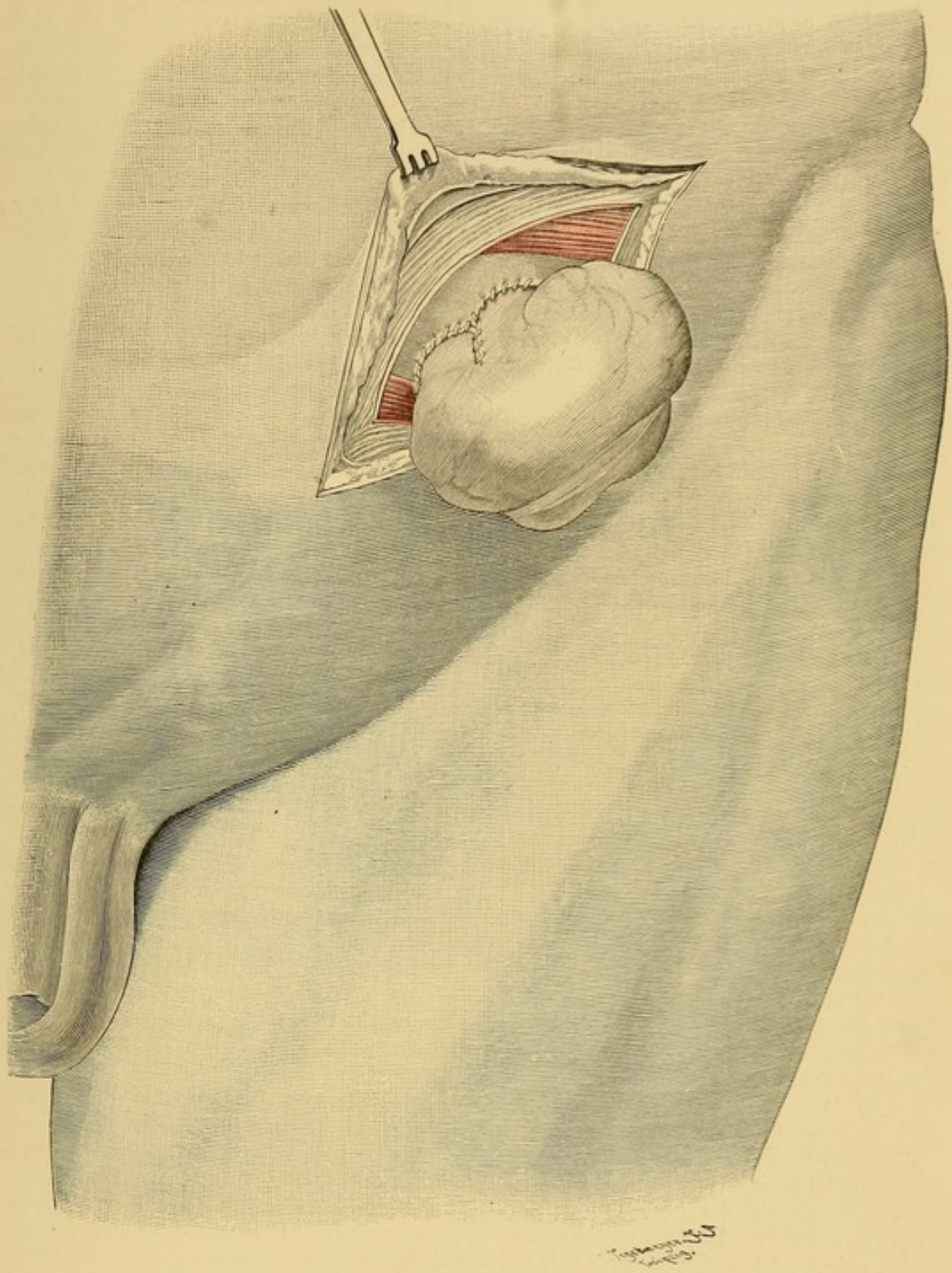


FIG. 116.—Formation of an artificial anus in the left iliac region; the bowel has been brought out through the aponeurosis of the external oblique, and between the fibres of the internal oblique and transversalis muscles. A loop of sigmoid flexure has been sutured to the parietal peritoneum

Another method is to divide the gut completely across and suture the upper end to the wound, the lower end being closed and replaced into the abdomen. Where it is important to prevent any fæces getting access to the lower end, and if the gut below is patent, so that the contents of the lower part of the gut can escape, this is the more satisfactory method. In this case too the upper part of the gut is kept closed for the first two to four days.

In the course of time the part of the gut which has been pulled forward becomes levelled with the skin surface through cicatrisation of the granulations which cover the serous surface.

Should this process take too long, the margin of the intestine may be divided with a thermo-cautery 1 cm. from the margin of the skin, so that the edges come to lie at the same level as the spur, which is somewhat prominent owing to congestion.

It will be seen that the construction of an artificial anus is entirely different from that of a fæcal fistula. In the fæcal fistula a *constant* outflow is desired in order to prevent any tendency to fæcal accumulation (especially any accumulation of gas in the intestine); for this reason no attention is paid to any closure of the opening. In the case of an artificial anus, on the other hand, the conditions present in the natural anus are to be imitated as closely as possible—that is, the fæces are to be retained as a rule, and should only be evacuated when a powerful contraction of the gut occurs, and when a certain quantity of intestinal contents have accumulated. This is secured by purposely bringing the gut through a thicker part of the abdominal wall, by bringing it out obliquely rather than too directly, and by choosing a muscular point, so that the muscles by their tension and contraction may keep the gut closed, and only give under the pressure and force exerted by the peristaltic contractions of the intestine. The patients evacuate the bowels once or twice daily, just as regularly as healthy persons.

160. Jejunostomy. Very occasionally the opening into the intestine is intended, not for the escape of the contents, but for the introduction of food. Such is the case when no nutriment can be given by the stomach. Jejunostomy, as described by Maydl, has been recommended for such cases.

Resection of the Intestine (Figs. 117, 118, 119)

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 of asepsis, the definite steps in the technique 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 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.

It is important to know that such very extensive resections can be performed without doing any 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 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 easy to feel. If there be any doubt another piece of gut should be resected before the parts are sutured together.

In resections of the ascending or descending colon, of the lower part of the pelvic colon, and of the upper part of the rectum, it is often difficult to judge whether the cut edges of the gut have a perfectly satisfactory circulation or not, and in such a case the only alternative, in order to secure a successful result, is first to make an artificial anus, and, at a later date, to suture the intestine.

161. Resection of the Small Intestine. If we are satisfied that the ideal intestinal resection (immediate union) may be safely performed, the following rules are to be observed :—

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 clamp forceps are applied close together to the part of the intestine where the section is to be made (Fig. 117), a part being chosen where the wound edges will be well nourished. These clamps are not to be applied exactly at right angles to the long axis of the intestine (as has been erroneously represented in Fig. 117), 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.

3. The intestine is cut through between the forceps, and the cut surfaces are carefully mopped with moist lysol swabs (1 per cent). The mesentery (mesocolon, mesosigmoid) 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 a clamp at each end is thus removed.

4. The intestinal contents of the ends to be united are now pressed along the lumen of the bowel away from the compression-forceps, and the emptied portions having been clamped or grasped between the index and middle fingers (Fig. 118), the compression-forceps are removed and the two intestinal openings disinfected with sterilised gauze swabs.

5. Now comes the end-to-end suturing of the intestine. In order to ensure the approximation of corresponding parts of the intestine, two *fixation sutures* are first introduced—one at the mesenteric attachment, and the other at the convexity. In this way the lumina are brought into accurate apposition, and are retained there by pulling upon the ends of the sutures. The continuous suture which is now put in unites first the mucous layer (catgut may be used), and then the whole of the rest of the wall is united with a fine silk suture. 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, and the protruded intestine washed with warm sterilised salt solution, while the surrounding cloths shut off the peritoneal cavity.

6. The cloths are now changed and a continuous Lembert suture is applied 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. The double suture (indicated in longitudinal section in Fig. 119) 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 removed by a warm sterilised salt solution. The towels having been removed, the intestine is put back into 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 so distended with flatus and fluid contents that its reduction is rendered difficult, it should be opened above the line of suture by a transverse incision 4 to 5 mm. in length, and the contents allowed to flow into a small glass dish, after

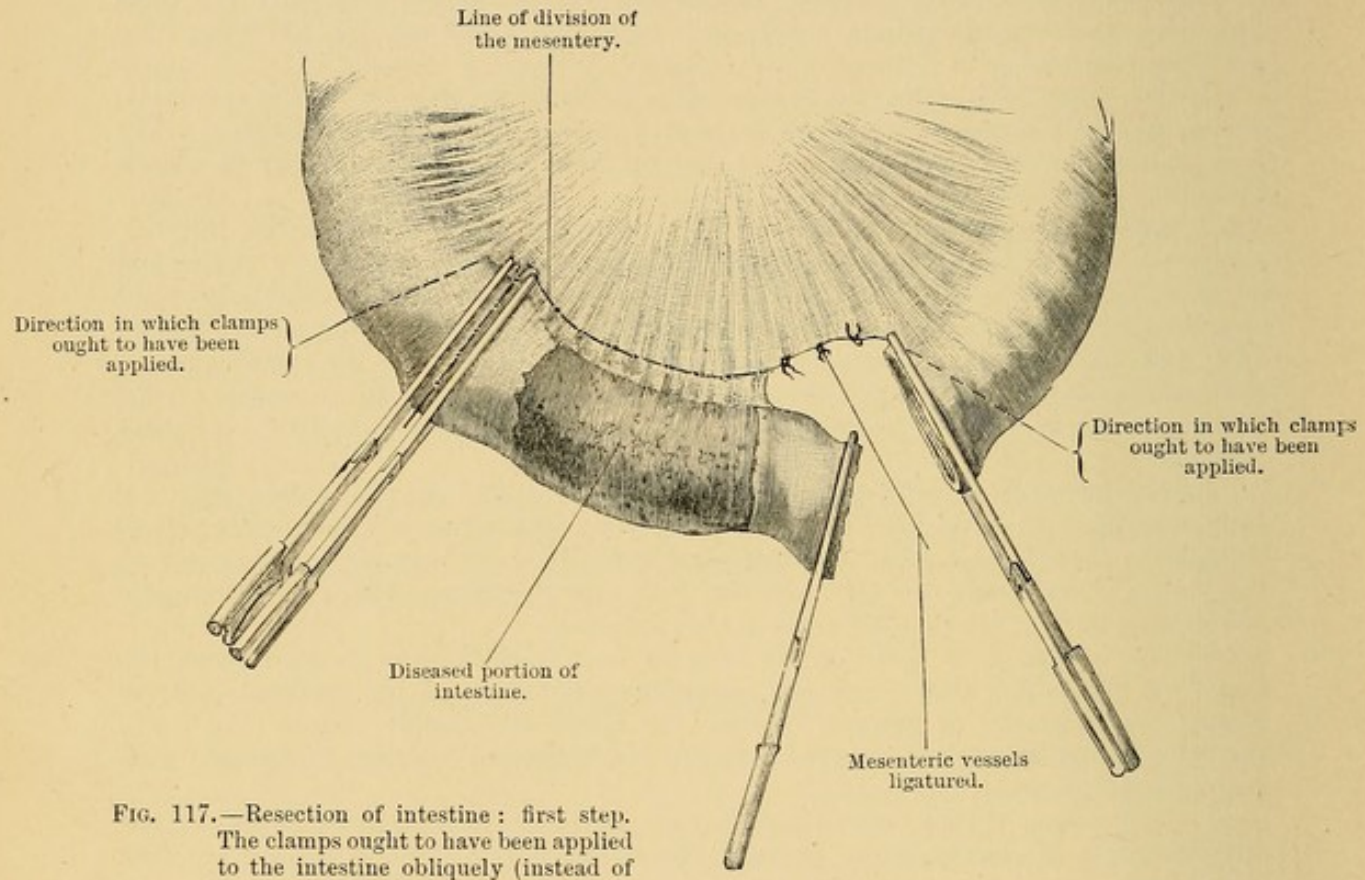


FIG. 117.—Resection of intestine: first step. The clamps ought to have been applied to the intestine obliquely (instead of transversely, as has been erroneously indicated) to ensure a good blood-supply. The intestine has been cut across between two of the forceps, and between the other two the line of 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.

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 put in 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

Fig. 118.—Resection of intestine: second step. The diseased piece of intestine has been removed; the ends of the intestine are compressed between the assistant's fingers, and fixed in position by two fixation sutures, one at the concavity and the other at the convexity; the posterior continuous suture has been introduced through the whole thickness of the wall.

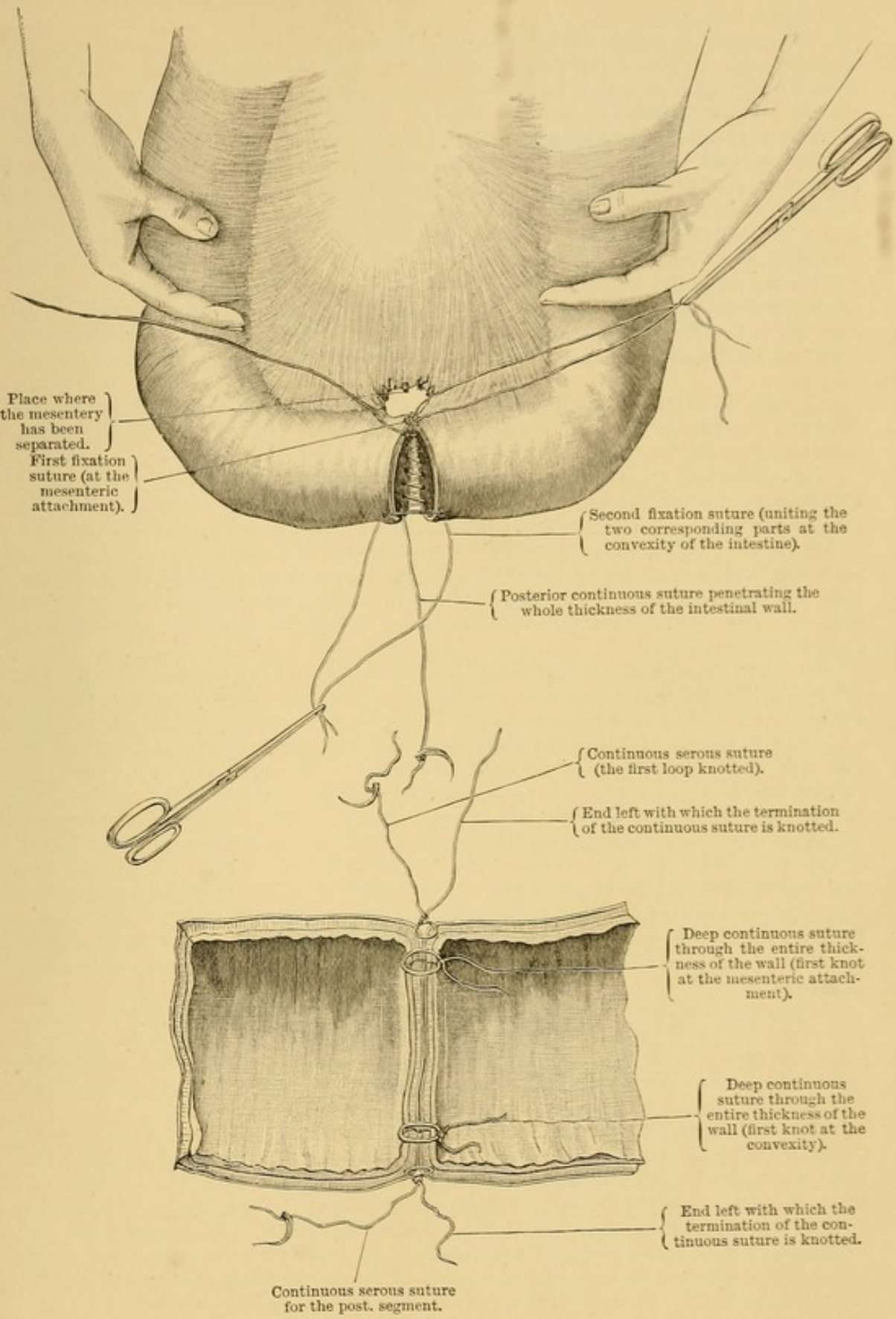


Fig. 119.—Intestinal suturing; to demonstrate the double row of sutures; posterior half of gut cut longitudinally; viewed from within.

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 reliable mechanical union than Murphy's button; and further, 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.

In cases in which the end-to-end method of uniting the gut cannot be employed, it is often necessary to close one or both of the intestinal ends and to perform a lateral anastomosis.

The 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 Quervain and confirmed by Haigler) 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 will be described under entero-anastomosis.

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" is put in behind the forceps, just as is done in resecting the stomach (cf. Fig. 98). The ends are not tied, but are held taut. By this means the gut is temporarily closed without using 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 without having to use clamps, the disadvantage of which is that they are liable to injure the circulation.

The use of compression (crushing) forceps and, when they can be borne, of clamps to prevent escape of intestinal contents, renders resection of the gut an exceedingly simple procedure in all those cases in which the ends of the intestine can be brought out of the abdominal wound, as is usually possible when dealing with the small intestine. Resection of the large intestine is much more troublesome.

162. Resection of Large Intestine. Ileo-cæcal resection has already been considered (see p. 255). Resection of the large intestine is frequently required for tumours of the hepatic and splenic flexures, and of the iliac and pelvic colon. In these cases it is very difficult to render the extremities of the gut sufficiently movable. Sometimes the splenic flexure and the junction of pelvic colon and rectum are so tightly bound down that excision can only be performed through a very large abdominal incision and, with the assistance of crushing-forceps and clamps, inside the abdomen itself. In such cases a variety of expedients may be adopted.

In a recent case where a carcinoma was fixed at the upper part of the rectum we

could only render the pelvic colon movable. We closed the greatly dilated pelvic colon and brought it down to the upper end of the rectum, which, with the aid of clamps, we succeeded in implanting in a lateral opening in the colon. The patient recovered. Where stenosis of the colon exists too much force should not be applied in loosening the parts, for, in consequence of the great dilatation, ulcers frequently form above the stricture and render the gut friable.

As a rule it is safer and more convenient, in resecting the large intestine, to close the divided ends and to form a lateral anastomosis. An incision of considerable size is essential for the procedure. For the *hepatic and splenic flexures* a long transverse incision is made parallel to the costal margin. For resection of the *pelvic part of the colon* free access is also necessary. An incision of considerable length is made parallel to Poupart's ligament on the left side, above the inguinal canal. After opening the peritoneum the relations of the tumour are defined. If it be removable the incision is extended towards the middle line above the pubic symphysis through the attachment of the rectus, care being taken that the bladder is empty. By this means free access is obtained, and even very difficult resections can be successfully carried out.

If the growth (along with the glands in the pelvic mesocolon) can be isolated, the mass should be resected and an end-to-end or a lateral anastomosis effected. If the isolation involves extensive injury to the vessels, it may be found preferable to extend the division of the mesentery higher up, thus rendering the pelvic and, if necessary, the iliac colon more movable, so that it may be invaginated into the rectum and pulled out through the anus, and there sutured in the manner which will be described under Excision of the Rectum. Kümmell showed how far one can go in this direction when he excised with complete success (in a girl with extensive tuberculous infection of the gut) the rectum, sigmoid flexure, and descending colon, and sutured the transverse colon to the anal ring.

163. Entero-anastomosis. This operation, proposed by Maisonneuve and inaugurated by Wölfler in his gastroenterostomy, is an excellent expedient in all cases where an obstruction in the gut cannot be removed. If, in a case of ileus, the abdomen has been opened and it is found that removal of the obstruction is impracticable, a continuity is established between the overfilled and distended gut above the obstruction and the empty shrunken gut immediately below it. For this purpose two pieces of intestine (as close as possible to the obstruction) are chosen which can easily be drawn out of the wound and applied to one another. This procedure is most frequently called for in advanced cases of carcinoma of the intestine with extensive adhesions.

Two varieties of anastomosis are usually recognised—the end-to-end and the lateral. The method of uniting the ends after excision of a section of gut has been described under resection of the small intestine (p. 261). We have to do at present only with union of two parts of the intestine in cases where no gut has been removed. This may be done either by dissociating and occluding the affected piece of gut and uniting the healthy ends above and below, or by forming a lateral communication between the gut above and below without closing up the affected part.

The simplest method is the following:—The two pieces of gut are placed with their antemesenteric aspects in apposition. They are emptied by pressing the contents along the bowel and by compression above and below by the fingers of an assistant, or better, by applying two pairs of clamps, which also prevent hæmorrhage. A longitudinal continuous serous suture is then put in along the convexities of both pieces of gut for 2 ins., and the ends of the suture are left long, with a needle threaded on one of them. A longitudinal incision is now made in each piece of gut, 5 mm. (nearly $\frac{1}{4}$ in.) from the sutures, for a distance of not quite 2 ins., and a continuous suture is put in through all the coats. This brings the two openings into apposition. Lastly, the other half (anterior segment) of the serous suture is introduced. A safe communication is thus rapidly established.

While the sutures are being put in, escape of the intestinal contents into the

peritoneal cavity is prevented by compresses of sterilised gauze. The parts are then swabbed with 1 per cent lysol, douched with sterile salt solution, and replaced.

In lieu of the main circular suture, in addition to Murphy's button and its modifications, a variety of plates and tubes have been devised. They have for the most part been constructed of materials which can be absorbed. Senn employed decalcified bone plates, Baracz pieces of a turnip, Landerer potato tubes, Alessandri tubes of maccaroni dough. No method is so well adapted to the employment of a Murphy's button or one of its substitutes as the method of lateral apposition first recommended by Senn. Two parts of the gut can be chosen which will fit well together: the opening can be made just as large and in just the direction that is most suitable, folding being entirely avoided, because the lumen of each part is of the same size, and because the insertion of the mesentery is not involved. A reliable union can, therefore, be obtained by using almost any one of these methods.

The operation has superseded enterostomy in all cases of intestinal stenosis where the stenosis cannot be dealt with direct, provided there is a piece of gut below the stenosis suitable for anastomosis.

Entero-anastomosis combined with intestinal occlusion was recommended by Salzer and Eiselberg, and then developed by Baracz and others. It may be required when the diseased part of the bowel may damage the function of the healthy bowel by suppuration and decomposition of its contents. The diseased portion of the gut is occluded in the manner described at page 264. Experience has shown that it should not be entirely shut off, but should be connected with the exterior by a fæcal fistula.

Operations on the Bladder

164. Suprapubic Cystotomy. The bladder can, even in very sensitive subjects, be quite well opened under cocaine, a point of considerable importance in view of the frequent occurrences of sympathetic affections of the kidneys and stomach. The mucous membrane of the bladder is very sensitive, and injury to it causes intense strangury and shooting pains in the penis.

The introduction of suprapubic cystotomy by Franco in 1556 was a great step in the surgery of the bladder. It is at the present time the usual method of opening the bladder for any of the divers reasons which require us to look into it, *e.g.* in the case of tumours, tuberculosis, hæmorrhage, calculi, and foreign bodies. A number of surgeons prefer it as *the* method of treating stone, because it 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 frequently leaves a fistula, and the continual and often incomplete outflow from the bladder causes the patient constant annoyance. Dandridge comes to the conclusion that high cystotomy with open after treatment impairs the contractile power of the bladder to a greater extent than the perineal operation, that it heals less rapidly, and that it is more difficult. In carcinoma of the floor of the bladder suprapubic cystotomy is preferable.

The normal incision, also employed by Bardenheuer, is made transversely in the fold above the symphysis, through the skin and superficial fascia. When the pelvis is raised into the Trendelenburg position a very clear view is got of the interior of the bladder. A few symmetrical vertical veins in the skin must be ligatured. In order to get plenty of room without bringing the peritoneum into danger, the soft parts above the symphysis are freely divided by a curved incision extending from above one inguinal canal to a corresponding point above the other. After division of the fascial layers covering the recti, the attachments of the recti to the symphysis are in part divided, together with the pyramidalis muscles and the tense insertion of the linea alba. The latter, together with the fascia and recti, retract well upwards. In order to get more

room, it is generally better, however, to make an additional longitudinal incision in the middle line through the linea alba. 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. The smooth bluish outer surface of the bladder appears with a few veins on its surface; these should be isolated, divided, and obliterated by torsion. By means of this manipulation, combined with elevation of the pelvis, distension of the bladder, or of the rectum, as recommended by Peterson, is quite superfluous; indeed it is attended with a danger of rupturing or injuring these organs when they are diseased. The bladder, after it has been cleansed aseptically, is better filled with air than with water.

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 puts in the fixing sutures laterally, but they then give no help in putting in the sutures afterwards.

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 opening may now 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. Finally, the external wound is closed.

The bladder is thoroughly washed out before the operation until the water comes away quite clear, and if decomposition is present, it is filled with 5 to 7 ounces of a boiled 4 per cent solution of boracic acid, at 98·6° F.

For the after treatment a Nélaton's catheter is introduced along the urethra and retained in position by a silk suture passed through the frænum. The urine is conveyed by a rubber tube into a vessel containing a 5 per cent carbolic or a 1 : 1000 sublimate solution. The catheter is kept in for eight to fourteen days—that is to say, until the bladder wound is healed. A glass drainage tube is introduced into the wound, as far as the bladder, through a separate opening, and is allowed to remain in eight to ten days till it is certain that the bladder sutures are holding.

165. High Cystostomy. When it is required to establish a temporary or a permanent fistula, the bladder can be opened suprapubically in the simplest possible way. After the bladder has been washed out with boric lotion it is filled with air (Socin). A vertical mesial incision extending to the root of the penis is made through skin and subcutaneous tissue down to the linea alba, which is here very well marked, and to which the pyramidalis muscles are attached. It is divided almost down to the bone, and the recti are partially separated from the symphysis in order to gain room. The fascia transversalis and the pad of fat which covers the peritoneum and bladder then appear. The finger is introduced behind the symphysis, and is passed down till it feels the first part of the urethra and the prostate below the soft rounded bladder. The fatty pad, together with the peritoneal fold, are hooked up with the finger over the anterior surface of the bladder. The bladder is opened with a stab, and the edges are caught with sharp hooks. The incision is then prolonged with a probe-pointed knife upwards and downwards to within ½ to 1 in. of the upper border of the prostate, so that two fingers can be easily introduced and the bladder palpated and inspected. No sutures are put in, the bladder is loosely packed with iodoform gauze, and the wound is covered by a pad of aseptic gauze. This is changed at first every half-hour, and later every two hours.

The method described is, according to R. Harrison, a certain cure for putrescent chronic catarrh of the bladder, and in prostatic hypertrophy it is a means of temporarily preventing the dangers which accompany the use of a catheter. Poncet sutures the edges of the wound in the bladder to the edges of the skin wound. Delore states that this procedure is a great preventive against infiltration of urine, and considers that the operation is indicated both as a temporary and a permanent cystotomy in a great number of cases of disease of the bladder and urethra, and specially in prostatic troubles.

The operation is generally performed for prostatic hypertrophy and for other irremovable obstructions to the outflow of urine, and for inoperable neoplasms. It is necessary, as a rule, to secure complete emptying of the bladder to wear a silver tube which renders syphon action possible.

The circumstances in which a perineal fistula is to be preferred to the above operation, which in France is named after Poncet, are considered under the heading of Perineal and Suprapubic Cystotomy.

166. Opening the Bladder, with Resection of the Symphysis. If a large transverse incision does not give sufficient room for operations in and upon the bladder (especially in the region of the vesiculæ seminales and of the prostate), it is best, after detaching the origins of the recti and pyramidales superiorly, and the obturatores externi below and externally, to resect subperiosteally a triangular portion from the symphysis with a broad base above and its apex below towards the pubic arch, the periosteum being well separated posteriorly (Helferich). This procedure does no harm to the rigidity of the pelvis. Bramann leaves the resected piece of bone from the symphysis connected with the muscles (temporary resection). Dr. Niehans performs the resection only on one side of the symphysis.

167. Puncture of the Bladder. As puncture of the bladder is only called for in retention of urine with marked distension, it is made in the middle line $1\frac{1}{4}$ in. above the symphysis, *i.e.* about the middle of our normal transverse suprapubic incision. The trocar is directed backwards and somewhat downwards for a depth of $1\frac{1}{2}$ to $2\frac{1}{2}$ in. (according to the amount of fat in the abdominal wall) until the urine escapes.

When the bladder requires to be emptied only once—or even several times, provided there is a prospect of soon restoring the outflow along the normal channel—the simple Potain's aspirator with a long canula is employed. If the urine has to be withdrawn suprapubically for a longer period (as in certain prostatic and urethral diseases), a larger curved trocar is employed, the calibre of which must be large enough to admit of the introduction of a blunt canula outside it into the bladder, so that the edge of the trocar will not injure the bladder wall.

The Surgery of the Ureters

The surgery of the ureters has of recent years attained considerable importance owing chiefly to experimental work. The ureter may be excised for tuberculosis, incised for impacted calculus, sutured if wounded. When valvular closure occurs the ureter below the obstruction may be implanted into the renal pelvis, or into the sac of the hydronephrosis, or, when the lower end of the ureter has been divided, into the bladder. In cases of extroversion of the bladder, or of ureteral fistula opening on the surface, the ureter may be implanted into the intestine. The implantation of the ureter into the bladder and intestine is such an important advance in the relief of otherwise incurable maladies that we shall give a short description of the method of performing the operation.

168. Uretero-Cysto-Neostomy. 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 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. Hegar (Büdinger) and Schede first performed the operation on the human subject.

Boari makes the following recommendations with regard to the operative procedure :—

Fig. 120.

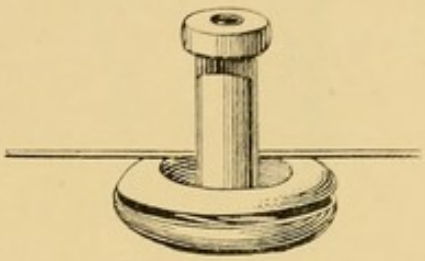


Fig. 121.

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 from a half-filled bladder. A ureteral sound is passed into the ureter (Bazy) from below through the incision in the bladder. 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.

Boari has introduced a button (Fig. 120, 121) analogous to Murphy's button, 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 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. 122, 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.

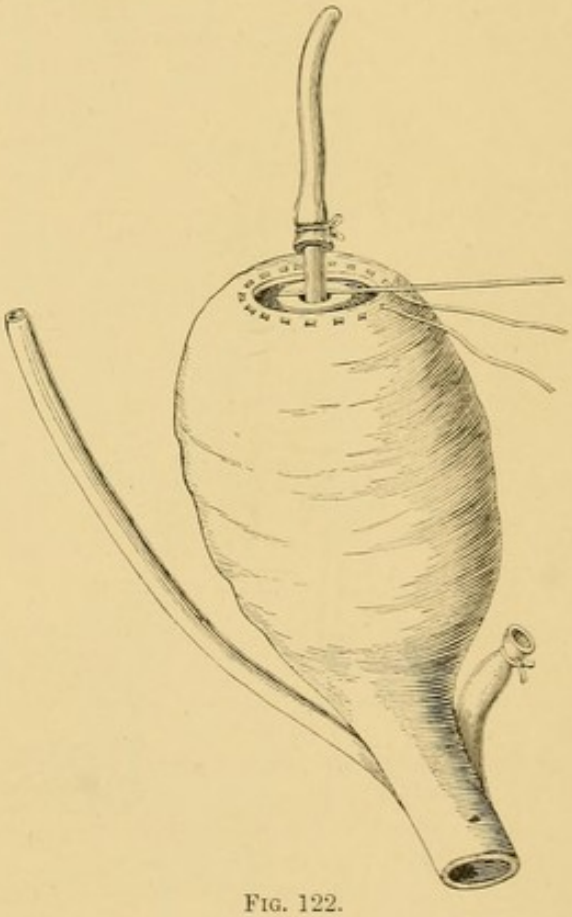


Fig. 122.

Unlike implantation into the intestine, the operation gives rise to no functional disturbance, neither to infection nor to stenosis.

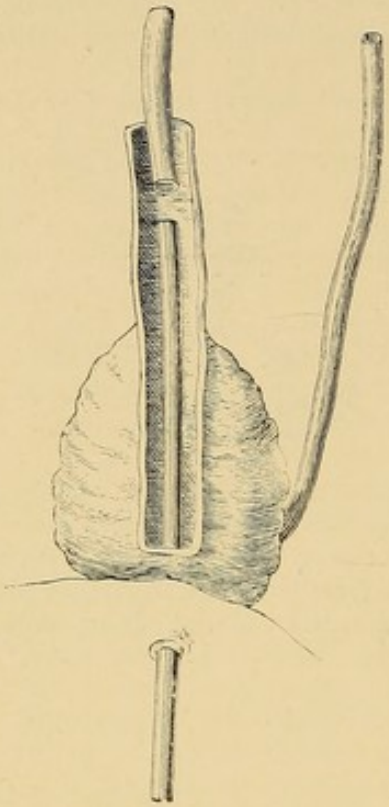


FIG. 123.

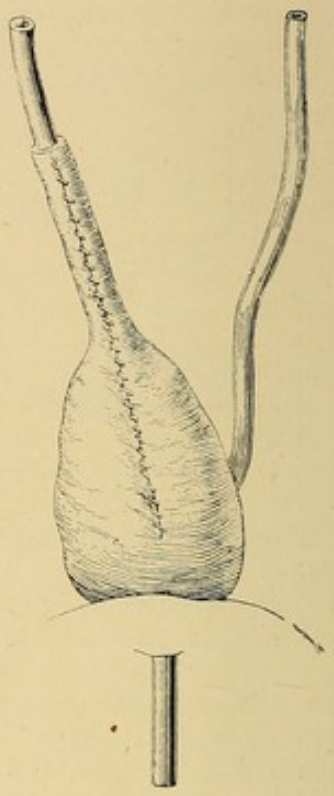


FIG. 124.

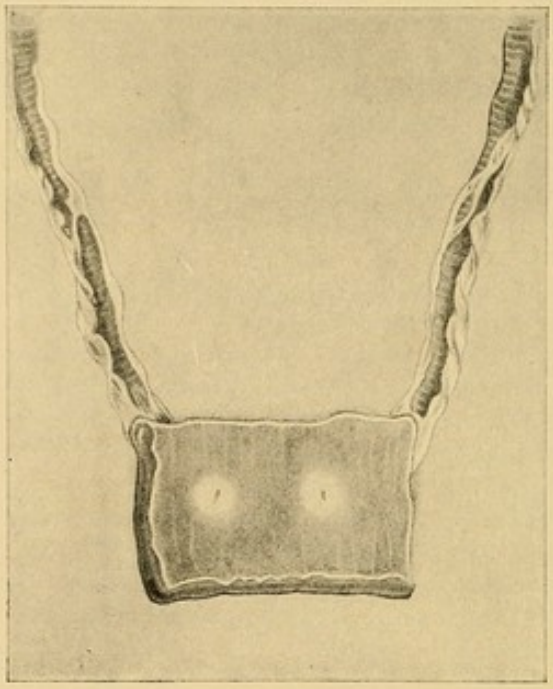


FIG. 125.

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 union, Boari recommends a uretero-plastic operation, which may best be illustrated by two diagrams borrowed from his work on the subject (Figs. 123, 124). 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.

169. Uretero-Trigono-Sigmoidostomy (Maydl's operation). This 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

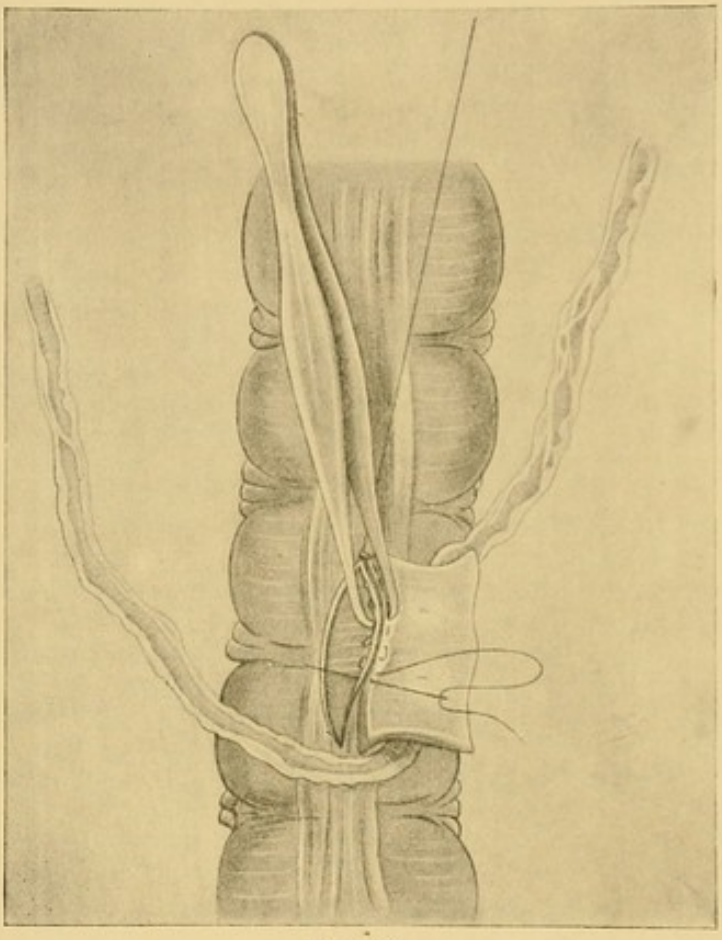


FIG. 126.

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 quite 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[1] 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 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 (Fig. 125). 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 first be emptied, and if necessary a clamp is 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. 126 (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 cleaned up and the serous suture 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. No known method has succeeded in establishing a valvular or muscular closure, and operative endeavours to this end are rather injurious than useful.

P. PERINEUM

Operations on the perineum are performed for the purpose of exposing the lower part of the rectum, the urethra, the prostate, the vesiculæ seminales, the floor of the bladder, the vagina, and the uterus. The prostate, apart from its middle lobe, which often projects into the bladder, is best reached from the perineum, by a method which has been practised by Dittel and Zuckerkandl.

Diseases of the uterus are treated by preference from the vagina, those of the rectum through a posterior incision (see surgery of the posterior pelvic region). The seminal vesicles can be easily reached through a perineal wound at the side of the rectum. For years, however, cutting for stone was the most frequent operation.

170. Perineal Cystotomy. In discussing suprapubic cystotomy we referred shortly to the conditions in which it is better to open the bladder from the perineum. The fact that the older statistics (Barling) credited the suprapubic incision with a much greater mortality should not influence us too much, for, with the development of asepsis, the mortality has fallen steadily.[2] On the other hand, there is no doubt that the perineal incision is indicated in all cases where it is necessary to drain the bladder (inflammatory conditions), where an incision into the floor of the bladder removes the original trouble (prostatic hypertrophy), and where an opening into the bladder without inspection of its interior is all that is required in order to carry out the operation (perineal lithotripsy).

[1] We shall speak of this important precaution in considering extirpation of the rectum.

[2] In 1887 Cunningham gives 11 per cent of deaths in 7201 perineal lithotomies and 42 per cent of deaths in 147 suprapubic lithotomies. In perineal cystotomy in children William White gives a mortality of only 3 per cent as compared with 13 per cent for the suprapubic operation. The former is therefore preferable for children, whereas in old people the reverse is the case.

Up till recently **Perineal Lithotomy** was admitted to be the normal operation, and the only question that had to be considered was which of the various modifications (lateral, bi-lateral, or median) was most suitable. The reason why the perineal incision was so long employed was, that it assured at any rate a free escape of the urine and discharges from the wound, so that the danger of infection was not increased by their infiltration into the tissues, whilst by the suprapubic incision infection of the wound could not be prevented.

At the present time it is considered correct to perform perineal lithotomy only in those exceptional cases in which small stones cannot be got rid of by litholapaxy, and are yet too large to pass along the intact urethra.

Perineal cystotomy, like median and lateral perineal lithotomy, is technically a very simple procedure, for the urethra is incised on a sound, as described for external urethrotomy, and a probe-pointed knife, guided by the finger, is then introduced to divide the prostate and the neck of the bladder.

171. External Urethrotomy. 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 strictures, for strictures complicated by fistulæ and abcesses, and in cases which are complicated 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. For if the stricture is not dilated it may be a difficult matter to discover the posterior end of the urethra. 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 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. The bladder should be kept empty by syphon drainage, and irrigation should be carried out.

172. Exposure of the Membranous and Prostatic Parts of the Urethra (Fig. 127 or 128). This operation also gives access to the prostate, vesiculæ seminales, the vasa deferentia, and the floor of the bladder. The external incision must be here an extensive one, so that the median incision is no longer suitable. A purely lateral incision, as formerly employed, divided the branches of the internal pudic artery and nerve passing towards the middle line, viz. posteriorly, the inferior hæmorrhoidal vessels and nerves, anteriorly, the superficial perineal vessels and nerves and the artery to the bulb. Although the sacral resections have shown that unilateral division of these nerves does not necessarily lead to permanent motor disturbances, nevertheless

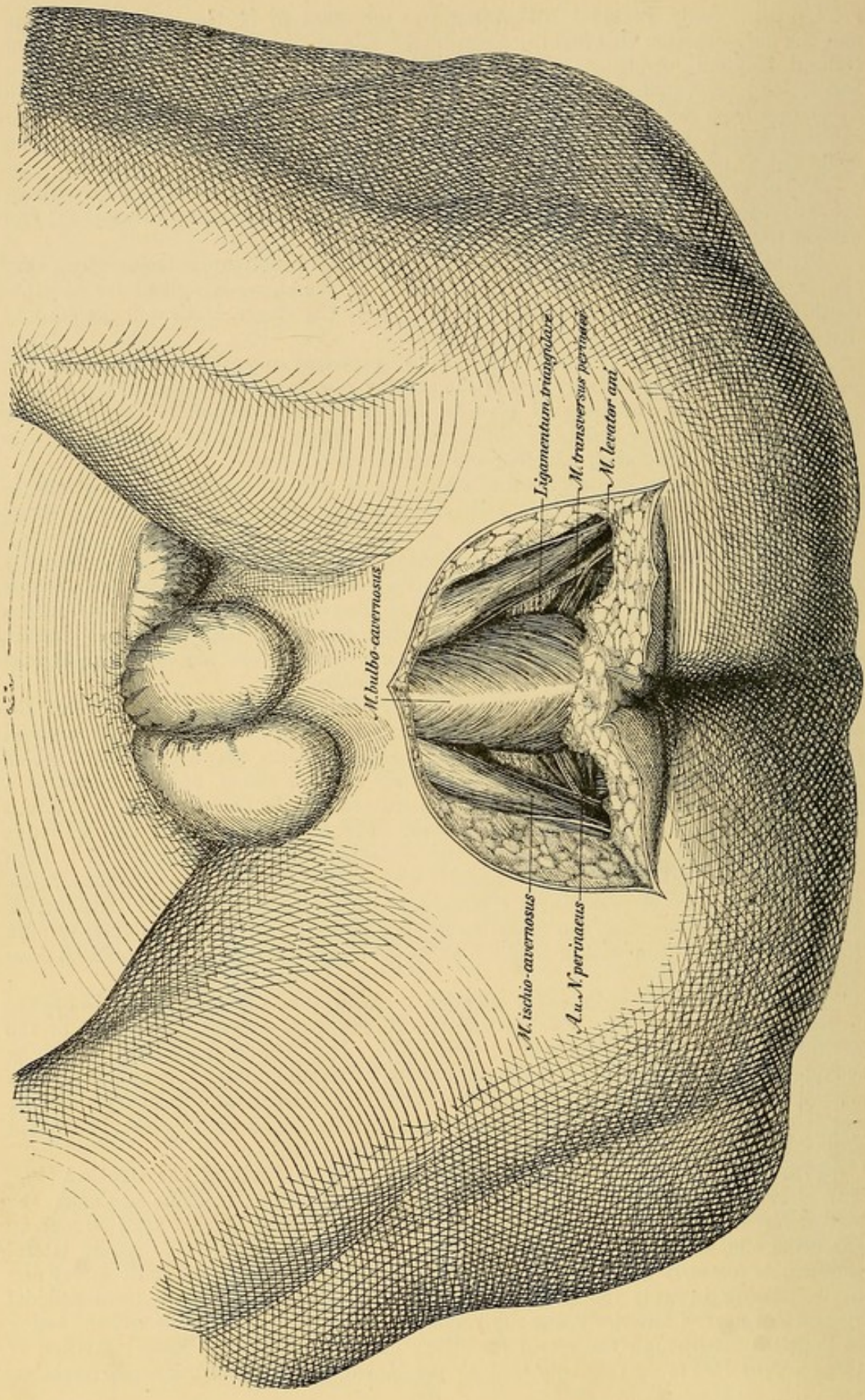

M. bulbo-cavernosus
Ligamentum triangulare
M. transversus perinæi
M. levator ani
M. ischio-cavernosus
A. u. N. perinæus

FIG. 127.

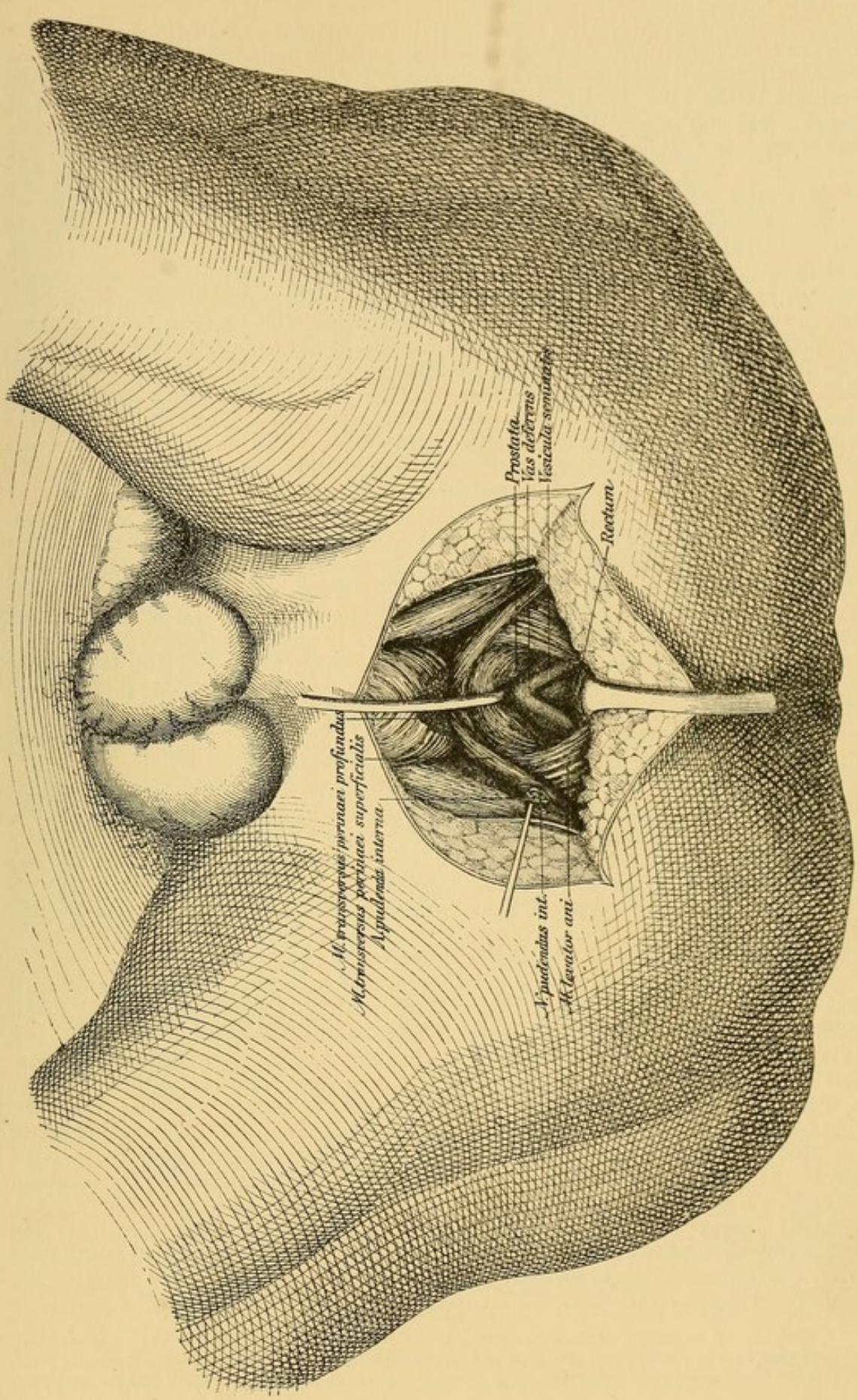

Prostata
Vas deferens
Vesicula seminalis
Rectum
M. transversus perinaei profundus
M. transversus perinaei superficialis
Ischiadicus interna
Pudendalis interna
Ischiadicus int.
M. levator ani

Fig. 128.

they should, if possible, be avoided, and the *transverse curved incision* should therefore be looked upon as the normal incision for obtaining free access. 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. 127). 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 and the accelerator urinæ 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, the posterior fibres of the compressor urethræ muscle, which covers the under surface of the membranous urethra, are exposed. 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. 128): lying immediately outside these are the vesiculæ seminales, which may be dissected out with a blunt instrument.

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.

173. Excision of the Testicle together with the Vas Deferens and Seminal Vesicle. Spermatocystectomy. 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 diathesis. It is now definitely proved that a number of patients remain quite healthy after castration. 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 (Bardenheurer, 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, or by evulsion (Bungener's method). If the seminal vesicle is also involved it should be excised. In many cases, of course, tuberculous foci are still left in the prostate, and excision of the vesicula seminalis, along with the vas deferens and testicle, is only justifiable when the seminal vesicle is specially seriously involved, or when the prostate is quite healthy. Ullmann performed the first spermatocystectomy in 1889.

[1] With regard to primary disease in tuberculosis of deeply-seated organs, it is almost unnecessary to draw attention to the fact that this does not imply that the tubercle bacillus entered at this point, but rather that this was the first place where its effects produced signs capable of clinical recognition.

Villoneuve attempted excision from the groin, 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, Zuckerhandl, Bungener, Guellot, and ourselves. We have performed the operation through the prerectal incision in the form of the sharply curved incision described in the last paragraph. This method may confidently be recommended as the rational one, and, if correctly carried out, 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 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 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 divided 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 proceeding, 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.

Vasectomy and Prostatectomy

In spite of the large number of cases of disease of the prostate, especially hypertrophy, partial or complete prostatectomy is relatively seldom performed, because the inconveniences and dangers of these conditions can, if no complication exists, generally be treated by less severe measures, as the disturbances caused by prostatic hypertrophy are dependent at first on purely mechanical causes. By the employment of abdominal pressure, or, later on, by temporary syphon-drainage of the bladder by means of a catheter, and, lastly, by measures calculated to diminish the volume of the prostate and to remove its spur-like third lobe, the obstruction can be so far overcome that the annoyance disappears.

174. 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 im-

portant 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.

175. Prostatotomy and Prostatectomy. Vasectomy is of no use if the swelling of the prostate is due to malignant disease or to the presence of fibromatous or adenomatous masses, neither is it of use when secondary changes have occurred in the bladder which are the result of old-standing retention. Reginald Harrison has drawn attention to the functional derangement of the bladder which results from the formation of diverticula, even of small size, between hypertrophied muscular trabeculæ of the bladder wall.

In such cases direct removal of the obstruction is the correct treatment. The removal of the prominent middle lobe by urethral prostatotomy is, according to Flœrsheim, quite obsolete. In place of it a few surgeons have adopted Bottini's operation, which consists in dividing the valve at the posterior border of the internal orifice of the urethra with a galvanic cautery.

Harrison avoids the evils of hypertrophy of the third lobe of the prostate with sacculation behind it by perineal prostatotomy and drainage. The other plan is to remove suprapubically the part of the middle lobe which projects into the bladder, and thus to establish a mechanically favourable internal orifice. Removal with the knife is followed by copious hæmorrhage unless the surface of the wound can be united by sutures. Removal may also be effected either with the galvano-cautery or with ring-shaped clamp forceps (angiotribes).

In exceptional cases the prostate must be removed by the perineal route either partially (enucleation of fibromatous or adenomatous nodules) or completely.

Complete Prostatectomy

Parker Syms prefers Alexander's method. The patient is so placed that the buttocks and upper part of the body are well raised, in order entirely to relax the abdomen. The bladder is filled with boric lotion. It is then opened suprapubically by a longitudinal incision large enough to allow of the introduction of two fingers, by means of which the prostate is pressed downwards into the perineum. A mesial incision is then made in the perineum and the entire membranous portion of the urethra is opened on a grooved staff. The prostate is now shelled out of its capsule by a finger introduced through the perineal opening, the separation being effected below and behind so as to free first the lateral and then the middle lobe. The mucous membrane of the prostatic part of the urethra and the bladder are left uninjured. The bladder is drained, both from above and from below, for four to seven days; and it should be frequently washed out. The wound is generally healed in five weeks.

Alexander has performed this operation without opening the bladder by pushing the prostate downwards with the hand applied to the abdomen above the pubis. In cases where the resistance of the abdominal wall is too great to allow of this being done, Syms' plan of introducing the fingers through a median incision, which avoids the peritoneum, is to be recommended.

176. Internal Pudic Artery and Nerve in the Perineum (Fig. 128). An

incision is begun at the inner border of the tuber ischii and carried forwards along the edge of the ascending ramus. The skin and fascia are divided, avoiding, however, the branches of the long pudendal nerve to the scrotum. The muscular fibres of the erector penis are exposed, and the transverse perineal muscle is either cut across close to its origin from the ascending ramus, or drawn downwards and inwards. By division of the base of the triangular ligament and the adjacent parietal pelvic fascia, the artery will be found passing forwards upon the inner surface of the obturator internus muscle above the attachment of the great sacro-sciatic ligament: the internal pubic nerve accompanies the artery, lying upon its superficial aspect.

177. 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 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 are divided at the level of the retracted skin. The corpus spongiosum is then freed and divided $\frac{1}{2}$ cm. lower down ($1\frac{1}{2}$ cm. distal to the division of the corpora cavernosa). The mucous membrane of the urethra is fairly tough, so that there is no harm in pulling in upon it with hooks. The two dorsal arteries, the dorsal vein of the penis, and one or two other subcutaneous veins are secured and ligatured. The two arteries in the substance of the corpora cavernosa can easily be seen and secured. The tunica albuginea is then stitched vertically over the divided surfaces of the corpora cavernosa, and the tourniquet is removed. The urethral mucous membrane is now pulled forwards and united circularly to the skin by stitches passing through the corpus spongiosum. The remaining skin edges are stitched vertically.

The wound is thus completely closed, primary healing rapidly occurs, and a proper urethral orifice is formed, which does not tend to become materially narrowed by cicatrisation.

Q. THE SACRAL REGION

Surgery of the Rectum

178. 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 thoroughly 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, after applying a wing-shaped clamp, is open to the risk of serious secondary hæmorrhage. 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*) *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. The operation 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 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 aseptically. In spite of every precaution slight infection and inflammation, with cutting of the stitches, not infrequently occurs. In these cases anal stenosis results, 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 a motion of the bowels and strives to prevent it.

In consequence of the occurrence of such complications, we have found it necessary to modify Whitehead's method considerably, and we now only employ it in its typical form in exceptional cases. 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.

179. Operation for Prolapsus Ani and Prolapsus Recti. A very effective method in prolapsus ani is the wedge-shaped excision. The wedge is taken posteriorly. Its base is at the anal margin, the upper angle extends into the rectum, the lower angle into the external skin. The wound is at once closed with deep catgut sutures, combined with superficial suturing of the mucosa, and of the skin.

When the prolapsus recti is combined with advanced changes in the mucous membrane, the result of ulceration and chronic inflammation, or with new growths, amputation of the rectum is advisable. The prolapse is seized with a powerful pair of clamp forceps above the diseased area, and the prolapse, which has been carefully cleansed and disinfected, is surrounded with gauze. A small incision is made into the mucous membrane and then into the wall of the rectum until the cellular tissue or the peritoneal fold is reached which separates the two walls of the prolapse. Immediately this space has been opened into, a suture is applied, and as the separation proceeds above the forceps, the interrupted suture is at once applied which is to shut off the peritoneal cavity. After the separation has been completed the mucous membrane is united with a continuous suture. This method has the disadvantage of leaving at the anal margin a circular cicatrix which is liable to tear if exposed to forcible stretching. Moreover, as Ludloff (Eiselsberg) has pointed out, a prolapse

may recur, because a protrusion of the rectovesical pouch, *i.e.* a perineal hernia, always precedes or coexists with the development of a prolapse.

When, in accordance with this view, the abnormal condition of the prolapsus recti does not justify excision, other methods of treatment may be advantageously employed. But neither Gersuny's method of dissecting up the rectum at its lower part, twisting it round and stitching it in the twisted position, nor Thiersch's plan of introducing a silver suture round the rectum in the direction of the sphincter, are likely to result in a cure in severe cases. It is different, however, with the methods of fixation.

Rectopexy, according to the method of Verneuil, is an operation to be recommended for prolapsus ani. The two ends of a thread are passed through the most prominent part of the prolapse so that the loop embraces the projection. The ends are then passed through near the coccyx and tied. As a result of this the rectum is tied up to the posterior pelvic wall, not only as long as the sutures remain in position, but also subsequently, on account of the cicatrisation which takes place along the course of the thread.

In prolapse of the rectum, sigmoideopexy, as described by Jeanel-Bogdanik, is more satisfactory. By this method even a very large prolapse can be easily and satisfactorily kept up. In a prolapse 4 inches in length, which remained permanently down (after high excision of the rectum), an incision was made above Poupart's ligament and the prolapse at once reduced by traction on the sigmoid flexure. The flexure, which was drawn well upwards and held there, was then fixed in the greater part of its length to the peritoneum of the iliac fossa by a row of serous sutures. Up to the present time the cure has been permanent.

180. Excision of the Carcinomatous Rectum. General Remarks on Technique. It has become recognised by surgeons of long experience that we must resign ourselves to see carcinoma of the rectum on the operation table only in its later stages. The great majority of patients pay too little attention to the early symptoms, and when at last a doctor is consulted, it is unfortunately still the practice of many to put the patient under treatment for "chronic enteritis" or for "hæmorrhoids," without even making a digital examination of the rectum. Yet the symptoms of stenosis of the intestine—the intermittent diarrhœa, the stools mixed with mucus or blood—are characteristic enough. And when the diagnosis has been settled, many surgeons, as a matter of routine, take up the erroneous position that no operation should be performed if the carcinoma is situated high up. If a carcinoma is accessible to rectal palpation and is movable,[1] *i.e.* moves downwards under pressure from above, it should be radically removed, for, compared with the radical removal of the disease in the gut, the establishment of an artificial anus, valuable as it is under other conditions, is here a poor substitute.

A decided contra-indication to operation is the presence of metastatic nodules in the liver. These are by no means uncommon even in circumscribed carcinoma, if situated high up. We have seen several patients who were completely cured of the local conditions die shortly afterwards of extensive carcinoma of the liver. Dissemination of the disease to the liver is much more frequent when the tumour is high up than when it is low down in the rectum. Early diagnosis of metastasis is difficult.

The difference of opinion existing as to the indications for operation are dependent entirely on questions of technique. Those who are not thoroughly versed in the technique of operating cannot expect to obtain satisfactory results from excision of the rectum. Firstly, because they are unable positively to exclude the risk of sepsis and therefore of immediate danger to the life of the patient; secondly, because they cannot be satisfied that they have removed all the disease and so ensured the patient even against local recurrence in the gut; and thirdly, because they must take into

[1] Under an anæsthetic with two fingers in the rectum a carcinoma of the pelvic part of the colon becomes easily palpable if pressure is made above. But it must be noted that confusion may arise where a carcinoma of the lowest part of the flexure is fixed by adhesions in the pouch of Douglas. Such cases must, of course, be treated by excision from above.

consideration the risk of a number of unpleasant possibilities, namely, incontinence, stenosis, and prolapse. It is true that in a great many cases extirpation of the rectum, even when correctly performed, is a difficult operation, and it must not be imagined that any amount of technical knowledge can convert it into a pleasant or easy undertaking in the majority of cases. 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 saccular 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 which descend 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.

Before proceeding to excise the rectum we must ascertain that the growth is palpable from below, and we must satisfy ourselves as to its mobility. We do not consider it in the interests of the patient to operate from below on a rectal carcinoma which is not movable, or which cannot be felt from below even with two fingers in the rectum and the patient under an anæsthetic. We can, of course, do anything, but some things should not be done. It may be taken as an established fact that the lymphatics from the upper part of the rectum ascend and open into lymphatic glands which lie upwards and outwards. According to the investigations of Sappey, Poirier, Gerota, and Waldeyer, only the lymphatics from the anal part of the rectum open into the upper and inner lymphatic glands of the groin. In carcinoma of the pelvic part of the rectum, on the other hand, it is the upper hæmorrhoidal lymphatics which lie in the hollow of the sacrum and higher up along the superior hæmorrhoidal artery which are involved. There is no sense in endeavouring to remove, from below, a carcinoma which is readily accessible from above, and which gives rise to lymphatic infection so high up. We excise from above carcinomata of the iliac colon which extend as far down as the commencement of the pelvic colon, opposite the sacral promontory. These tumours can be removed even though they are not movable (as far as can be made out by palpation), and though their presence cannot be established by palpation, either from above or from below. But in such cases it is not correct to speak of the operation as being done upon the rectum. Preliminary ligature of the superior hæmorrhoidal artery, recommended by G. Bruno, and Quénu and Hartmann, need only be considered in the removal of adherent tumours of the flexure, and when it is necessary to remove the entire rectum at the same time. Whether this

indication was always imperative in the cases hitherto operated on in this way is a question we leave undecided.

We have already expressed our opinion as to the procedure to be adopted in the treatment of carcinoma of the flexure, basing our views on the results of personal experience (see Resection of the Intestine).

Since the discussion on excision of the rectum at Berlin, in 1900, a large number of papers from different clinics in Germany have been published with the object of ascertaining the results that are obtained, and of deciding on the different methods to be employed. Unanimity has not been reached. Individual authors, such as Hochenegg and Kraske (the originator of the method), have adhered to the sacral method and endeavoured to show that this procedure gives the best results, the mortality being only 5 per cent, with 25 per cent of permanent cures. Hochenegg, by his 121 cases of sacral excision of the rectum, has shown, that, in the hands of those who have a large experience of the operation, very good results may be obtained by the sacral method. Kraske in his last 51 operations had a mortality of only 3·9 per cent.

Prutz (Eiselberg) questions the accuracy of Pichler's (Hochenegg) statistics, as he finds that there were 115 deaths in 542 sacral operations published by fourteen surgeons, a mortality of 21·2 per cent. Prutz is perfectly right if it be borne in mind that in Hochenegg's operation the perineo-coccygeal methods are included.

Hochenegg does not make any reference to our coccygeal method,[1] and yet it must be obvious to any one who examines the statistics that this method, which is included in the statistics of individual authors, has materially improved the statistics of the sacral method. Other authors, including Schneder (116 cases from Madelung's and from Garre's clinic), do not find any material difference in the results between the sacral and coccygeal methods. In Wendel's statistics (46 cases from Küster's clinic) it seems that the coccygeal and sacral methods are both included without being distinguished, and the results show that, as against 11 deaths in 34 sacral operations, the coccygeal method gave 11 cures without a death. The same holds good with regard to the cases published by H. Wolff from Bargmann's clinic. Wölfler, too, "almost always" employed our method—that is to say, he removed only the coccyx. The same may be said of Schuchardt and others.

The conclusion most certainly to be drawn from the statistics of recent years and from the discussions in the different learned societies is, that there is a distinct tendency to limit the use of the sacral methods—using the term in its narrow sense, *i.e.* excluding our coccygeal method. Senn is very strong in his denunciation of the sacral method, his own experience having led him to regard the sacral operation for rectal carcinoma as not only unnecessary, but absolutely harmful. He hopes that the operation will soon become obsolete. All high excisions of the rectum, in which the conditions present justify the procedure, can be performed satisfactorily by our method of excising the coccyx without the mutilation which the sacral method involves. In excisions involving only the part of the rectum below the peritoneal pouch, even resection of the coccyx is unnecessary.

The majority of surgeons are satisfied that specially the osteoplastic sacral methods should be abandoned. We may therefore confine our attention to the perineal, coccygeal,[2] vaginal, and, lastly, the combined methods for excision of the rectum. There is absolute unanimity as regards the vaginal method.

(*a*) *Vaginal excision of the rectum* (Camperon and Rehn). 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

[1] Although Hartmann has quite recently drawn attention to the fact that Verneuil's proposal to resect the coccyx was applicable not only to cases of imperforate anus but could also be employed in cases of carcinoma, nevertheless I think that I am justified in designating the coccygeal method "Kocher's" because without previous knowledge of Verneuil's proposal as applied to carcinoma I first gave the method importance.

[2] We do not consider it advisable to include the coccygeal operation under the perineal methods. The region posterior to the anus is not, strictly speaking, part of the perineum.

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*.

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, of which, according to Schuchardt, it is so important to make full use 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.

Eiselberg 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 (if the para-vaginal incision of Schuchardt is not sufficient), 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, an endeavour must be made to remove the lymphatic glands which lie at the bifurcation of the common iliac artery, as they receive the lymphatics from these parts.

(*b*) *The perineal method of excision of the rectum* (Lisfranc). This method is particularly suited to carcinoma of the anal portion, or, at most, to the part of the "pelvic" portion of the rectum immediately adjacent to it. In such a case, where the muscular sphincter apparatus cannot possibly be saved, the operation is commenced by a free incision passing round the anus at a sufficient distance from the diseased tissues, and the anal portion is freed by cutting into healthy tissue surrounding it. If the sides of the wound be forcibly drawn apart, there is no difficulty in arresting the bleeding from the branches of the middle and inferior hæmorrhoidal arteries, which are relatively small in the region of the anal portion of the rectum.

In the male, the bulb of the urethra is separated up; in the female, the vagina is either incised, or excised, as is deemed necessary. By dissecting upwards along the membranous part of the urethra (into which a large catheter, which is easily felt, has been introduced) the space between the prostate and the prerectal fascia is opened up, the bundle of vessels being avoided by keeping to the side. The rest of the operation is as in the following description.

(*c*) *Total extirpation of the rectum by the coccygeal method with a posterior extra-rectal longitudinal incision.* This method of excision is our usual procedure for all carcinoma of the rectum above the anal portion and up to the highest permissible point. We shall therefore describe it fully.

We are glad to know that, as regards the main points in the technique of the operation, we are entirely at one with such an expert and bold surgeon as Rehn of Frankfort. We believe we were the first, in recent years, to point out the advantage of the median incision (which Dieffenbach employed in his time) when we recommended the combination of the posterior longitudinal incision with extirpation of the coccyx. Whenever it is found necessary to suture part of the wall of the gut which has no peritoneal covering, one is on uncertain ground as regards asepsis, especially if the wound be carried to any depth. The principal advantage of median incisions is that they preserve the nerve supply, especially to the muscles—a point of just as much importance as the preservation of the mucous membrane of the lower end of the rectum.

High amputation should be aimed at in all cases of carcinoma of the rectum. The level at which resection (excision of a portion of the gut with union of the two ends) becomes preferable depends upon the relations of the peritoneum to the part to be dealt with. Where both upper and lower ends are surrounded by peritoneum the ends may be sutured together with perfect safety. But when this is not the case, resection is attended with the risk of imperfect asepsis, with subsequent stenosis, as well as with

the difficulty of removing all the disease.[1] In all cases, therefore, in which the wound is to be closed and primary union aimed at, the healthy upper end of the gut should be implanted into the anal portion, the sphincter apparatus of which must be unimpaired.

Which method, then, is best adapted to carry out these requirements in the greatest number of cases? Rehn agrees with us in recommending the posterior longitudinal incision, but he prefers not to excise the coccyx, and merely pulls it aside. If this procedure is to be effective, either the joint must be luxated or the bone fractured, and if this is done there is no material advantage to be gained from his method, while entire removal gives much more room, and consequently better access. Rehn, on the other hand, always first splits the anterior raphe down to the sphincter, and reaches the deeper parts by passing between the two layers of the recto-vesical fascia and then between the prostate and the rectum. We, on the other hand, make the anterior incision only as a last resource, *i.e.* when the posterior one has not been found to give proper access.

We were amongst the first to draw attention to the advantage of excising the rectum *in toto*, like a cyst, without opening it, and then suturing the upper divided end to the anus as Quénu and Baudet again proposed in 1898. In this connection we may refer the reader to the earlier editions of this work. We are not, however, always able to perform the operation in this manner, on account of the friability of the rectum and of the adhesions in the neighbourhood of the tumour. If, in the endeavour to separate the rectum intact, a tear be accidentally made into it and the contents contaminate the surrounding tissues, the result is much worse than if the rectum had been split open in the first instance. In such cases we have adopted a method of resecting the rectum which may be employed in any case with a fair prospect of success, and which may be recommended to the less expert on account of the certainty and simplicity of the technique and the ease with which hæmorrhage may be arrested. It will be described as a second alternative. If the rectum can be excised *in toto* down to the anal portion, the advantage noted by Rehn is obtained, viz. that, after notching the mesentery, the flexure can be pulled down with less injury from obstruction to the circulation than can the pelvic part of the colon, because the vessels going to the flexure anastomose freely with other large mesenteric arteries.

Before every operation of excision of the rectum the parts must be thoroughly disinfected in view of the possibility of a tear in the wall of the gut. It must not be imagined that this can be effected by emptying the gut from above. It is quite comprehensible how some surgeons, such as Hochenegg, entirely abstain from the use of purgatives. For, as Peterson found out when he implanted the ureter into the sigmoid flexure, the worst thing that can happen is for diarrhœa to exist at the time of operation. We administer a strong purgative eight days before operation and then keep the patient on a fluid diet, and administer bismuth and opium so as to prevent any movement of the bowels during the four or five days preceding the operation. The final cleansing can be best performed, according to Peterson, under the anæsthetic at the time of operation, when the sphincter is fully relaxed.

The rectum is then thoroughly irrigated with soap and water, but in such a manner as to prevent anything passing into the gut above the tumour, so as not to flood the site of operation later on. The fluid is then carefully mopped up and the rectum stuffed with sterilised gauze as far as the tumour.

With the patient in the dorsal position, the pelvis raised, and the thighs held back, an incision is made in the middle line from the anus backwards to the lower part of the sacrum. The posterior and lateral aspects of the coccyx are exposed, the tip is seized with a sharp hook and the anterior surface cleared, keeping close to the bone so as to avoid the middle sacral artery; the base of the bone is then cut through with bone forceps—unless the joint can be located at once. Next, the median incision is carried down to the fascia enclosing the rectum, and the latter is freed on both sides by blunt dissection above the sphincters surrounding the anal portion (pars perinealis), until the finger can be passed completely round the bowel and sufficient room got to

[1] See the results of Bergmann, published by H. Wolff, in which the mortality after amputation of the rectum was 14·7 per cent, after resection of the rectum 47·7 per cent.

allow two compression forceps and two strong ligatures to be applied to the lower part of the pelvic portion of the rectum. The part between the ligatures is then divided with the thermo-cautery and the mucous membrane of the stumps is cauterised.

The finger is then passed up between the hollow of the sacrum and the rectal fascia, and the rectum is separated as far as the upper limit of the growth. The bundles of vessels which pass to the lateral aspect of the rectum are first freed with the finger, ligatured with the aid of a large aneurism needle, and then divided between the ligature and a strong pair of artery forceps applied distally. The rectum is drawn down as far as possible. On the anterior aspect of the rectum the peritoneum is quickly reached, and as soon as a healthy part can be found well removed from the tumour the peritoneum is incised and separated upwards and backwards from the rectum as far as its junction with the pelvic colon. Whenever the peritoneum has been thoroughly separated the rectum immediately becomes much more movable, and can be drawn further downwards. It is still held, however, by the mesenteries of the pelvic colon and of the sigmoid. These are divided until no further relaxation of the rectum is produced. Care must be taken to see that the vessels in the mesenteries are not torn but are pulled down with them and secured. The chief strain, according to Rehn, falls upon the superior hæmorrhoidal artery. If too much strain is put upon it, and if it is kept stretched, the circulation suffers as a consequence, for which reason it is better to divide it between a proximal ligature and forceps.

Care must be taken to take away as much as possible of the cellular tissue in front of the sacrum and to remove the hæmorrhoidal lymphatic glands as high as possible. The gut can be so far freed as to allow of 12 inches, and even more, being drawn down. By this means we fulfil the requirements of Friedrich and Schuchardt regarding the cleaning out of the whole of the hollow of the sacrum and the pulling down of the flexure.

The anal portion of the rectum, which is tied just above the sphincters, is now evaginated through the anus, the ligature is cut off short, the edges are grasped with artery forceps, and great care is taken to protect the wound from contact with the mucous membrane. The gut above the level of its division, which is also closed with a ligature, is pulled through the anal ring and through the evaginated anal portion (pars perinealis) until the tumour is brought well outside. The rectum is then cut across $1\frac{1}{2}$ in. above the tumour, the bowel being previously clamped. Before doing this, however, the posterior part of the wound must be carefully stuffed with gauze to protect it from contamination.

Successive portions of the circumference of the bowel are now divided above the forceps and at once united by catgut sutures for a corresponding extent to the free margin of the evaginated pars perinealis.

The evaginated anal part is next pushed back through the anus, and it is only now that the pars analis is divided posteriorly, after which a continuous catgut suture is applied on both sides over the interrupted sutures.

The upper part of the skin wound is now closed with a few deep silver (or aluminium-bronze) wire sutures, followed by a few superficial silk sutures. The anal part of the rectum, situated below the sutured gut, is left unsutured, so that there may be no obstruction to the escape of the contents of the bowel, and should the stitches give way the contents of the gut will not infiltrate the cellular tissue. A strip of xeroform gauze should be introduced down to the sutured bowel.

If, instead of preserving the anal portion this be excised, or only its mucous membrane removed, the operation can be simplified by closing entirely the posterior part of the wound and putting in two or three drainage tubes. But, as Wölfler has pointed out, for the proper performance of the functions of the anus we require not only a muscular apparatus but also a sensory connection to regulate the action.

(*d*) *Coccygeal resection of the rectum by a posterior longitudinal incision extending into the lumen of the gut.* The method of total excision of the rectum without opening it, followed by implantation of the lower part of the flexure into the anal portion, is certainly ideal, if the presacral cellular tissue and glands be cleared out at the same time. This cannot, however, always be accomplished. In the attempt to isolate the rectum, one or other of the ligatures frequently breaks away under

the force applied, or else cuts through. In such cases we have found by experience that an excellent substitute for the above procedure consists in utilising Dieffenbach's posterior longitudinal incision and combining it with resection of the coccyx. We shall describe the procedure in a case where it was found necessary to give up the idea of extra- or peri-rectal enucleation of the whole rectum.

The preliminary steps of the operation, viz. the cleansing and stuffing of the rectum, the incision, and the excision of the coccyx, are the same as already described. Next, however, two fingers (wearing a gutta-percha glove) are introduced into the rectum, and the posterior longitudinal incision is carried through the whole thickness of the rectum and the soft parts covering it, and the edges of the wound caught with strong artery forceps and drawn aside. In this fashion the rectum may be slit up longitudinally as far as the lower edge of the tumour, even although it be situated high up. The bleeding is prevented by applying forceps to the edges of the gut as it is divided.

The rectum is again thoroughly cleansed. A finger (protected by a gutta-percha finger-stall) is introduced through the stricture and the mass is invaginated downwards. The anterior rectal wall is cut through transversely below the level of the tumour so as to expose the serous coat of the bowel above the tumour. The cut edge of the gut below the tumour is now turned downwards so that the bowel above the tumour may be divided from its serous aspect. The cut edge of the bowel above the tumour is grasped with forceps, pulled downwards, and brought in contact with the serous surface of the gut below the tumour, and the two are sutured. The same is done with the muscular and mucous coats. The transverse division of the bowel is then continued across its lateral and posterior aspects until the tumour is completely resected, the sutures being inserted step by step as the bowel is divided.

If it be desired to be on the safe side and to finish the operation quickly, the whole length of the posterior longitudinal incision through the rectal wall should be sutured to the skin edge. In this manner we have performed a thorough and radical resection of a rectal carcinoma without applying a single ligature.

If an endeavour is to be made to obtain a more perfect result, the wound in the posterior wall of the rectum must be closed independently with catgut, a xeroform gauze drain must be introduced as far up as the highest suture, and the skin wound stitched over it. Our experience, however, agrees with Küster's that in the majority of cases a rectal fistula results, so that in only a small percentage is the result better than in the cases in which the rectal mucous membrane was united to the skin in the whole length of the posterior longitudinal incision.

The open method, however, is much less likely to be followed by a serious wound infection, and the results which we have obtained by it have, on the whole, given us greater satisfaction than those which we have got by closing the longitudinal wound in the rectum. As regards the principle of this simple and safe procedure we desire again to point out that the result mainly depends on the removal of the retro-rectal cellular tissue and lymphatic glands *above* the site of the tumour, and we may remark that neglect to clear out the hollow of the sacrum *below* this point need hardly be considered a serious fault. We shall soon be in a position to publish our results.

If, following H. Wolff, we desire to perform a tedious and careful removal of the lymphatic glands of the mesorectum and mesosigmoid, a combined operation is the only method available. A laparotomy must be performed simultaneously, as described under the head of resection of the large intestine. The same holds good for cases with extensive adhesions to surrounding organs. Such cases can only be operated on from below when the pelvic organs involved are movable and can be excised along with the tumour, after first exposing them to view, as described in the vaginal method. Otherwise excision of an adherent carcinoma is only justifiable if it can first be ascertained by examination from above and below that the adhesions can be divided in perfectly healthy tissue.

181. Sigmoideo-rectostomy (Bacon and Rotter). Instead of excision of the rectum for obstinate strictures of the rectum, the above-mentioned authors perform laparotomy and effect an anastomosis between the upper end of the divided sigmoid flexure (the lower end being closed) and the rectum below the stricture.

SECTION III

SURGERY OF THE EXTREMITIES

1. EXPOSURE OF VESSELS AND NERVES

THE larger vessels are cut down upon for the purpose of arresting hæmorrhage by the application of a ligature. The vessel is exposed by making a suitable incision which avoids injuring the neighbouring structures, and just enough of the vessel is isolated to allow of an aneurism needle threaded with a ligature being passed round it and tied in such a way as to cut through the middle and inner coats and bring together the adventitia.

A silk ligature is still commonly used to arrest bleeding from wounds, but to avoid the introduction of a foreign material there is a growing tendency to employ torsion or forcible compression by angiotribes (forceps which close very firmly). The latest suggestion is to suture a tear in the wall of a larger vessel. Lateral closure of the wall is effected by the introduction of one or two rows of a continuous suture. The method has been employed successfully, especially in veins of large size (Zoege-Manteuffel), for example in a large tear in the inferior vena cava. We have employed it for the subclavian vein, and at the angle between it and the internal jugular.

The exposure of nerves for resection or stretching in neuralgia and spasm and for suturing has become of still greater importance, since we have learned, that by cocainisation of the nerve trunks large areas of the body can be rendered insensitive, thus admitting of operations being performed without the induction of general anæsthesia. For this object one must have an accurate knowledge of the distribution of even the smaller nerves.

R. UPPER EXTREMITY

(a) Region of 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 374 and 376). The axilla may be opened up by means of an incision along the anterior or posterior axillary folds, or better, 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

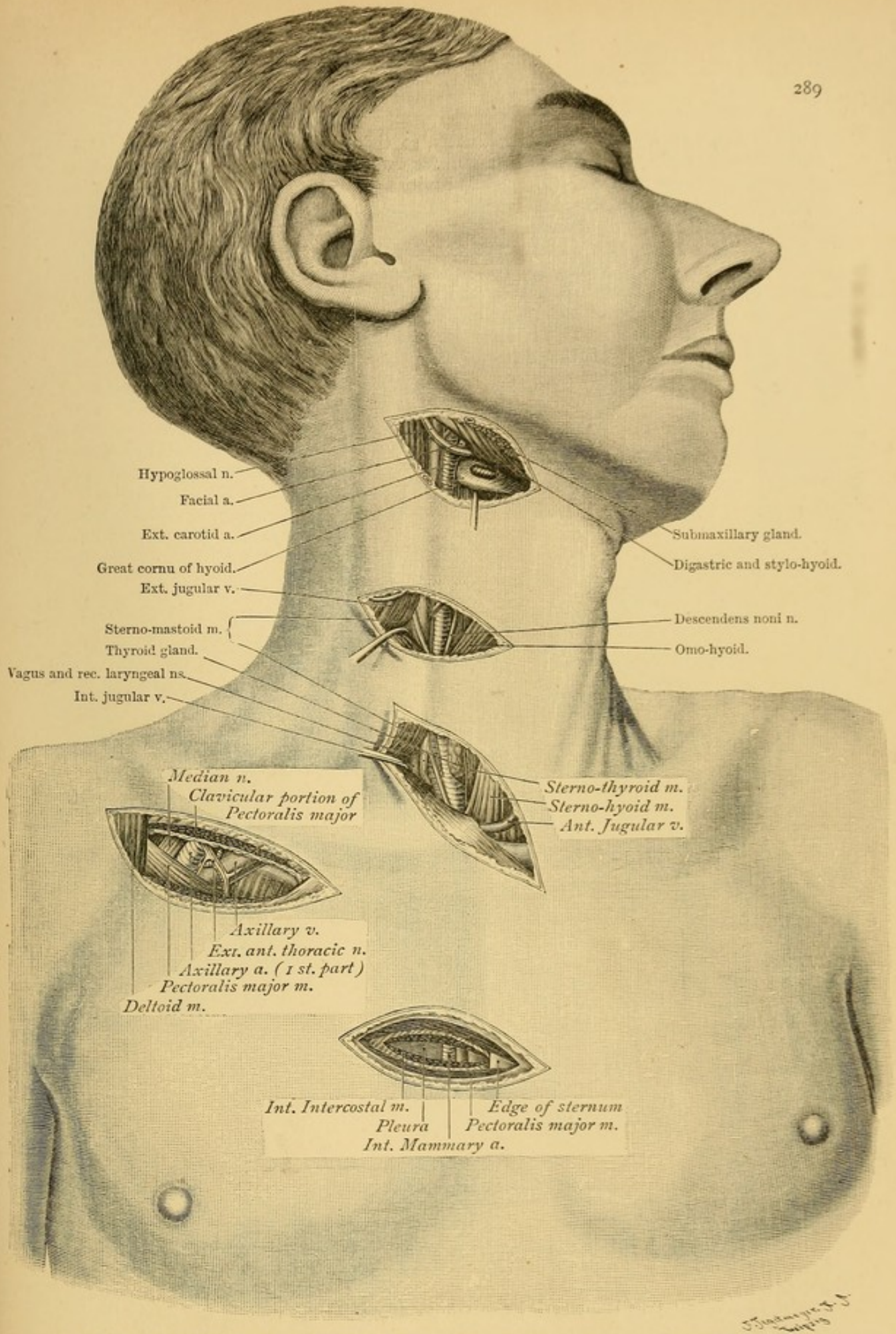


FIG. 129.—Ligature of the lingual artery above the greater cornu of the hyoid. Ligature of the common carotid at the level of the cricoid cartilage. Ligature of the innominate artery. Ligature of the first part of the axillary artery. Ligature of the internal mammary artery.

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.

182. Ligature of the Axillary Artery (Figs. 129 and 130). *By a transverse incision below the clavicle* (Fig. 129). The incision is made 1 cm. below the middle third of the clavicle, dividing the fibres of the platysma together with the sensory *supra-clavicular nerves.* In dividing the fascia, the *cephalic vein* at the anterior edge of the deltoid is to be avoided. 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 nerves are small; they appear below the clavicle, and cross

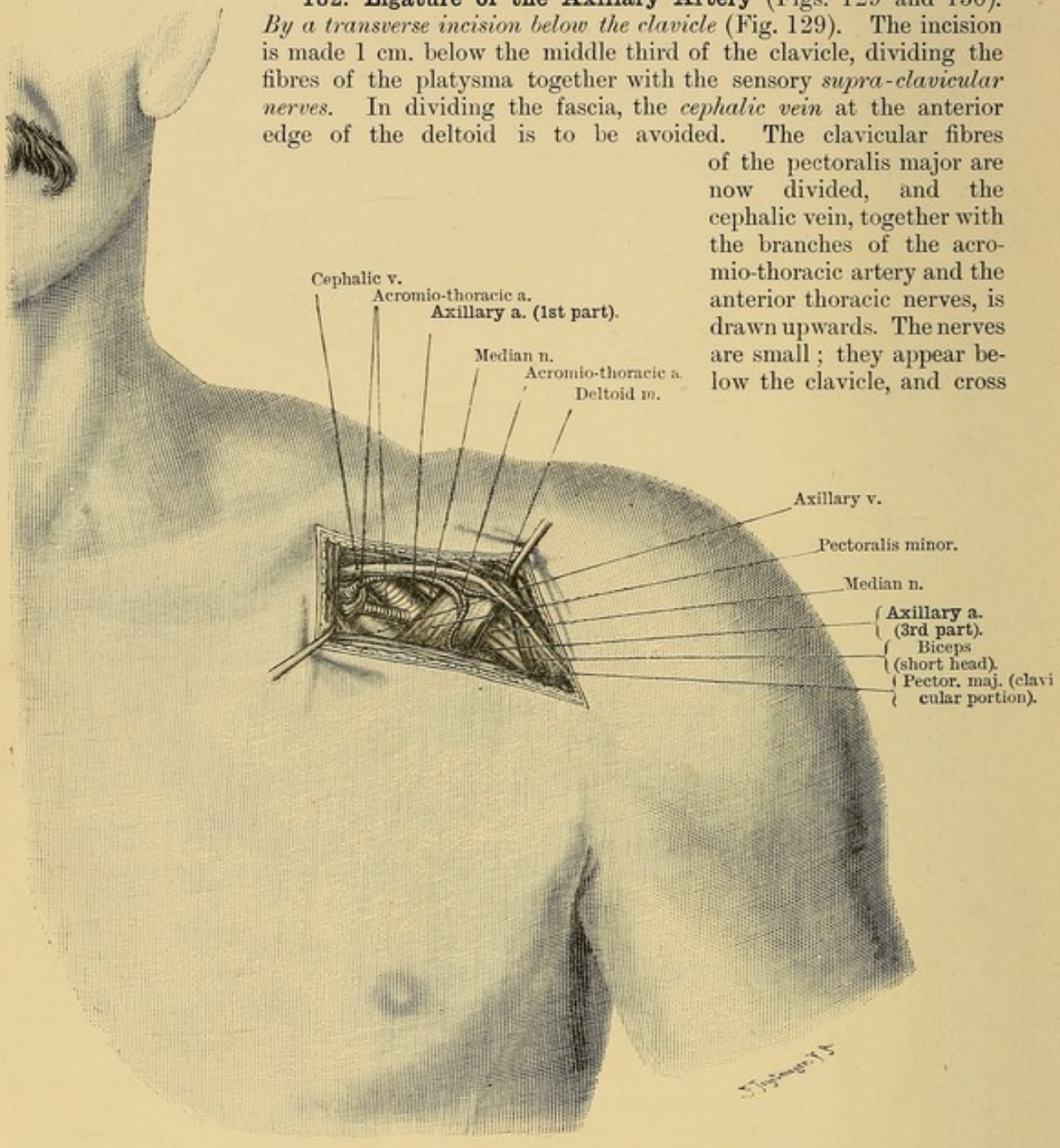


FIG. 130.—Ligature of the axillary artery, above or immediately below the pectoralis minor.

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.

By a longitudinal incision (Fig. 130). 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.

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 rendered easier by separating the pectoralis major muscle from the clavicle for a short distance.

183. The Superior Thoracic Artery passes forwards from the main trunk below the subclavius muscle (Fig. 129). In this situation, also, the axillary artery is embraced by the *anterior thoracic nerves* going to supply the pectoral muscles.

184. The Acromio-Thoracic Artery arises from the axillary at the upper border of the pectoralis minor, and can be ligatured by the above incision (Fig. 130).

185. The Long Thoracic Artery. With the arm abducted, an incision is made along the anterior fold of the axilla, extending as far as the lateral wall of the thorax. After division of the fascia the artery is found descending in the line of the axilla immediately behind the edge of the pectoralis major, and lying on the wall of the thorax in contact with the serratus magnus muscle.

(b) Axilla

186. The Third Part of the Axillary Artery (Fig. 131). 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 lies 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.

187. Anterior Circumflex Artery (Fig. 132). 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

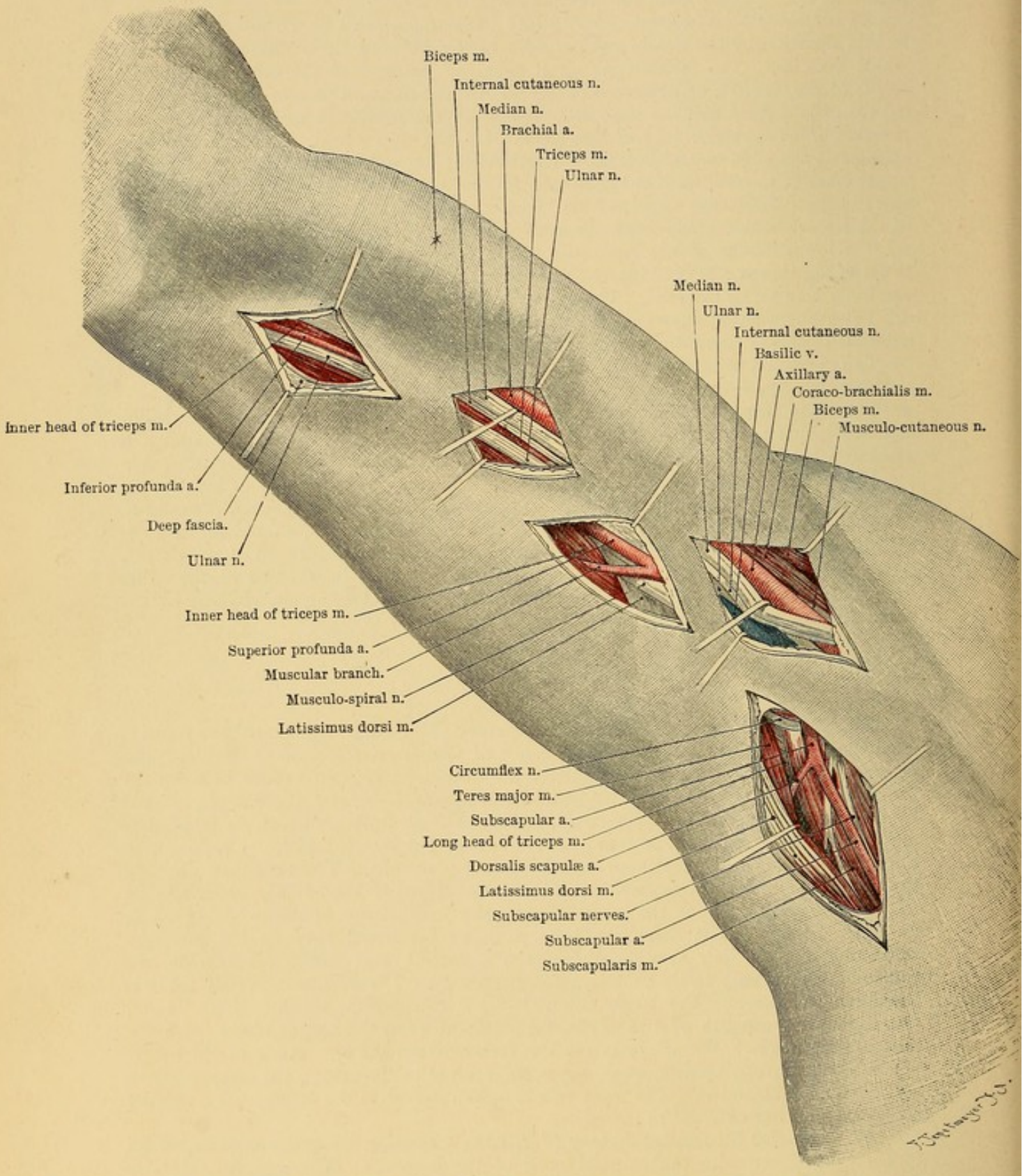


FIG. 131.—Axillary artery, brachial artery, superior profunda artery, subscapular artery, median, subscapular, musculo-spiral, and circumflex nerves.

outer borders of the short head of the biceps and the coraco-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.

188. Posterior Circumflex Artery and Circumflex Nerve (Fig. 133). For the exposure of the circumflex nerve in the axilla, see *ligature of the subscapular artery* (page 295).

If, with the arm abducted, 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

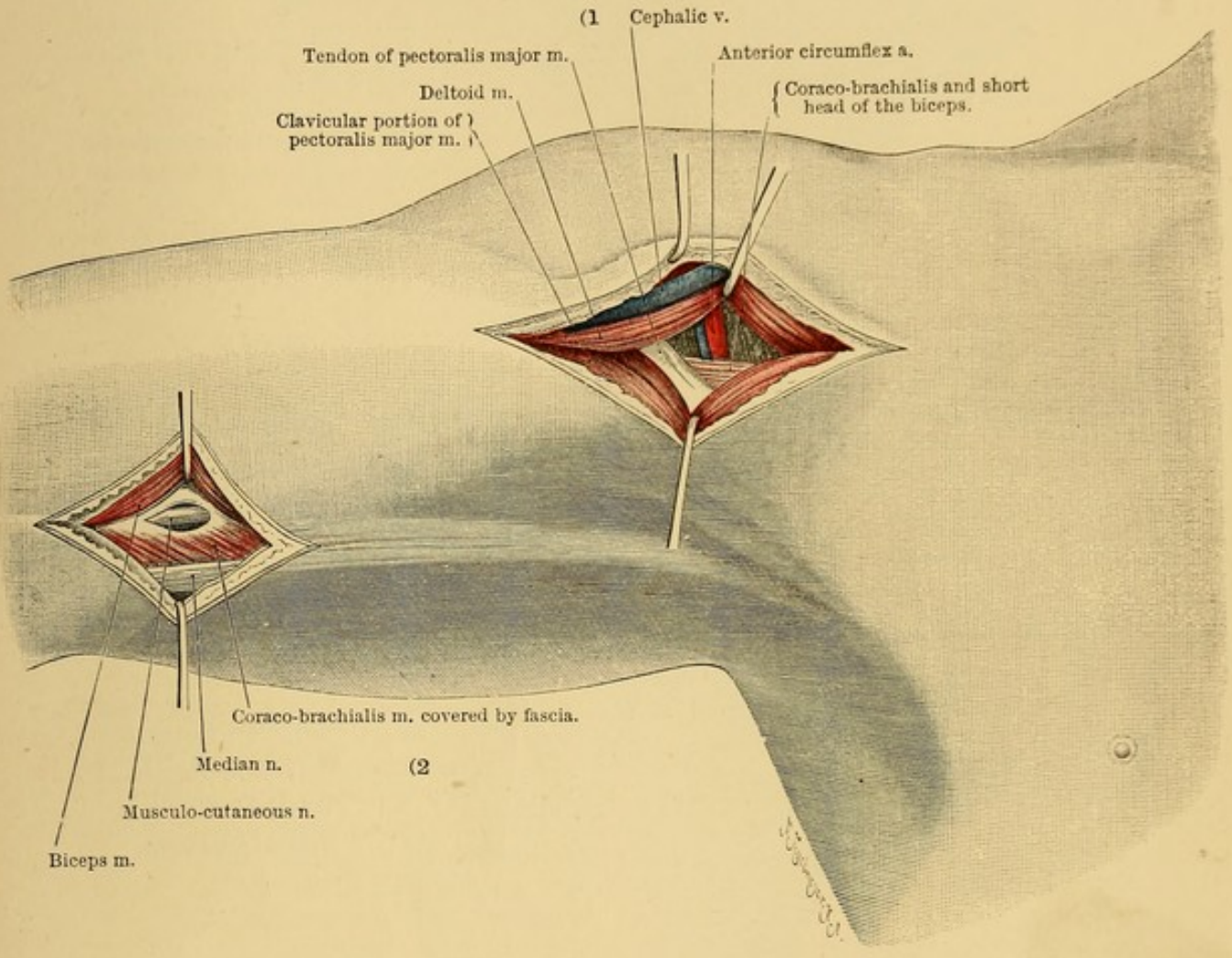


FIG. 132.—(1) Ligature of anterior circumflex artery. (2) Musculo-cutaneous nerve.

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 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

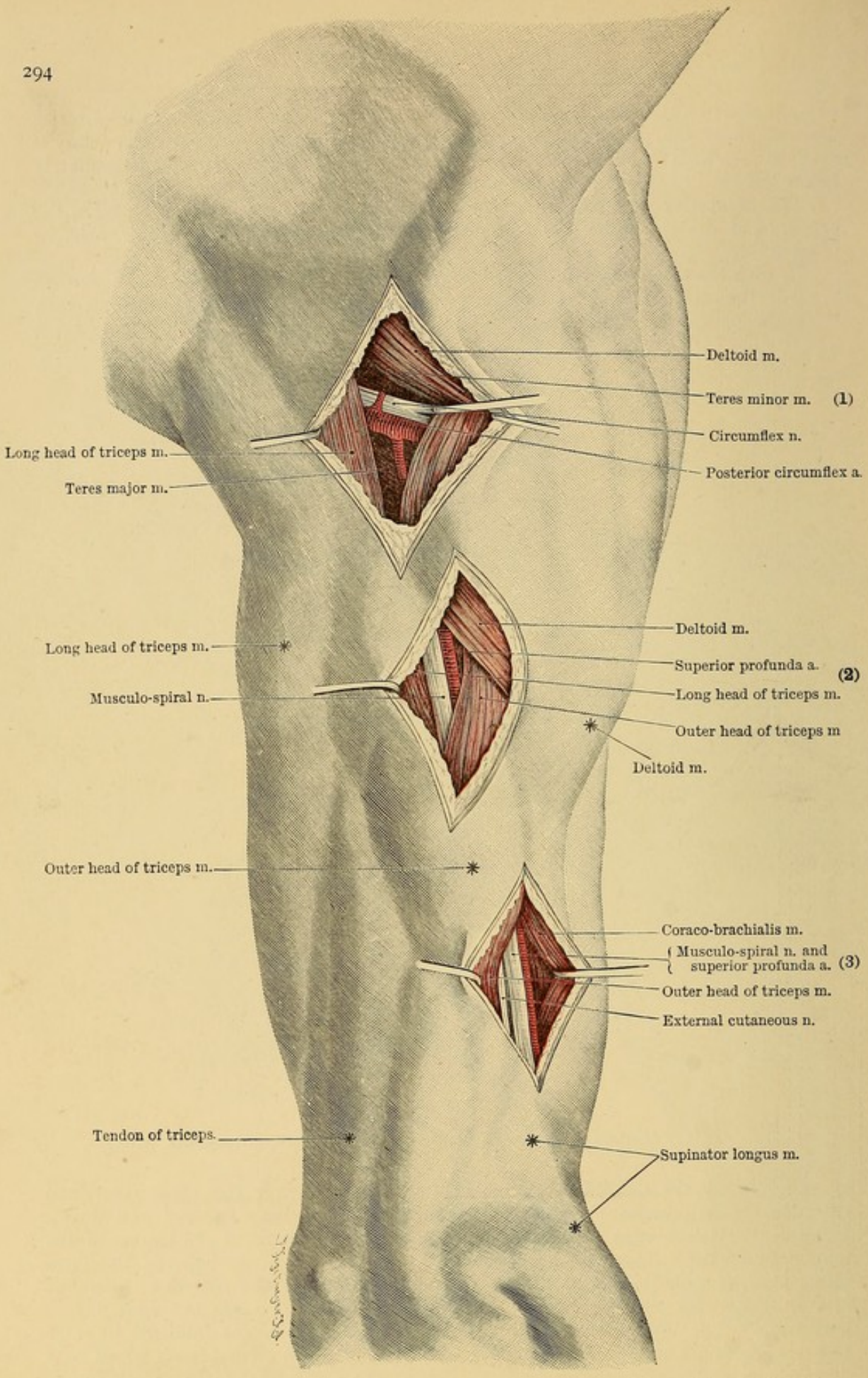


FIG. 133.—(1) Ligature of posterior circumflex artery, circumflex nerve. (2) and (3) Musculo-spiral nerve and superior profunda artery.

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.

189. Subscapular Artery and Subscapular Nerves (Fig. 131). 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 upper edge of the insertions of the latissimus dorsi and teres major muscles, which 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.

190. The continuation of the trunk towards the thorax is accompanied by the *long subscapular nerve* to the latissimus dorsi (Fig. 131).

191. The Dorsalis Scapulæ Artery (Fig. 131) passes backwards through the triangular interval between the latissimus dorsi (with teres major), the subscapularis, and the long head of the triceps. Accompanying it is a branch of the middle subscapular nerve to the teres major.

(c) 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.

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.

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 felt 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. The artery can be compressed in its whole length against the biceps.

192. The Brachial Artery in its Middle Third (Fig. 131). 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.

193. Superior Profunda Artery. *Upon the inner aspect of the arm in its upper third—at the lower border of the latissimus dorsi muscle* (Fig. 131). 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. One must be careful not to go too far backwards, otherwise one 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.

Upon the posterior surface of the arm above the middle. See exposure of the *musculo-spiral nerve* (Fig. 133).

Upon the outer aspect of the upper arm in the lower third (Fig. 133). 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.

The terminal branch of the superior profunda artery may be tied opposite the base of the external epicondyle in the interval between the brachialis anticus and the supinator longus : it lies behind the musculo-spiral nerve.

194. The Inferior Profunda 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. 131) 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.

195. 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.

196. The Median Nerve (Fig. 131) may be exposed by the same incisions as for ligature of the brachial artery, to which it is closely related throughout the upper arm, lying upon its outer aspect in the upper half, and crossing it at the middle to lie upon its inner aspect at the lower half.

197. Ulnar Nerve in the Lower Half of the Upper Arm (Fig. 131). 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.

198. Musculo-Spiral Nerve. *In the upper third upon the inner aspect* (Fig. 131). The operation is the same as that for ligature of the superior profunda artery in the internal bicipital sulcus.

Above the middle of the posterior surface (Fig. 133). As a guide to the incision, a line is drawn along the posterior surface of the upper arm from a point a finger-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.

Below the middle of the arm at its outer surface (Fig. 133). The incision ascends vertically from the external epicondyle along the outer border of the triceps towards the insertion of the deltoid. Expose the tendinous outer head of the triceps, and pass in at its border towards the outer surface of the humerus by separating the fibres of the brachialis anticus muscle, which here project laterally for some distance beyond the biceps. The nerve lies upon the bone, accompanied by the superior profunda artery, which runs along its outer side: behind it is the *external cutaneous branch of the musculo-spiral*, which supplies the outer aspect of the posterior surface of the forearm. At the junction of the middle and lower thirds of the humerus the nerve passes through the external intermuscular septum to its anterior surface.

199. Musculo-cutaneous Nerve. *Above the middle of the upper arm* (Fig. 132). 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 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-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.

(d) Region of the Elbow

200. 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.

201. Brachial Artery at the Bend of the Elbow (Fig. 135). 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-breadth below the level of the joint.

202. The Median Nerve (Fig. 135) lies half a centimetre internal to the brachial artery at the outer edge of the pronator teres muscle. The vessels and nerve are

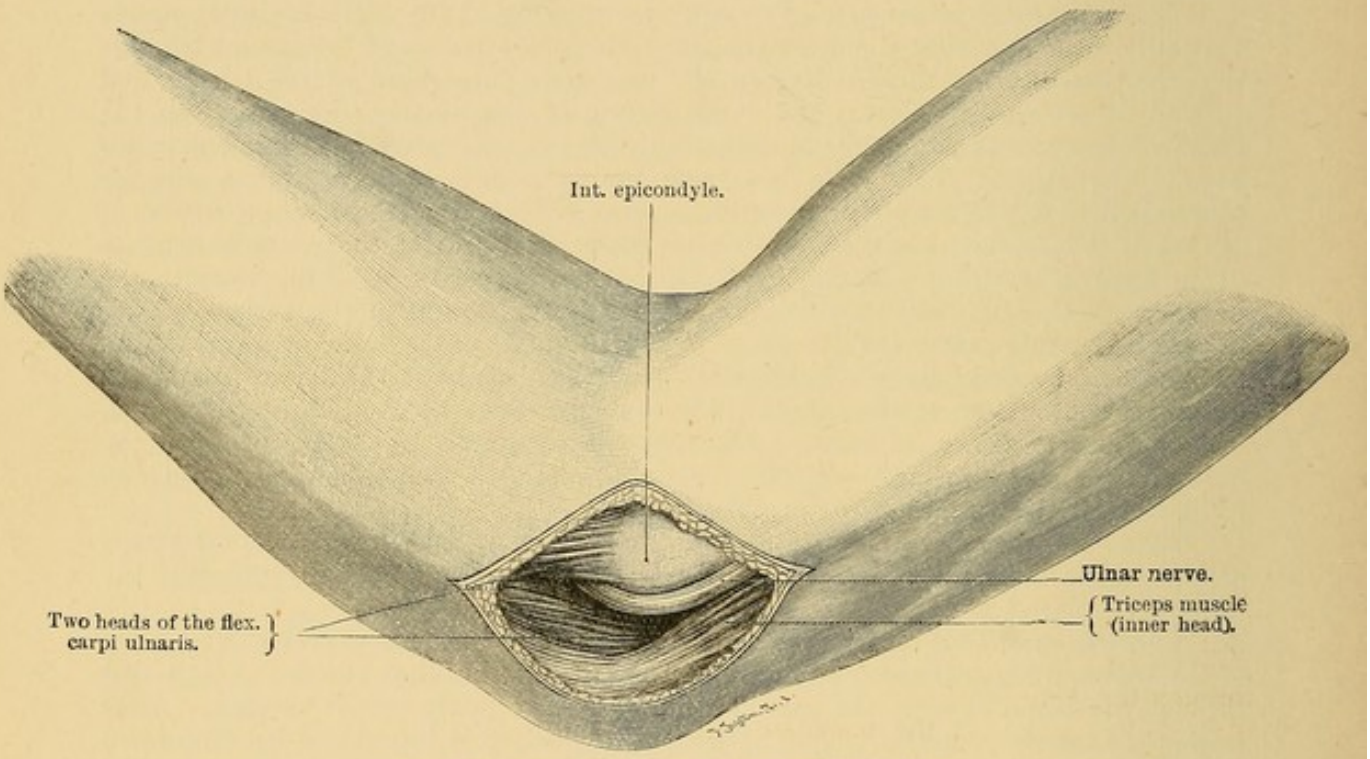


FIG. 134.—Ulnar nerve at the internal epicondyle.

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.

203. The Ulnar Nerve (Fig. 134). 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.

204. Musculo-spiral Nerve at its Bifurcation. 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 (Fig. 135). 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 inter-osseous nerves, the one in front of the other, and beneath them the terminal branch of the superior profunda artery.

(e) Forearm. Flexor Surface

205. 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.

206. The Radial Artery (Fig. 135). 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.

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 radial nerve covered by the supinator longus.

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.

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 sheaths 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.

207. The Ulnar Artery (Fig. 135) 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 digitorum muscles. Incisions for ligaturing the artery are made along a line extending from the internal condyle of 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 shall 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.

208. Interosseous Artery (Figs. 135 and 136). This branch of the ulnar artery may be exposed by the same incision as that for the ulnar artery in its upper third, 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.

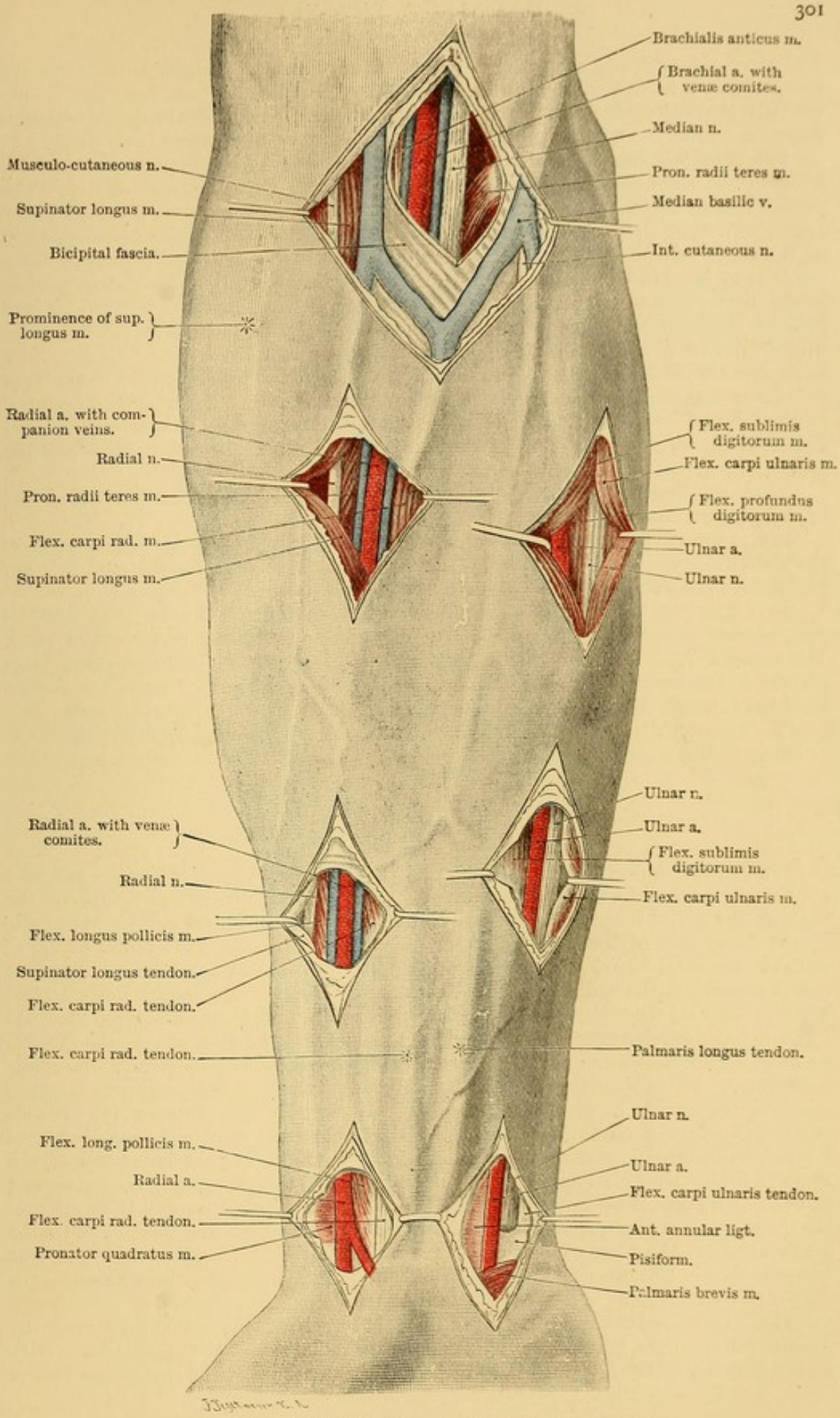


FIG. 135.—Brachial artery. Radial and ulnar arteries.

The interosseous artery may also be exposed by the same incision as that for the median nerve in the upper third (Fig. 136). 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.

209. Median Nerve (Fig. 136). *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.

210. Palmar Cutaneous Nerve (Fig. 136). 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.

211. The Anterior Interosseous Branch of the Median Nerve (Fig. 136) is seen passing outwards from the median in exposing the latter in its upper third. The 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.

(f) Forearm—Posterior Surface

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.

212. Posterior Interosseous Nerve (Fig. 137). 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

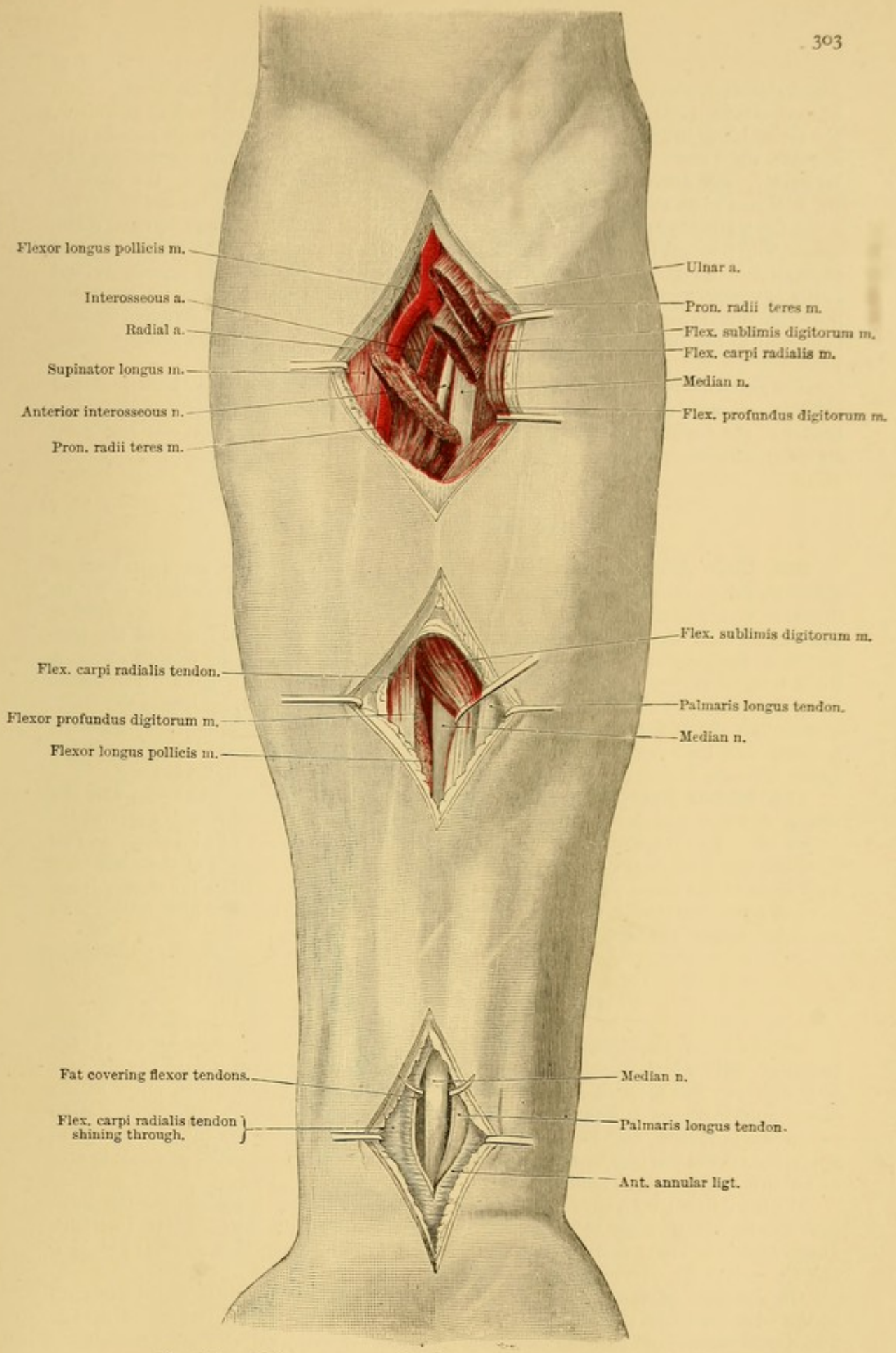


FIG. 136.—Median nerve, anterior interosseous nerve, interosseous artery.

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 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.

(g) Palmar Aspect of the Wrist-Joint

213. Ulnar Artery at the Pisiform Bone (Fig. 135). Its pulsation can here be distinctly felt. As the ulnar artery becomes the superficial palmar arch, it must be ligatured in bleeding from the arch which cannot be otherwise arrested. An incision is made through the skin and fascia half a centimetre to the radial side of the projection of the pisiform bone. After division of the fascia close to the pisiform bone, a cushion of fat protrudes and should be cut away. The artery lies under a considerable amount of fat upon the annular ligament, the large ulnar nerve being nearer the bone. The tendon of the flexor carpi ulnaris is seen descending to its insertion into the pisiform, and the muscles of the ball of the little finger are observed passing downwards with the transverse fibres of the palmaris brevis muscle lying upon them.

214. Median Nerve (Fig. 139). 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.

(h) 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 affections 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.

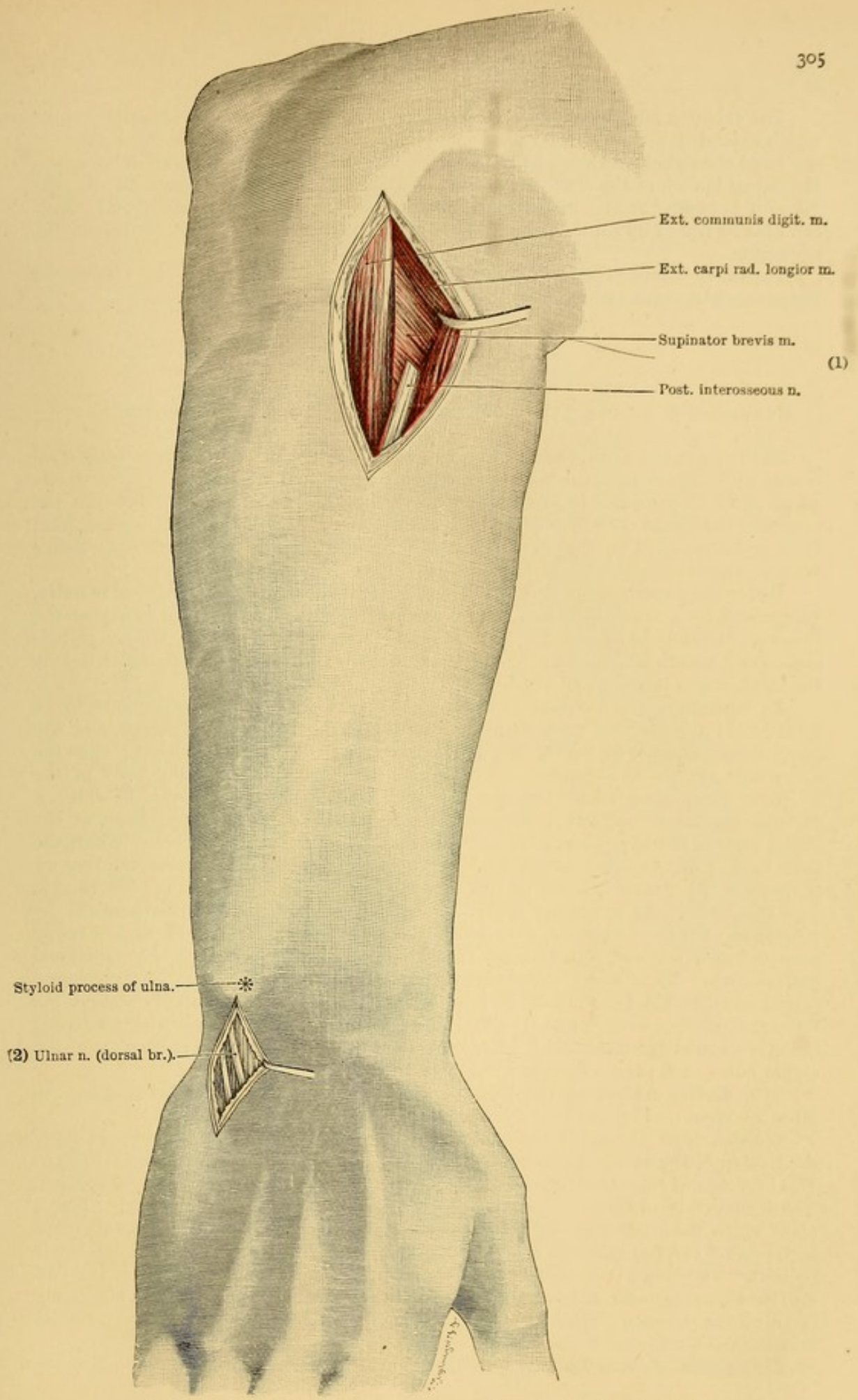


FIG. 137.—(1) Posterior interosseous nerve, below the head of the radius.
(2) Dorsal branch of ulnar nerve at the wrist.

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.

(i) Palm of the Hand

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 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.

215. Radial Artery at the Back of the Hand (Fig. 138). 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 (abductor indicis). 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 mistaken for the main trunk.

216. Radial Artery upon Trapezium (Fig. 138). Longitudinal incision from the

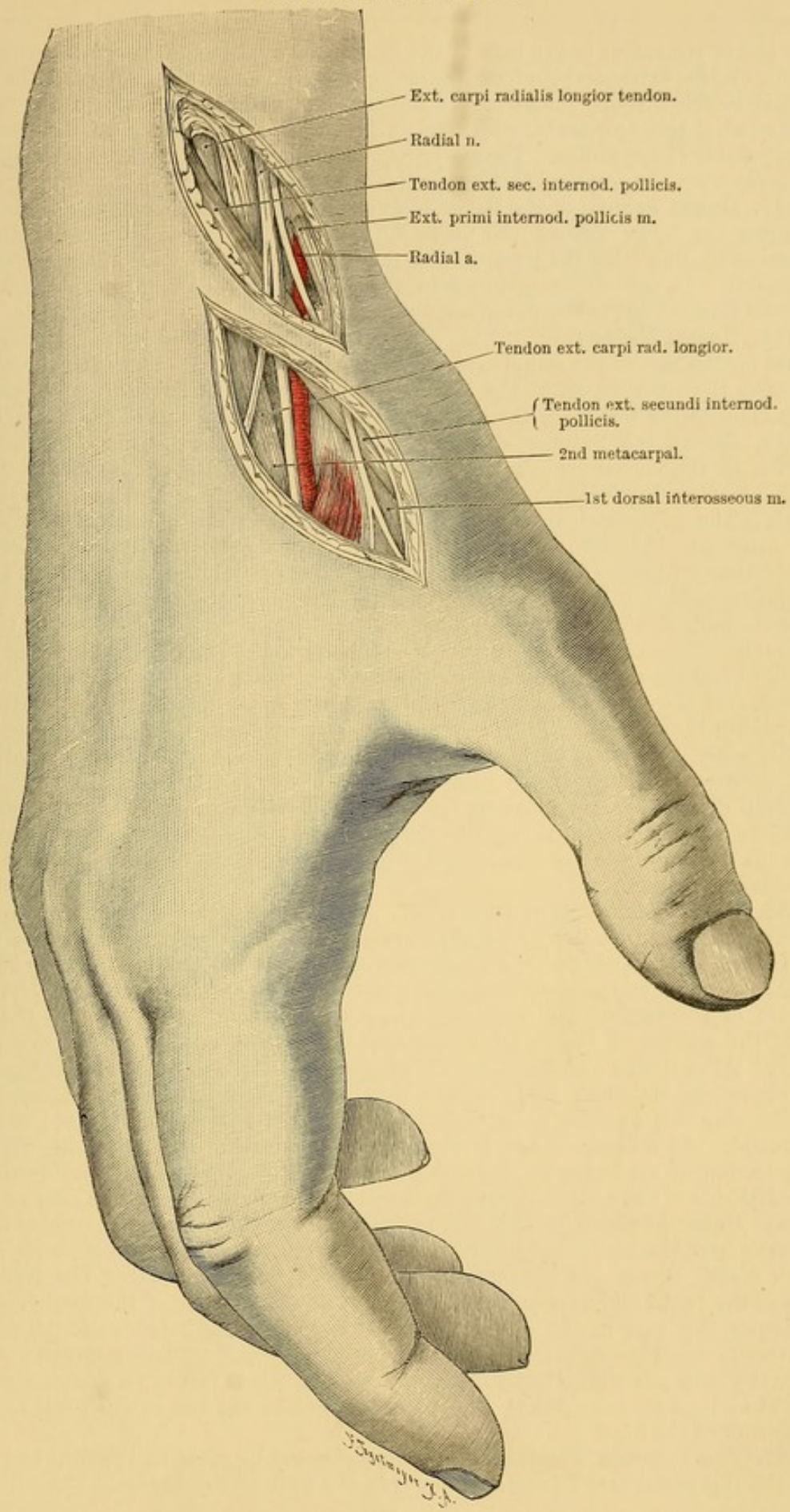


FIG. 138.—Radial artery on the back of the wrist. Radial nerve.

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 tendons 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.

217. Dorsal Branch of the Ulnar Nerve (Fig. 137). The nerve may be distinctly felt upon the ulnar side of the unciform bone. It is exposed by a longitudinal incision extending from the lower end of the ulna downwards along the ulnar edge of the carpus. It lies either upon or in the fascia, after having passed backwards from the forearm under the flexor carpi ulnaris.

218. Radial Nerve (Fig. 138). This nerve may be exposed by the same incision as that for ligature of the radial artery upon the trapezium. It can be felt through the skin upon the outer aspect of the lower end of the radius, after having passed backwards beneath the tendon of the supinator longus at the lower third of the forearm.

219. Superficial Palmar Arch (Fig. 139). 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 dividing 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 the same incision. Its superficial division 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.

220. Deep Palmar Arch (Fig. 139). In 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 exposed, 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. This exposes the—

221. Outer Division of the Median Nerve, which divides into branches for the forefinger and thumb. These nerves, together with the superficial muscles of the thumb (flexor brevis and abductor), are drawn to the radial side. The transverse fibres of the broad adductor pollicis now appear at the bottom of the wound. After division of this muscle, the deep arch will be exposed immediately under it, running transversely upon the deep fascia above the origins of the interossei muscles, a little nearer the wrist-joint than the superficial arch. The best means for defining exactly the seat of ligature is to feel for the proximal end of the first interosseous space on the dorsum of the hand.

222. The Common Digital Arteries are exposed by dividing the skin and fascia from the superficial arch downwards towards the web of the fingers. In addition to

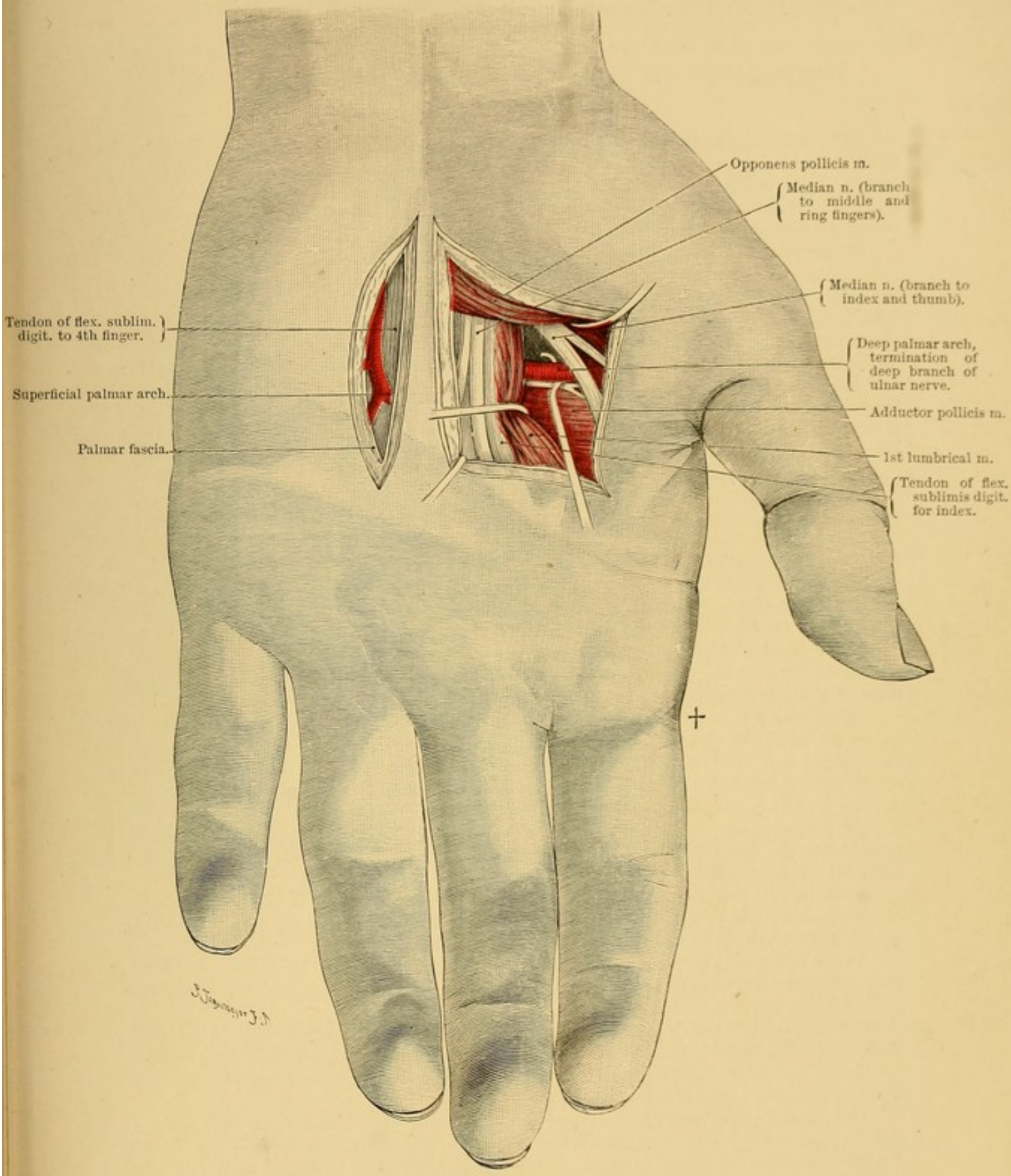


FIG. 139.—Superficial palmar arch (left). Deep palmar arch (right), with two branches of median nerve.

the vessels, which gradually become more superficial as they descend, are the large digital branches of the median and ulnar nerves.

Tendon Suture and Plastic Operations on the Tendons of the Hand and Fingers

223. 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.

S. LOWER EXTREMITY

Region of the Buttock

Branches of the Internal Iliac Artery

224. Gluteal Artery (Fig. 140). 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.

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 passing the finger 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.

225. Sciatic Artery (Fig. 140). 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 small sciatic nerve, appears from under the proximal end of the pyriformis. The nerve, after giving off large branches to the gluteus maximus, 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.

226. The Small Sciatic Nerve accompanies the continuation of the sciatic artery under the deep fascia along the middle of the posterior aspect of the thigh.

227. The Great Sciatic Nerve lies directly upon the bone, deeper than and external to the small sciatic. It forms a very large and broad trunk, which may readily be felt lying upon the base of the spine of the ischium and descending upon the obturator internus muscle.

228. Internal Pudic Artery (Fig. 140). Incision the same as for ligature of the sciatic artery.

The artery lies upon the posterior surface of the ischial spine, below and external to the sciatic artery, and accompanied by the *internal pudic nerve.* It is recognised by its re-entering the pelvis below the ischial spine.

Iliac Region

229. The Common Iliac Artery (and Abdominal Aorta) (Figs. 141 and 142). Keen has lately reported a case in which a patient was operated on for aneurism of the aorta. The aorta was exposed and ligatured through the peritoneum. The

patient survived forty-eight days, but died of hæmorrhage due to the ligature cutting through. Keen recommends a clamp in place of the ligature.

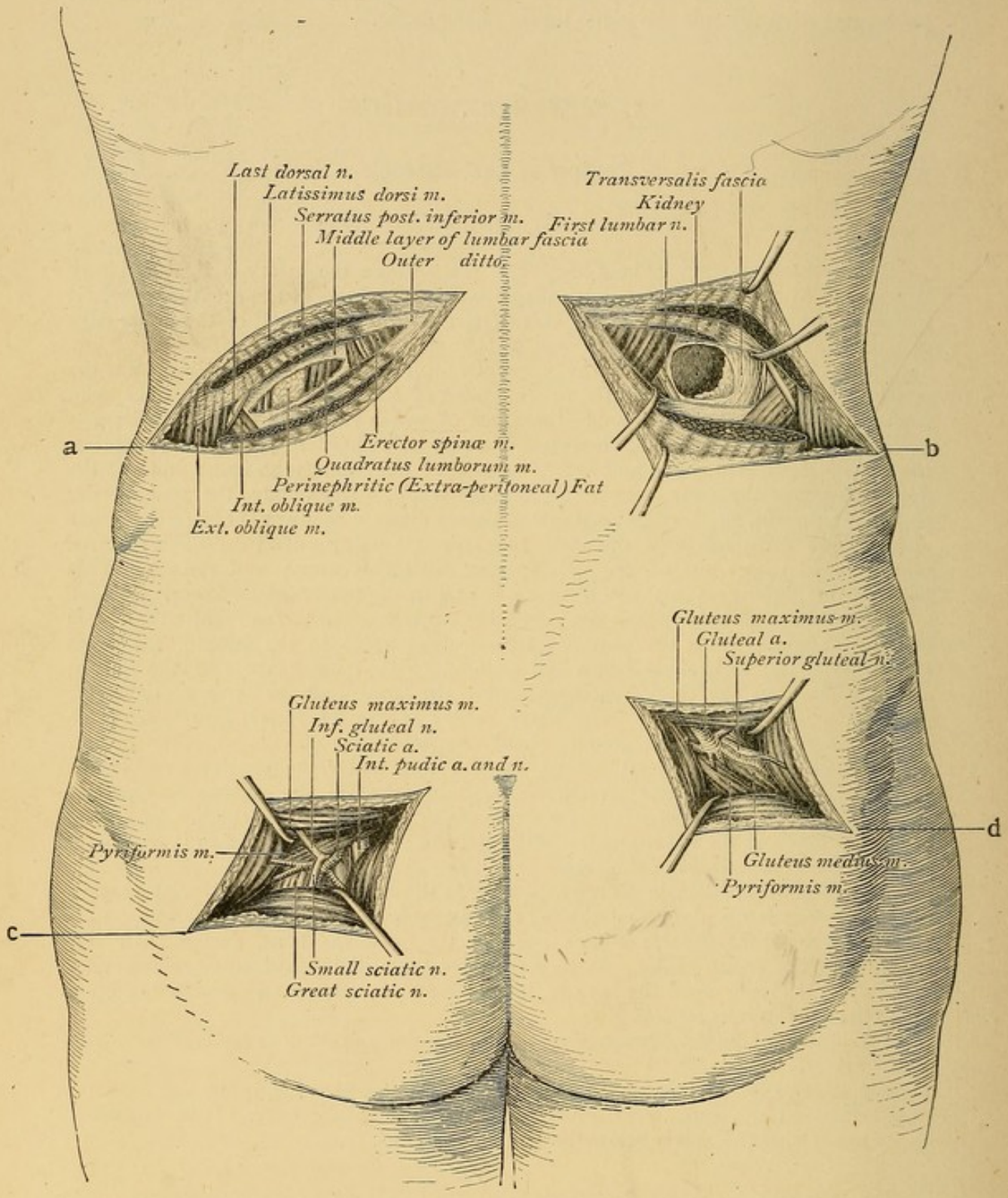


FIG. 140.—(*a*) and (*b*) Nephrotomy. (*c*) Ligature of the sciatic and internal pudic arteries, and exposure of the great sciatic, small sciatic, and internal pudic nerves. (*d*) Ligature of the gluteal artery and exposure of the superior gluteal nerve.

The aorta divides into the two common iliac arteries at the umbilicus (at the level of a horizontal line joining the anterior superior iliac spines).

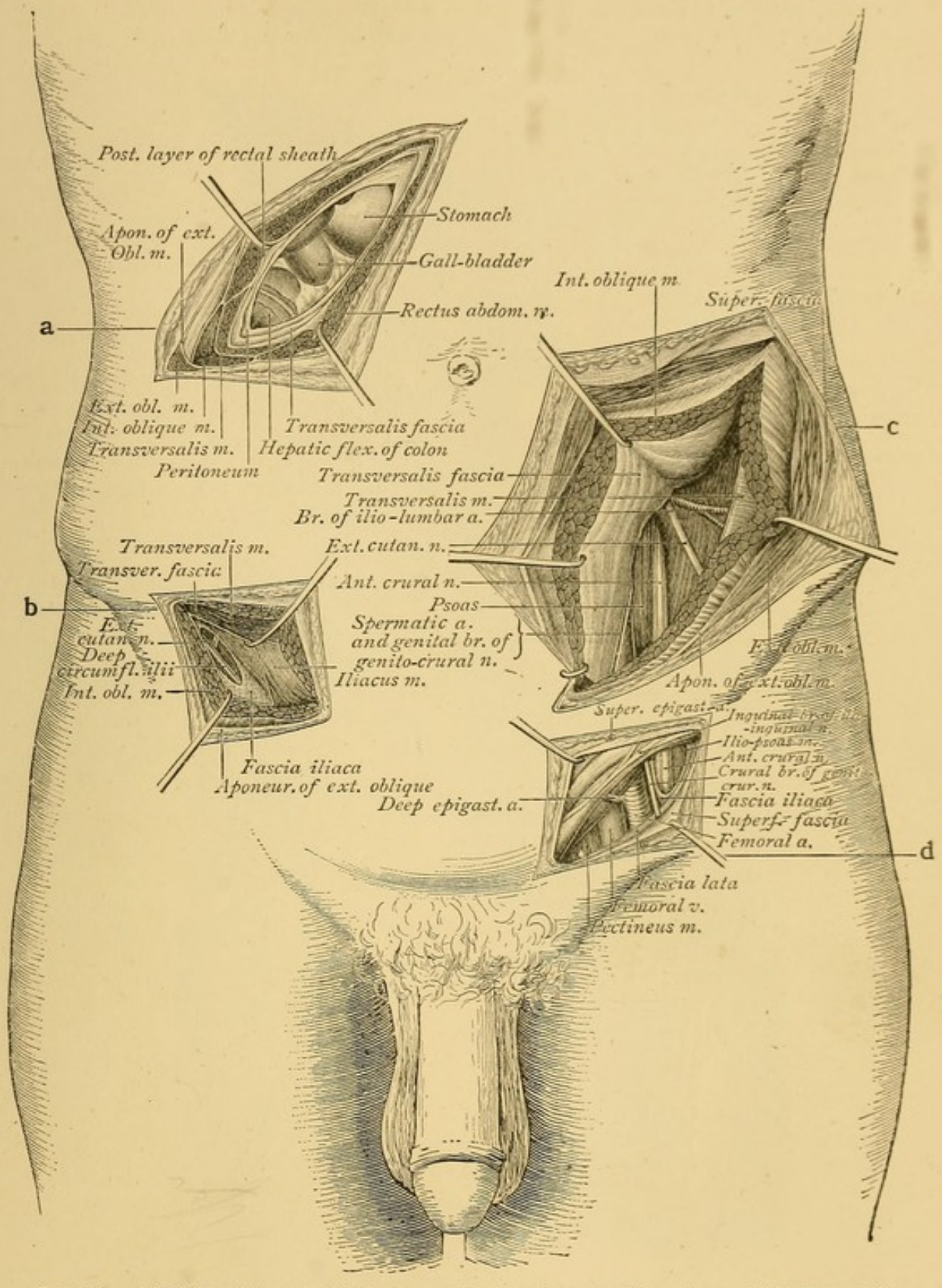


FIG. 141.—(*a*) Cholecystotomy.[1] (*b*) Ligature of the deep circumflex iliac artery. (*c*) Ligature of the common iliac artery. (*d*) Ligature of the common femoral artery.

[1] The incision for cholecystotomy is drawn as large as this in a difficult case. For simple cases an incision half the length suffices, the centre of it being placed at the edge of the rectus.

The common and external iliac arteries descend along the inner border of the psoas muscle to a point midway between the anterior superior iliac spine and the

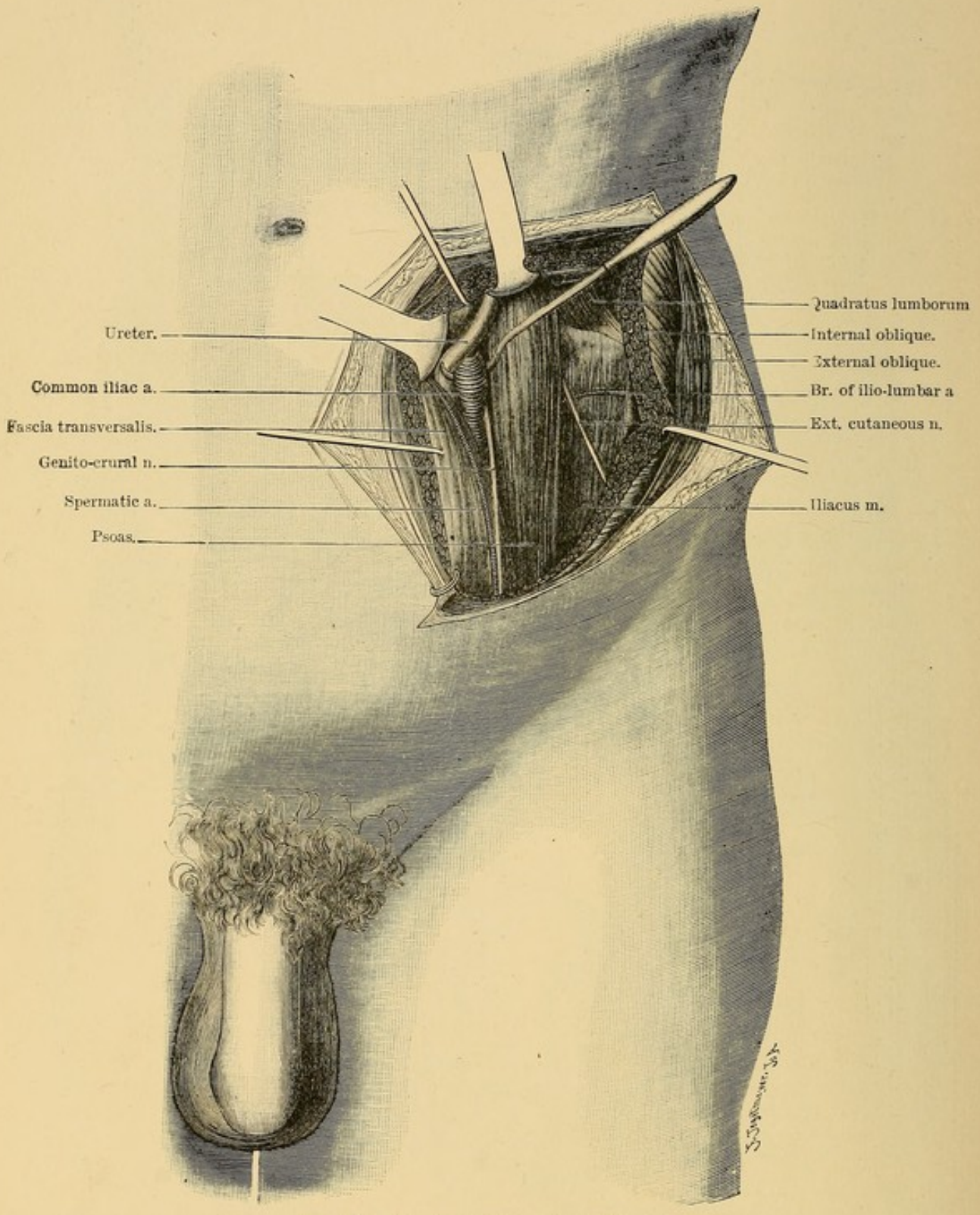


FIG. 142.—Ligature of the common iliac artery.

symphysis pubis. The upper third of this line corresponds with the common iliac, the lower two-thirds with the external iliac.

The incision, which corresponds with that recommended by Mott, begins at the tip of the eleventh rib on the left side, descends at first vertically downwards to a point two finger-breadths internal to the anterior superior iliac spine, and then obliquely downwards and inwards to a point two finger-breadths above the middle of Poupart's ligament. The skin, the superficial fascia, and the strong muscular layers of the abdominal wall, namely, the external oblique, the internal oblique, and the thinner transversalis muscle, each with its fibres running in a characteristic direction, are divided. The main branches of the lumbar arteries and nerves lie between the two latter muscles. Next, the well-developed fascia transversalis and the extra-peritoneal fat are divided. The peritoneum is separated from the iliac fascia (which covers the iliacus muscle with glistening transverse fibres), at first downwards, and then backwards as far as the inner edge of the psoas muscle, and from here upwards as far as the sacral promontory. The *external cutaneous nerve* appears from beneath the psoas, and runs obliquely downwards and outwards upon the iliac fascia. Running transversely above the nerve is the iliac branch of the *ilio-lumbar artery*.

230. The next step in the dissection is to raise the **Spermatic Artery** and the *genito-crural nerve*, along with the peritoneum, from the surface of the psoas. The nerve descends upon the psoas, and its genital branch accompanies the spermatic artery into the inguinal canal to form one of the constituents of the cord.

The *genito-crural nerve* has been resected by Heinlein in Nürnberg, in a case of spermatic neuralgia, with severe testicular pains, spreading out over the inferior abdominal and upper femoral regions. After he had divided the abdominal wall and stripped off the peritoneum, the common iliac artery was exposed as far as the point where the ureter crosses it. Both the genital and crural branches of the nerve were distinctly visible, the former lying upon and the latter close to the artery.

231. The Ureter, which descends almost vertically in front of the bifurcation of the common iliac artery, is also stripped off somewhat farther towards the middle line, above the place where it crosses the bifurcation of the common iliac to enter the true pelvis. The *genito-crural nerve* passes downwards close to the common iliac artery, and its crural division crosses over (lies upon) the anterior surface of the external iliac artery. In front of the vertebral column is the bifurcation of the aorta.

232. The Inferior Mesenteric Artery passes vertically downwards upon the aorta, and may also be lifted off along with the peritoneum. About 3 cm. above the bifurcation of the aorta a lumbar artery is seen passing outwards.

The common iliac artery can, as proposed by Mitchell Banks, Marmaduke Sheild, and others, be more easily ligatured, under certain conditions, *by opening the peritoneal cavity*.

233. Internal Iliac Artery. 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 done by Dennis and Treves.

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. 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 aneurisms of the gluteal and sciatic arteries.

Quenu 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.

234. Uterine Artery. This artery is ligatured as a preliminary to hysterectomy (Snegireff), and with the view of producing atrophy of myomata of the uterus. The following is the procedure recommended by Altoukhow :—

The abdomen is opened in the middle line and a small incision is made into the

broad ligament 1 cm. from the ilio-pectineal line behind and parallel to the round ligament, the dissection being then continued behind the anterior layer of the broad ligament for a depth of 12 to 16 mm. The ureter and the ovarian vein adhere to the posterior layer of the broad ligament.

235. External Iliac Artery. Incision close above and parallel to the middle

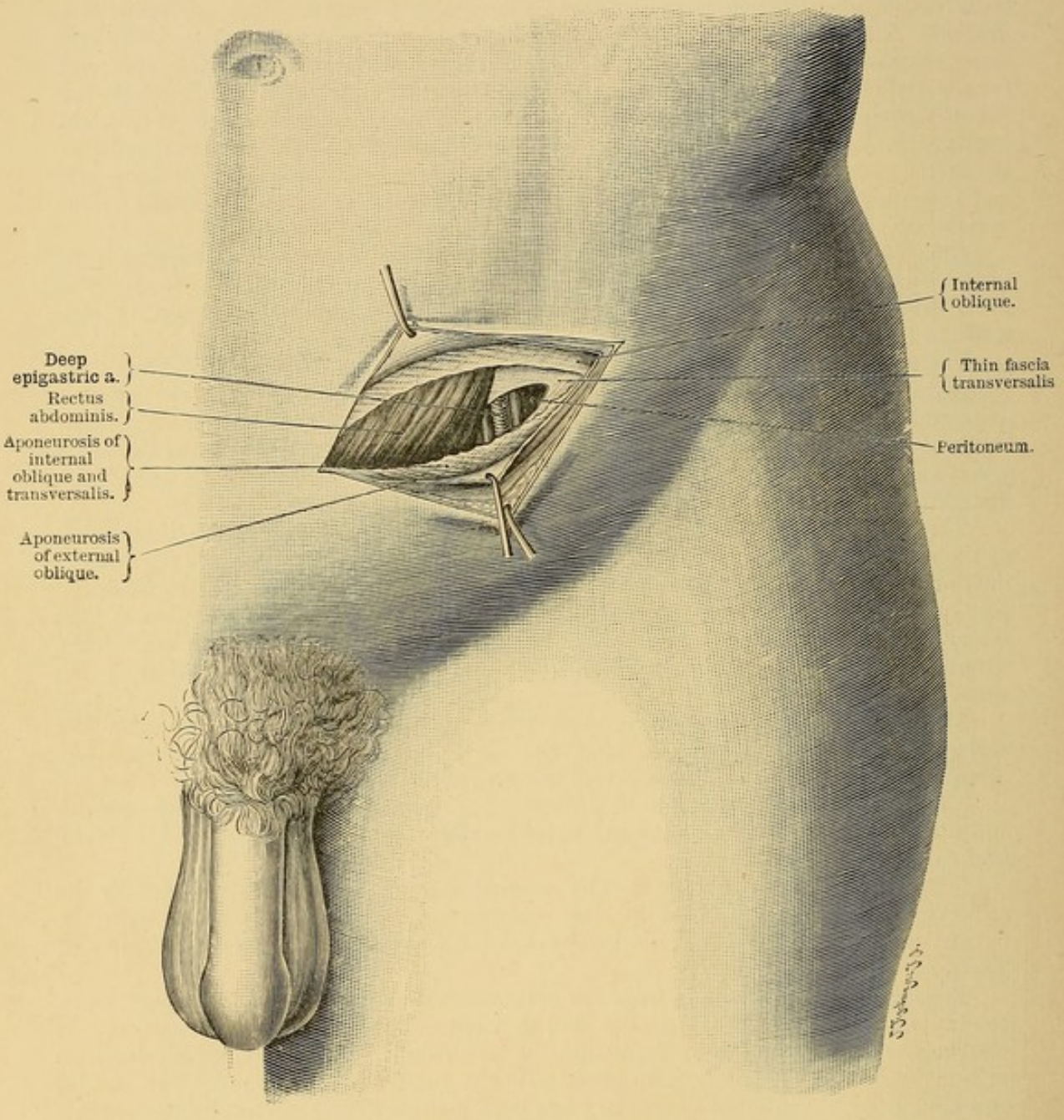


FIG. 143.—Ligature of the deep epigastric artery.

third of Poupart's ligament. Division of the skin and well-developed superficial fascia; the superficial epigastric artery which ascends vertically in the fascia must be divided. After dividing the tendon of the external oblique, the internal oblique and transversalis muscles are detached upwards from out of the groove of Poupart's ligament with the handle of the scalpel, and the dense transversalis fascia 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.

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.

236. Deep Epigastric Artery in the Anterior Abdominal Wall (Fig. 143). Incision three fingers' breadth above and parallel to the inner half of Poupart's ligament, 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 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. After reaching the under surface of the rectus the artery ascends over the semilunar fold of Douglas to enter the sheath of the muscle.

237. Deep Circumflex Iliac Artery (Fig. 141). Incision above the outer third of Poupart's ligament. Division of the skin, the superficial fascia, the strong oblique fibres of the external oblique, the thick ascending fibres of the internal oblique, and the transversalis muscle. 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.

238. Obturator Artery and Nerve (Fig. 144). The artery is a branch of the anterior division of the internal iliac.

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 accompanied by the—

239. Obturator Nerve, which lies above it (Fig. 144).

Thigh—Anterior Surface

240. Femoral Artery. It courses in a line from the middle of Poupart's ligament directly downwards towards the middle of the posterior aspect of the knee-joint, and passes 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 (Fig. 145). Incision parallel to and below the middle

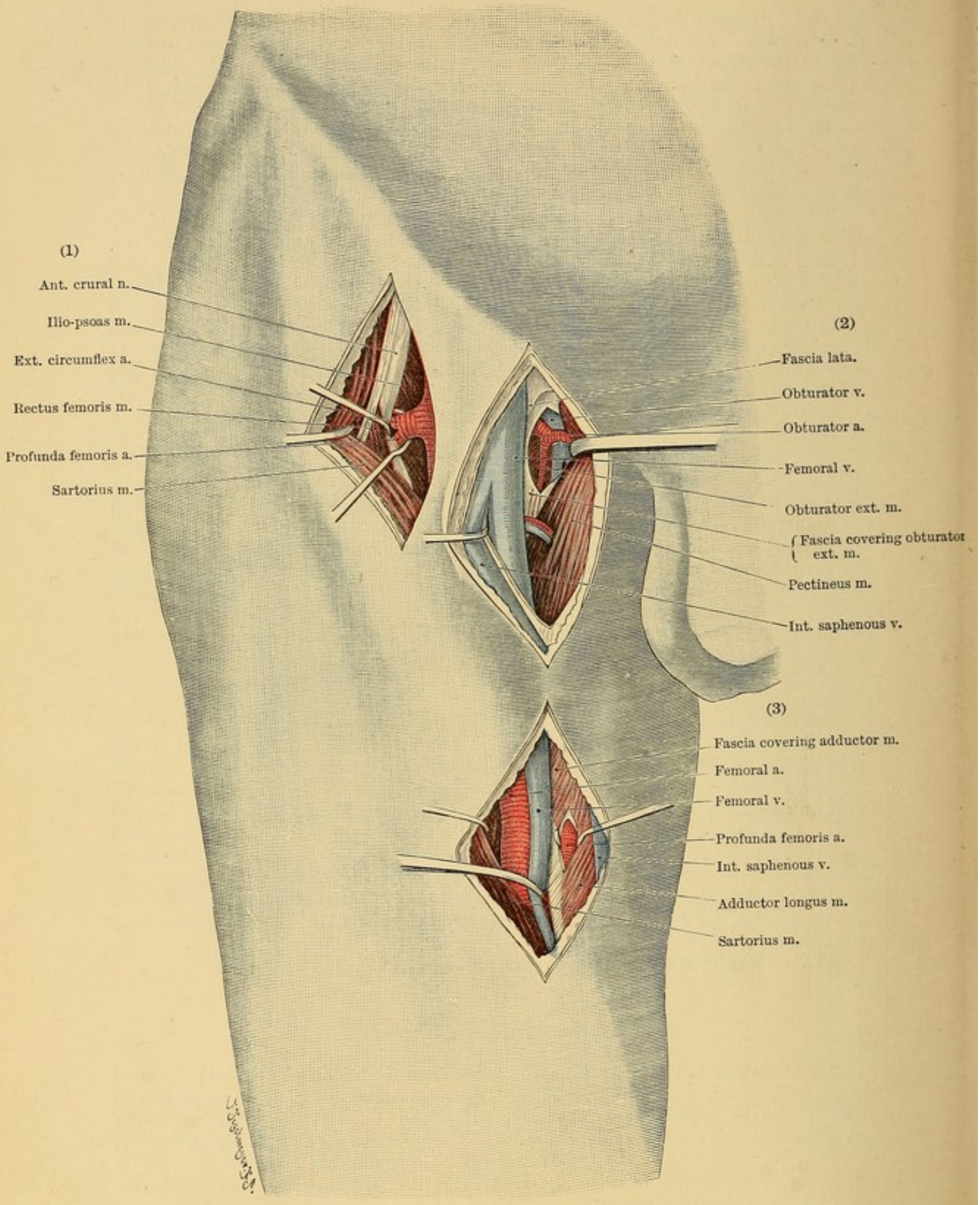


FIG. 144.—(1) Ligature of profunda femoris artery and external circumflex artery. (2) Ligature of obturator artery. (3) Ligature of profunda femoris artery.

third of Poupart's ligament. Ligature of the superficial epigastric artery in the subcutaneous tissue. 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 (Fig. 145). The skin and fascia lata are divided along the line already mentioned. The sartorius is 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) (Fig. 145). Longitudinal incision 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 (Fig. 145)—**(a) From the Inside** (Fig. 145). Incision 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 easier done from the outer than the inner side. Incision 8 to 10 cm. ($3\frac{2}{3}$ 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.

241. Branches of the Femoral Artery—(a) Profunda Artery at its Origin, together with its External Circumflex Branch (Fig. 144). 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

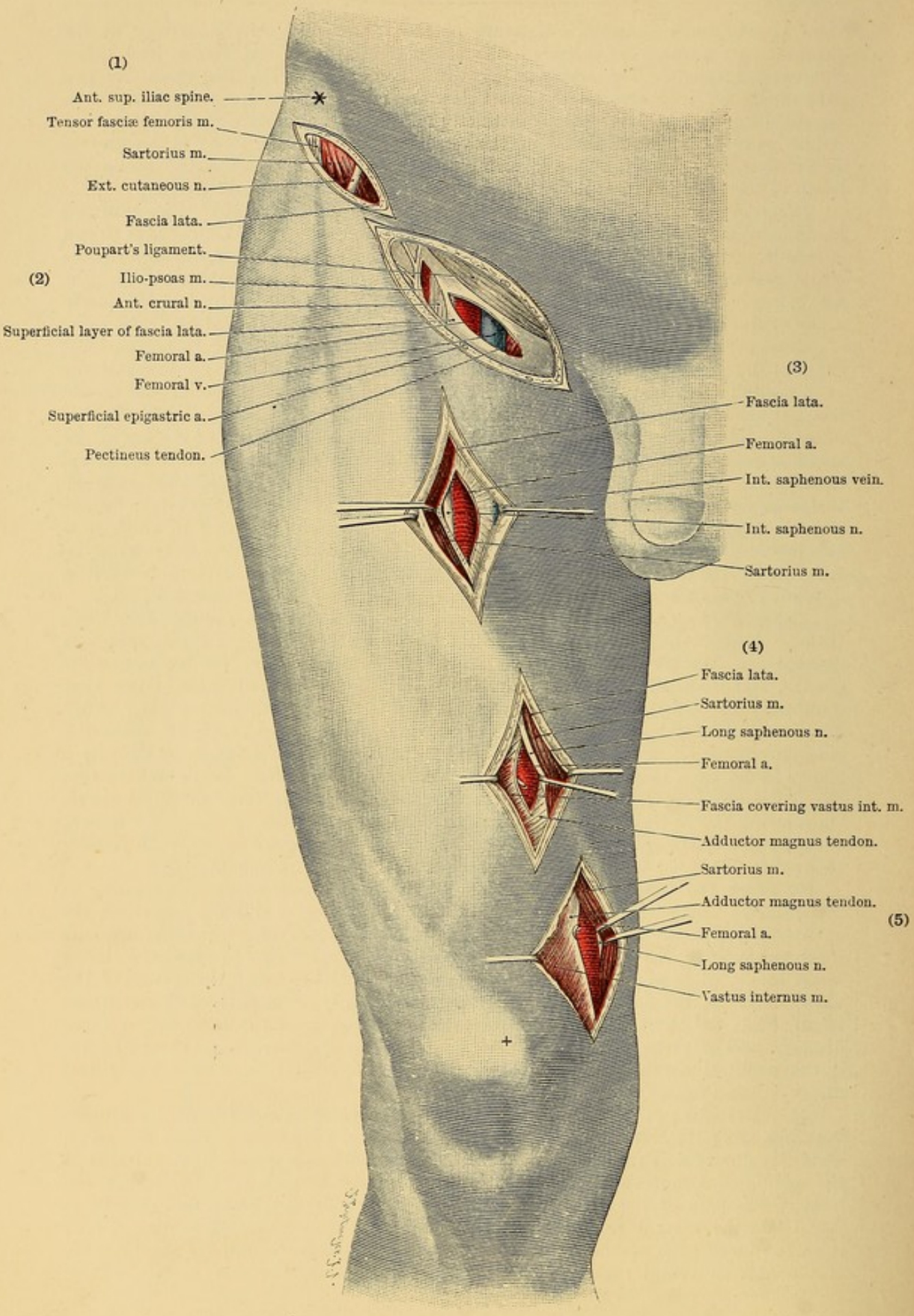


FIG. 145.—(1) External cutaneous nerve. (2) Common femoral artery. (3) Femoral artery. (4) Femoral artery at the opening in the adductor magnus. (5) Femoral artery at the lower end of the femur.

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) The Terminal Branch of the External Circumflex Artery lies upon the bone a finger's breadth below the most outwardly projecting part of the great trochanter. It may be exposed by a transverse incision dividing the skin, the strong fascia lata, the tendon of the gluteus maximus, and the glistening tendinous covering and muscular fibres of the vastus externus.

(c) Profunda Artery at the Upper Edge of the Insertion of the Adductor Longus (Fig. 144). 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 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.

242. The Internal Circumflex Artery (Fig. 146) arises as a rule from the common femoral; in many cases, however, 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 branch which passes inwards.

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.

243. Anastomotica Magna Artery (Fig. 145). Incision 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.

244. Anterior Crural Nerve (Figs. 144 and 145). This nerve may be exposed by the same dissection as for ligature of the external circumflex artery; or it may be exposed by making a transverse incision below the middle third of Poupart's ligament as if for ligature of the common femoral artery. The incision through the fascia lata is prolonged outwards through the sheath of the ilio-psoas muscle, immediately under which, along the inner aspect of the muscle, is the large nerve breaking up into several branches.

245. The Internal Saphenous Nerve (Figs. 147 and 153) accompanies the femoral artery as far as the opening in the adductor magnus, lying at first external to and then in front of the sheath of the vessels.

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.

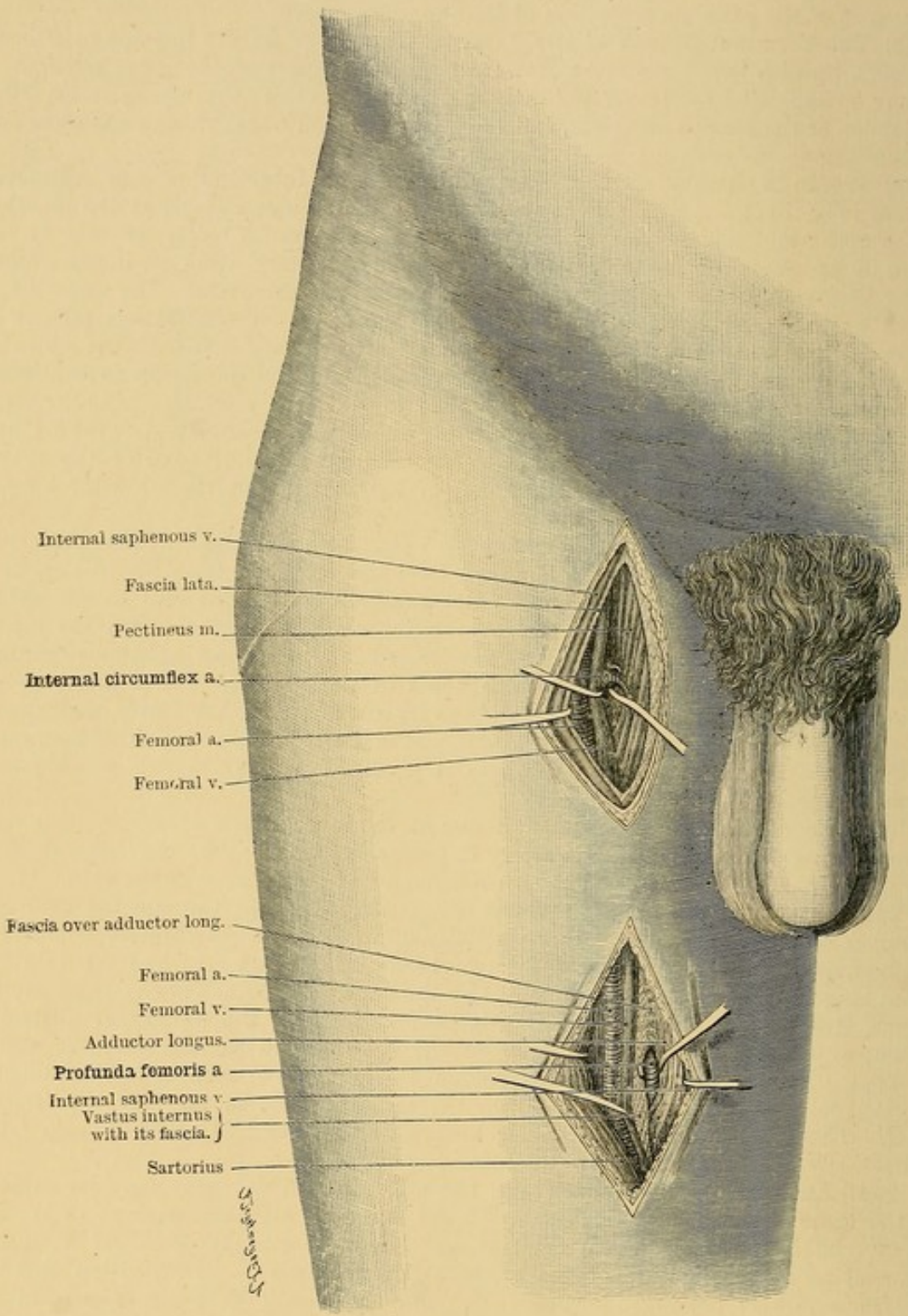


FIG. 146.—Ligature of the internal circumflex artery. Ligature of the profunda artery.

246. The long Saphenous Vein is ligatured at its upper end for the cure of varicose veins (Trendelenburg). It is easily ligatured, as its course is visible as far

as the saphenous opening, where it pierces the cribriform fascia to enter the femoral vein. In case the vein be double, it is better to expose it by means of an oblique incision passing downwards and inwards across the course of the vessel. According to Casati, better results are obtained in varicose veins by excising the vein in its entire length by means of several small incisions.

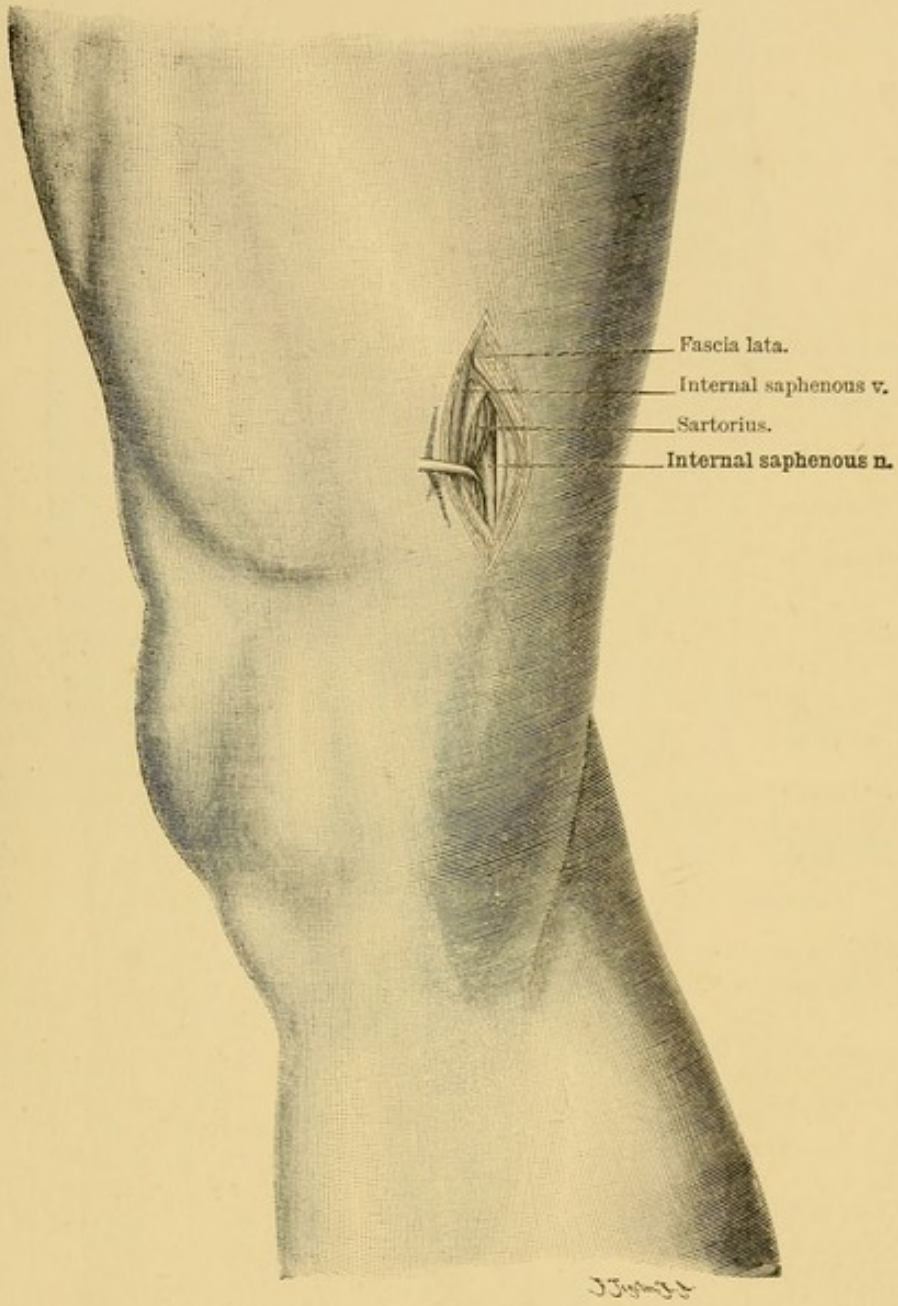


FIG. 147.—Exposure of the internal saphenous nerve at the internal condyle of the femur.

247. External Cutaneous Nerve of the Thigh (Fig. 145). Incision 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.

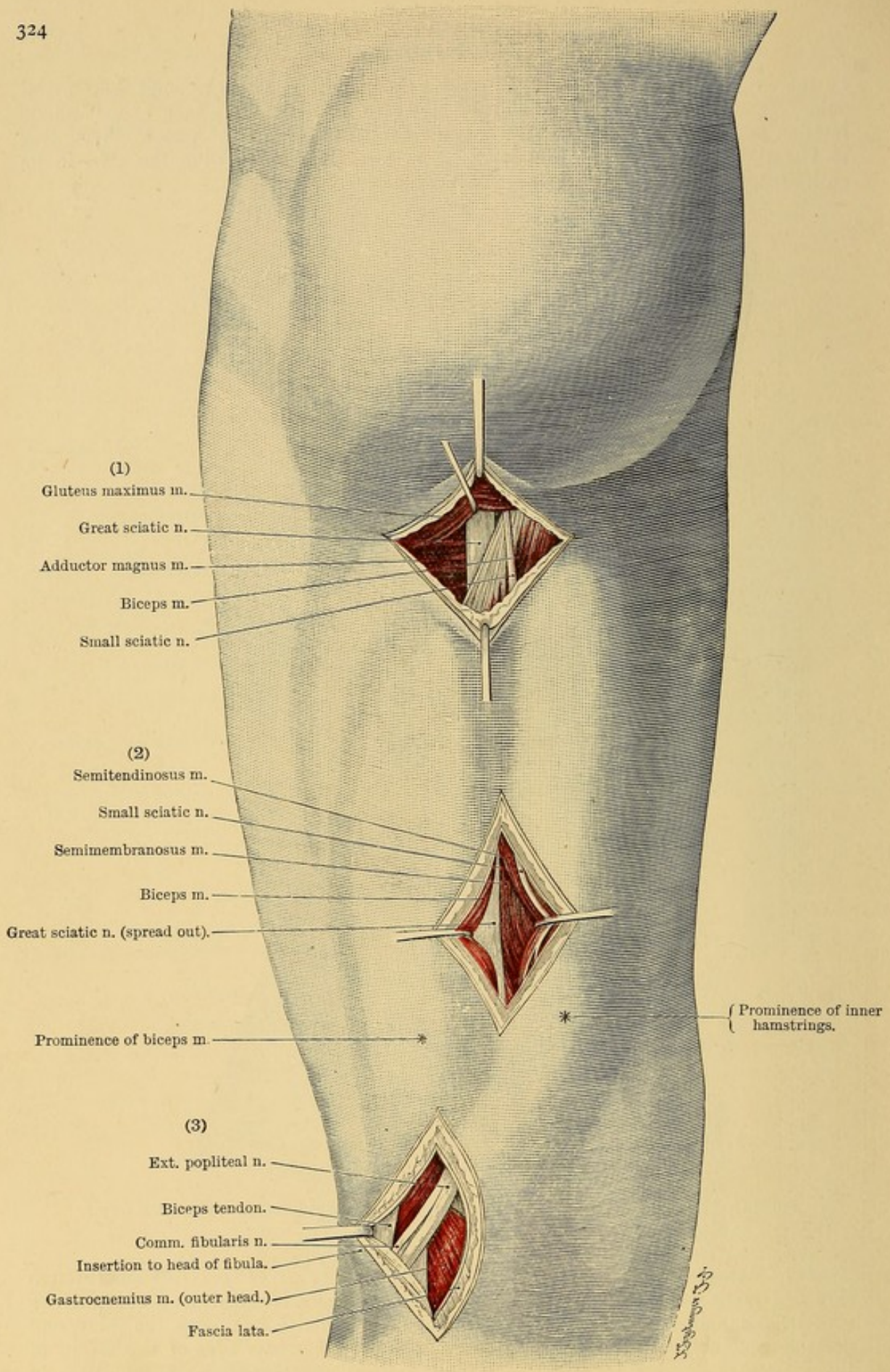


FIG. 148.—(1) Great sciatic nerve at the fold of the buttock. (2) The same in the middle of the thigh. (3) External popliteal and musculo-cutaneous nerves.

Thigh—Posterior Surface

248. Great Sciatic Nerve (Fig. 148). For its exposure *where it enters the buttock*, see ligature of sciatic artery (Fig. 140).

To expose it at 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.

Popliteal Space

249. Popliteal Artery (Fig. 149). 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.

250. The External Popliteal Nerve (Fig. 148) may be distinctly felt (and even seen) behind the head of the fibula, and still more distinctly upon 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.

251. The communicating Peroneal Nerve is given off from the external popliteal (Fig. 148) above the head of the fibula. This nerve may also be felt through the skin upon the external condyle of the femur.

Leg—Anterior and External Surfaces

252. Anterior Tibial Artery (Fig. 150). 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.

At its upper end. 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

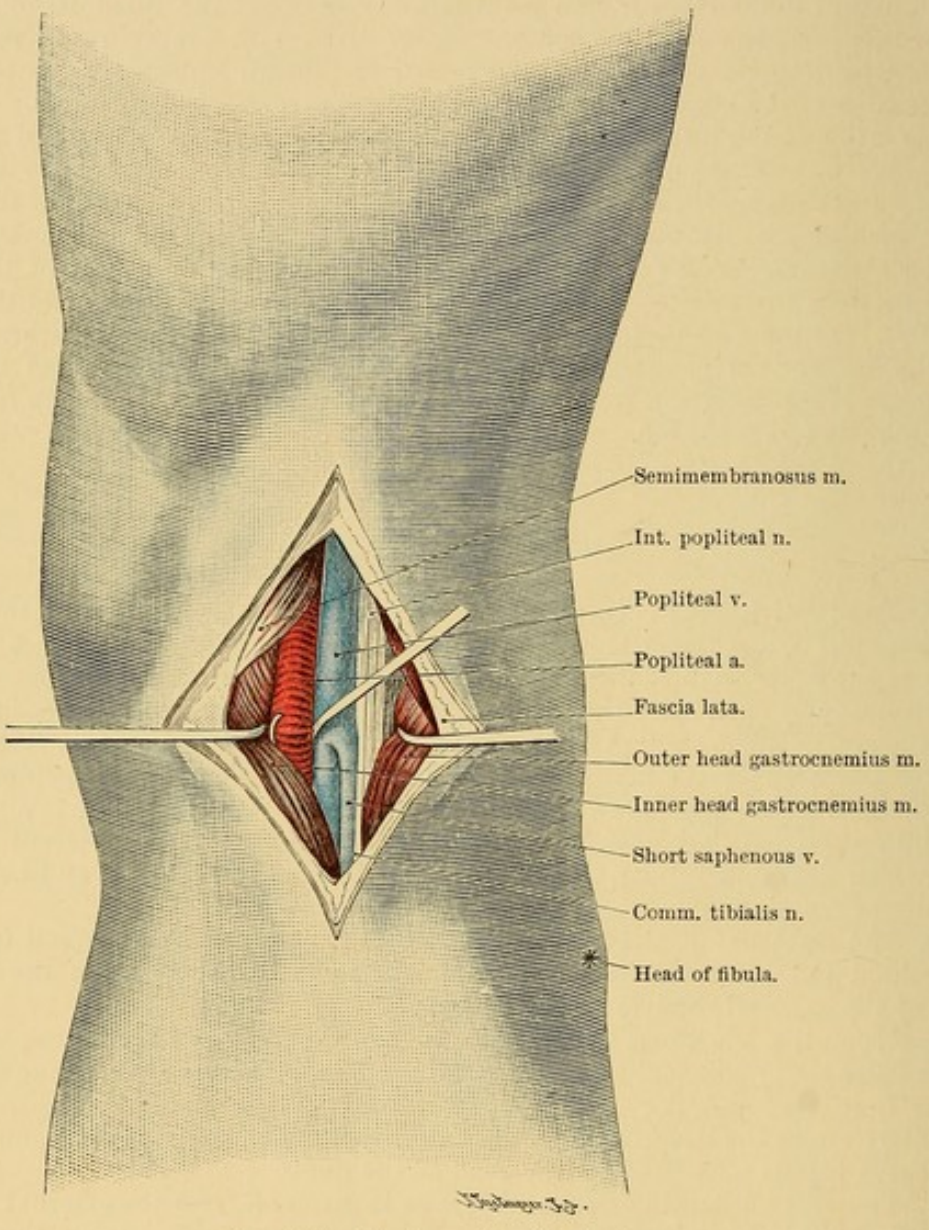


FIG. 149.—Ligature of popliteal artery.

finger down to the interosseous 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

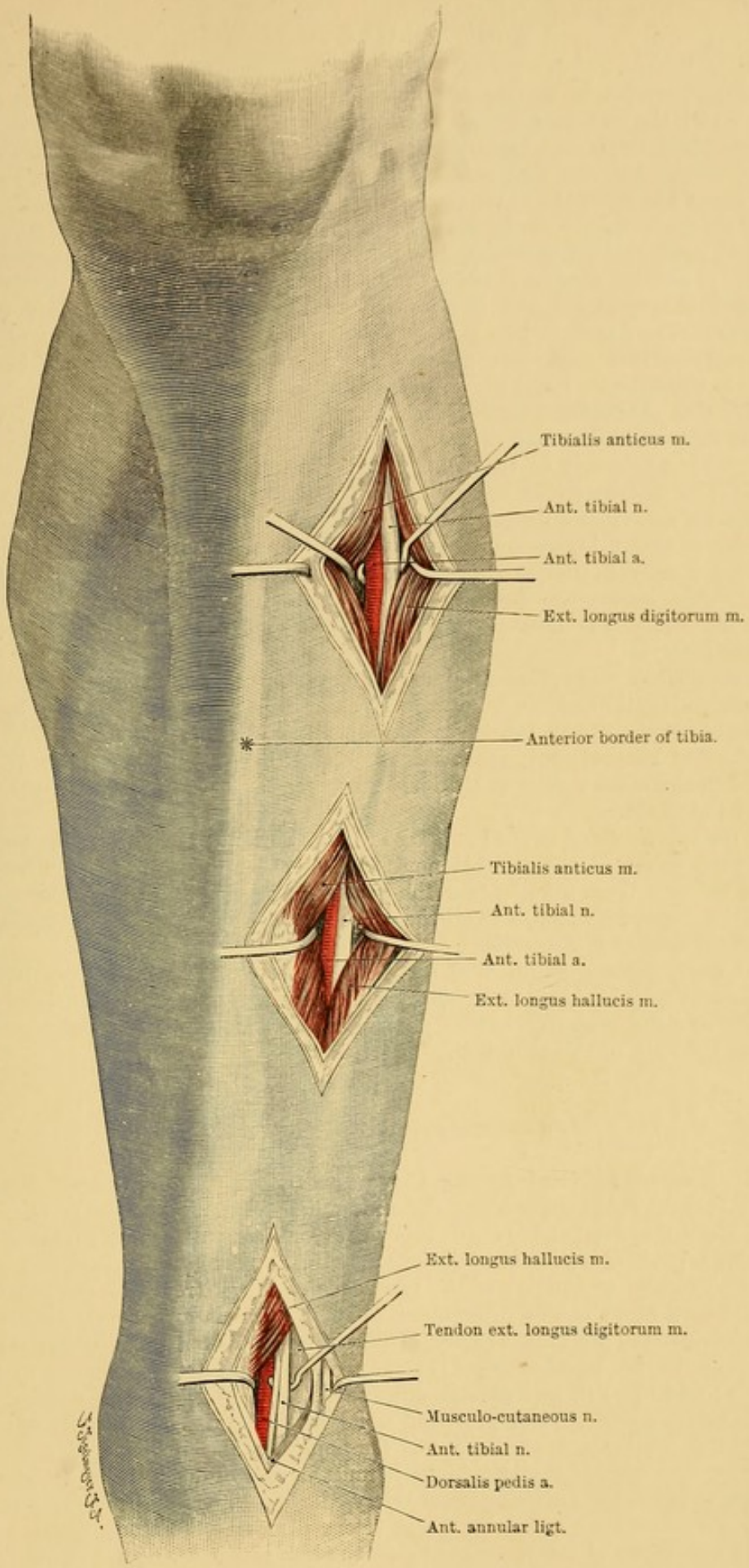


FIG. 150.—Anterior tibial artery and nerve.

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 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. Incision 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.

253. The Anterior Tibial Nerve close to its Origin (Fig. 151). 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.

254. The Musculo-cutaneous Nerve (Fig. 151) *in the upper third of the leg* is exposed in the same wound as that just made for the anterior tibial nerve below the head of the fibula.

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.

Leg—Posterior and Inner Surfaces

255. Posterior Tibial Artery above the Origin of its Peroneal Branch (Fig. 152). Incision downwards along the middle line, beginning at the level of the head of the fibula three fingers' breadth below the popliteal crease. In dividing 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 2½ inches below the line of the knee-joint (a finger's breadth

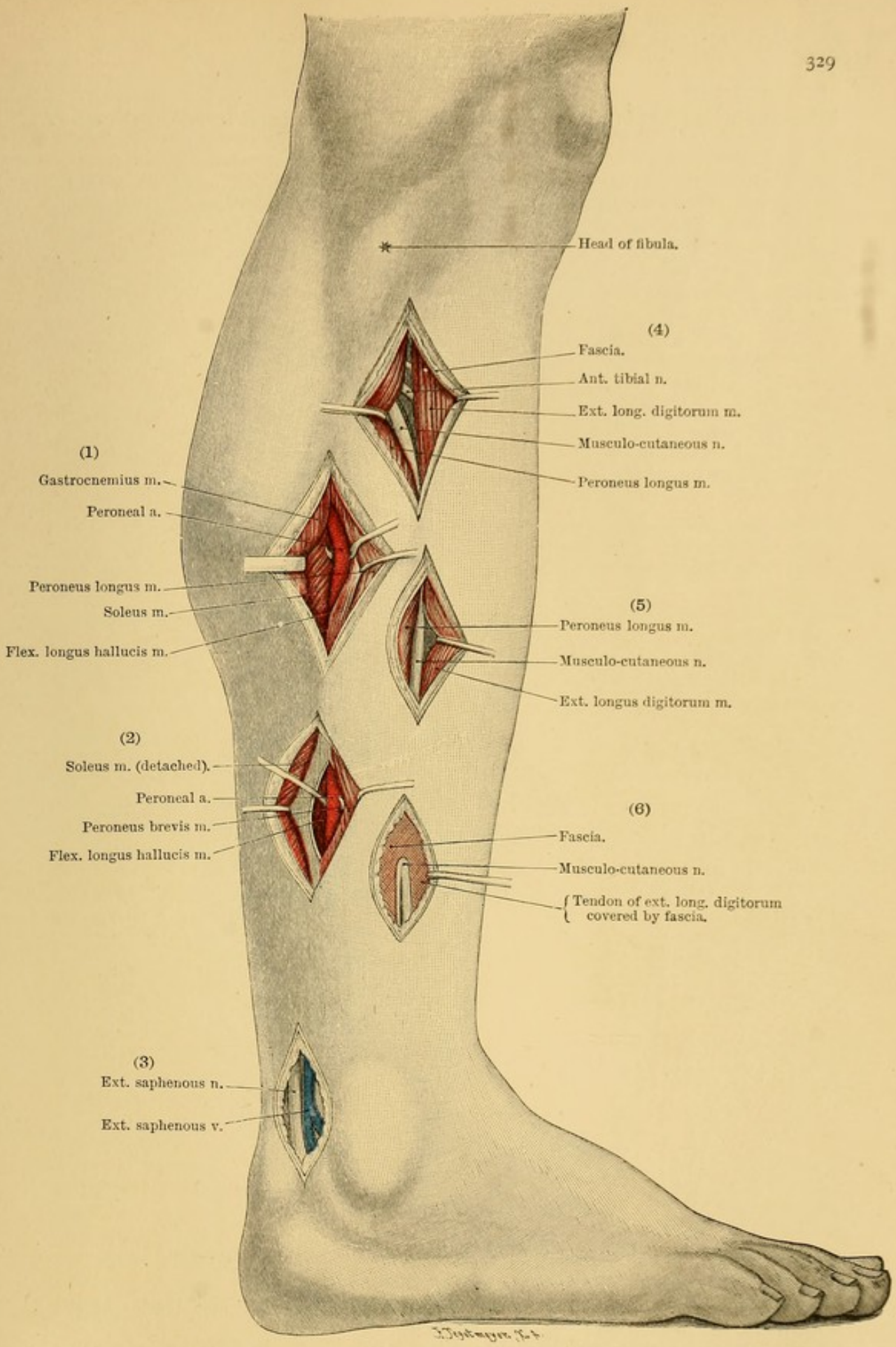


FIG. 151.—(1) Ligature of peroneal artery in its upper part. (2) The same in its lower part. (3) Exposure of external saphenous nerve. (4) Exposure of posterior tibial and musculo-cutaneous nerves below the external condyle of tibia. (5) Exposure of musculo-cutaneous nerve in the middle of the leg. (6) The same in the lower third, where it pierces the fascia.

below the lowest part of the head of the fibula). The tendinous surface of the soleus

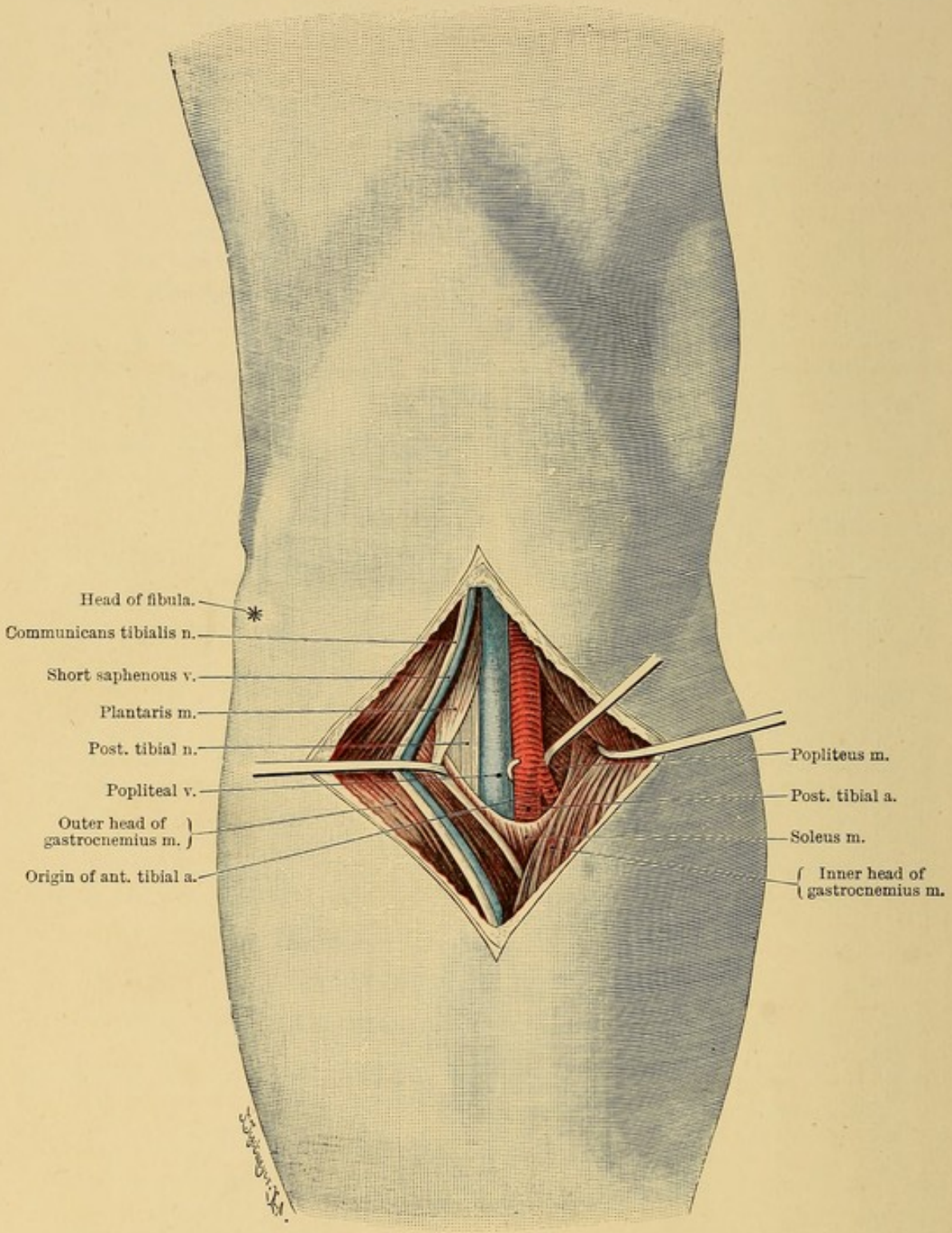


FIG. 152.—Ligature of posterior tibial artery above origin of the peroneal.

can be distinctly seen descending obliquely inwards towards the inner border of the tibia, under the inner head of the gastrocnemius.

256. Posterior Tibial Artery below the Origin of its Peroneal Branch (Fig. 153). The incisions are made upon the inner aspect of the leg 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.

In the upper half. The incision lies 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.

In the lower third. 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 midway between the posterior 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 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.

257. Internal Saphenous Nerve (Fig. 153). *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.

At the ankle-joint. The nerve along with the internal saphenous vein can be felt at the anterior border of the internal malleolus.

258. Peroneal Artery (Fig. 151). The peroneal artery arises from the posterior tibial in the upper third of the leg. 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.

In the upper part of the leg. Incision at the posterior surface of the fibula behind the peroneal muscles. The communicans fibularis nerve is exposed, and the deep fascia is divided behind the peronei. The origin of the soleus is detached from

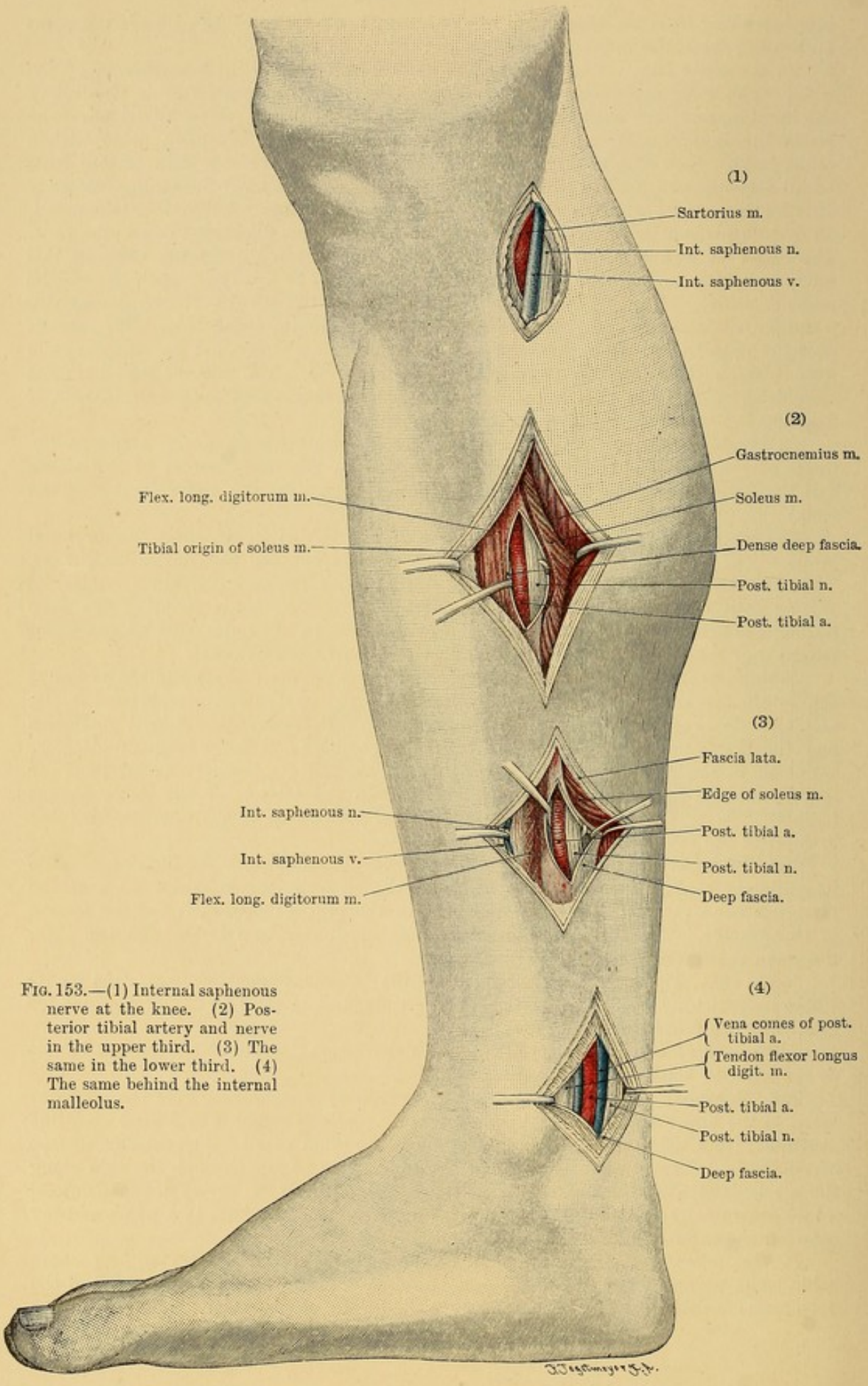


FIG. 153.—(1) Internal saphenous nerve at the knee. (2) Posterior tibial artery and nerve in the upper third. (3) The same in the lower third. (4) The same behind the internal malleolus.

the fibula and from the glistening tendinous fascia covering the flexor longus hallucis, which lies upon the posterior surface of the bone. After dividing this fascia, we continue deeply the dissection between it and the flexor longus hallucis, until the oblique inner border of the latter is reached, above which the artery will be found previous to its entering the substance of the muscle. The posterior tibial nerve lies still deeper—that is to say, internal to the artery.

In the lower half. Incision again at the posterior surface of the fibula. After division of the fascia the thick outer border of the soleus is exposed and drawn inwards, exposing beneath it the fibres of the flexor longus hallucis, covered by a tendinous-looking fascia. On separating the flexor longus hallucis from the posterior surface of the fibula, we find the artery at the outer border of the tibialis posticus muscle which lies upon the interosseous membrane.

259. Cutaneous Branch of the External Popliteal Nerve. This nerve arises from the external popliteal in common with the communicans fibularis. The latter descends upon the posterior surface of the limb to unite with the communicans tibialis in the lower half of the leg to form the external saphenous nerve; the former pierces the fascia at the outer aspect of the upper third of the leg and supplies the skin upon its outer surface. (In sciatica the pain is often particularly severe along the area of distribution of these branches.) The branch of the external popliteal from which these two cutaneous nerves spring is exposed by the same incision as that for the external popliteal nerve itself, namely, along the edge of the biceps tendon behind the external condyle of the femur.

The External Saphenous Nerve (Fig. 151) is exposed by making an incision midway between the external malleolus and the tendo Achillis, the nerve lying either upon or under the fascia. In front of it is the external saphenous vein.

260. Communicans Tibialis Nerve (Fig. 152). This nerve has already been exposed in ligaturing the popliteal and the upper part of the posterior tibial arteries. It accompanies the external saphenous vein, descends vertically upon the fascia along the middle of the upper two-thirds of the calf, and unites with the communicans fibularis to form the external saphenous nerve.

261. The Posterior Tibial Nerve (Fig. 153) accompanies the posterior tibial artery, which it crosses from within outwards at its upper part.

Foot

Plantar Vessels and Nerves. The deeper structures which lie along the middle of the sole of the foot are covered by the flexor brevis digitorum, so that to expose them we pass in (analogous to the palm of the hand) at one or other side of this muscle, between it and the two lateral masses of muscles, the superficial ones being the abductors of the great and little toes.

262. Plantar Arteries at their Origin from the Posterior Tibial (Fig. 154). 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.

263. Internal Plantar Artery and Nerve (Fig. 155). Incision 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 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.

264. The Internal Plantar Nerve lies beside the corresponding artery, which

is much smaller. Both structures are covered by a thick layer of fat, and beneath them (deeper) is the tendon of the flexor longus hallucis.

265. External Plantar Artery (Fig. 155). 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.

266. The External Plantar Nerve (Fig. 155) lies beside the corresponding artery, the former being relatively much smaller than the latter.

267. The Plantar Arch at the first Interosseous Space (Fig. 155). An incision is made backwards in the hollow outside the ball of the great toe, in the direction of

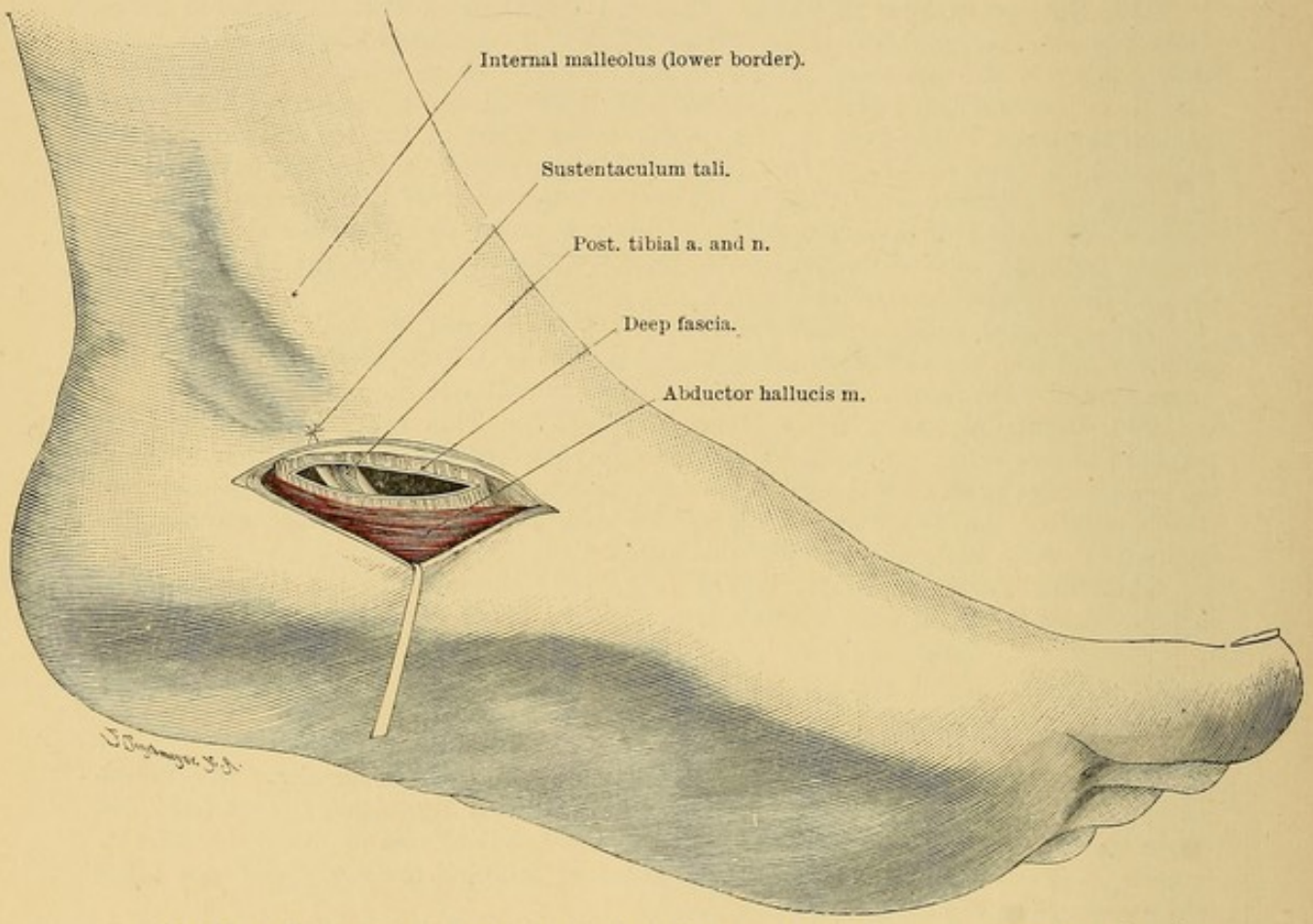


FIG. 154.—Plantar arteries at their origin from the posterior tibial artery. Posteriorly, the posterior tibial nerve.

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, 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 pro-

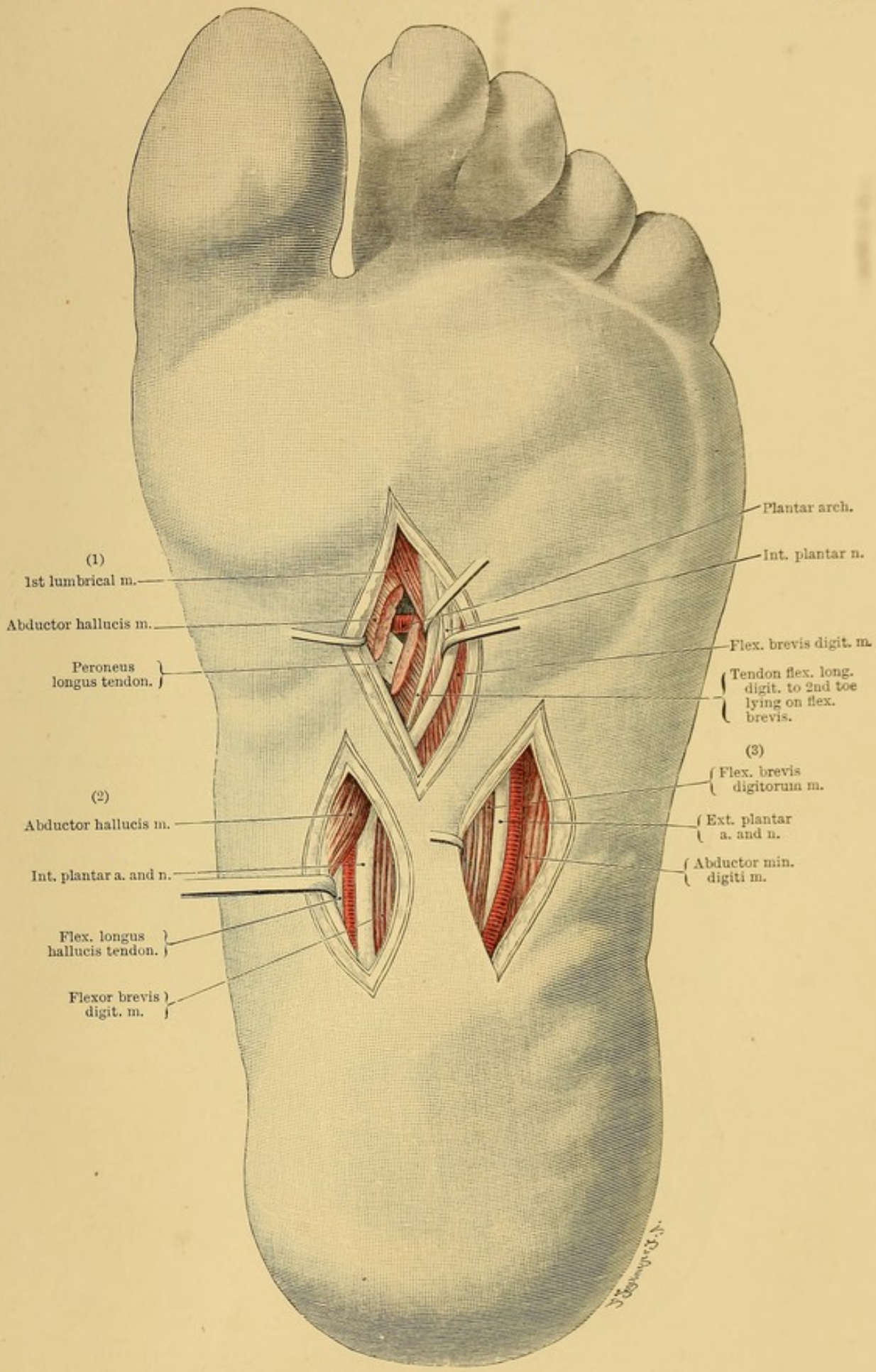


FIG. 155.—(1) Plantar arch. (2 and 3) Internal and external plantar artery and nerve.

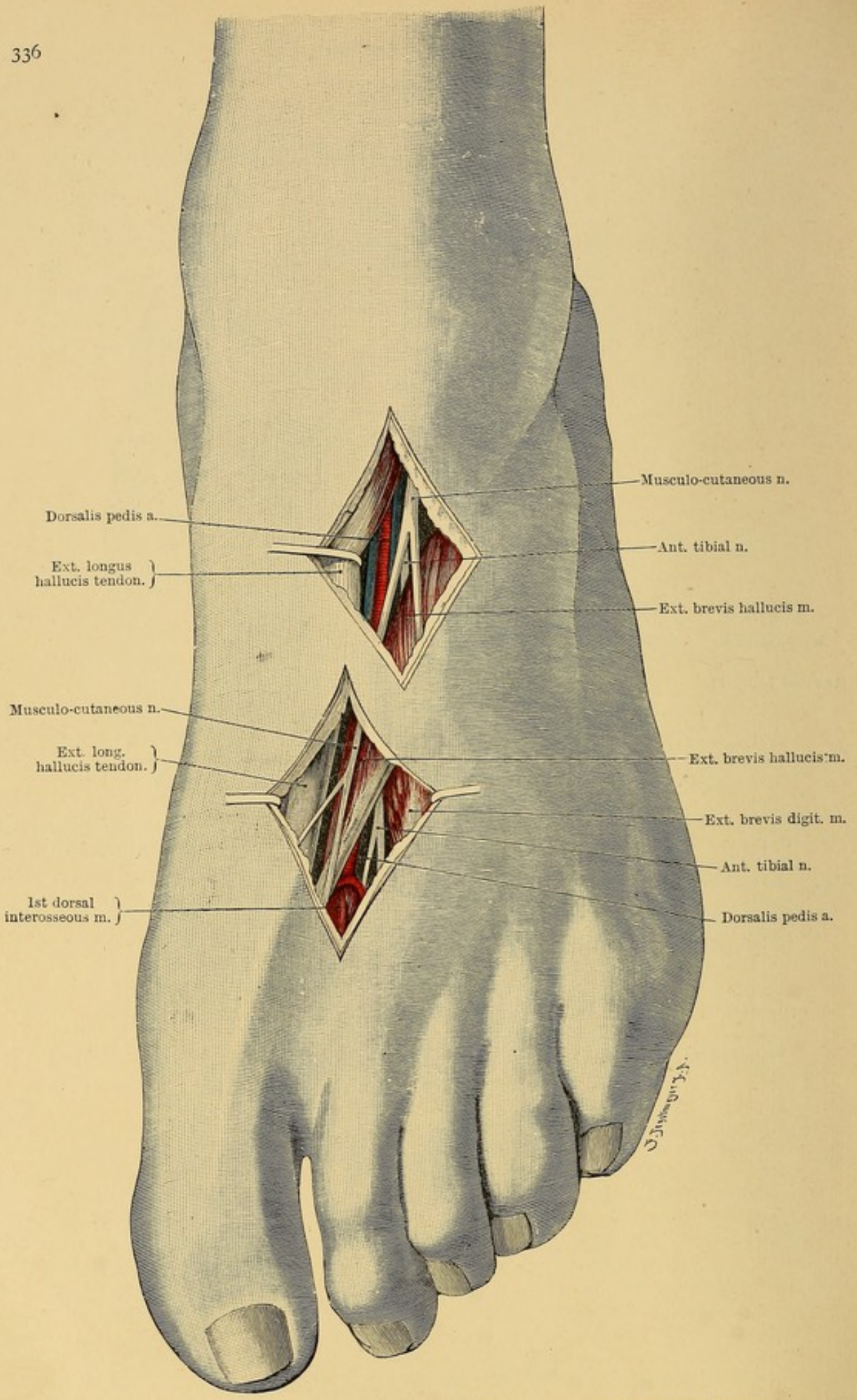


FIG. 156.—Dorsalis pedis artery, with anterior tibial and musculo-cutaneous nerves.

jecting border of the first metatarsal bone, to the base of which is inserted the tendon of the peroneus longus muscle.

268. Dorsalis Pedis Artery (Fig. 156). 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. Incision along the line already mentioned. The inner branch of the musculo-cutaneous nerve which lies upon the fascia is drawn outwards. Under the fascia lies 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.

SECTION IV

EXCISIONS AND RESECTIONS

T. GENERAL CONSIDERATIONS

If, instead of simply making an incised wound, it is our intention to remove a healthy or diseased portion of the body from its connections with the surrounding tissues, the term *excision* is used, an expression which it would be better to employ instead of the customary term *resection* when speaking of the bones and joints. Here again the main point is to make the first incision in such a way that the part to be removed is freely exposed with the least possible amount of injury. In the case of the joints, therefore, the first question to be considered is: What is the best incision for opening the joint?

The incision into the joint (arthrotomy) is the basis of every resection. Whether it be made large or small—that is, whether the usual incision is employed in its full length or not—depends upon the indications for operating. Whether after performing arthrotomy one is to proceed to arthrectomy, to partial or complete excision of the joint-capsule, synovial membrane, articular extremities, interarticular cartilage, and ligaments, will depend upon the conditions found when the joint is opened.

As regards technique, excisions are among the simplest of operations. When once the affected part is exposed, the next step is to free it from its surroundings as cleanly as possible, by separating the adjacent soft parts with sharp or blunt instruments close to the affected osseous structures. The more completely the bone is laid bare and freed from soft parts, the more orthodox is the resection. This simple rule is often broken by beginners.

To Langenbeck belongs the credit of having called attention to a very important point in excising joints, viz. that the incision through the soft parts should be as simple as possible, and that in cleaning the bones they should be retained 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, with removal of nothing but the diseased soft parts and bone, should replace the stereotyped excisions formerly the rule. Kappeler has applied the term "Atypical" to such resections, but the name conveys too much the impression that there is some irregularity in the methods of performing them. Hence we think it should be given up. 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 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 attachments 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 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. 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 subperiosteo-subcapsular method; and it may also be pointed out that union occurs more rapidly, so that less pain is caused by the early attempts at movement; for, 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 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), special care being taken not merely to place it in the intervals between the muscles, ligaments, and tendons, but to carry it down to the bone in such a way that the smallest vessels and nerves can be avoided, and also to place it in the frontier line 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 with the articular extremities, should this be deemed necessary in order to obtain a better functional result. If attention be paid to these points, with strict aseptic precautions, arthrotomy can be undertaken with benefit in the early and mild stages of joint disease. Whatever statistics are 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. How often do we believe that we have completely removed a circumscribed caseous focus from the patella, humerus, etc., through a small incision, until the onset of a diffuse tuberculous arthritis shows us how much better it would have been to have thoroughly opened the joint at first. When we consider the distressing and tedious course that follows non-operative treatment in the various forms 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 one keeps too much to the older methods of excision. The incisions we suggest here are not intended merely for resections, but equally also for simply opening into a joint (arthrotomy), for excision of the joint-capsule, or even of the articular cartilage (arthrectomy).

The method employed to expose a joint should in no way bind the surgeon as to what he is to do next. The incision should be equally suited for cases where, after opening 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 "hook incision," which will be described under the individual operations.

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.

In performing arthrectomy the incision is only carried down to the diseased and thickened synovial membrane (generally tubercular), and the fibrous capsule is stripped off it, so that the synovial membrane can be removed in one mass (like a tumour) after detaching the visceral layer from the bone. In arthrectomy, where the bone is excised, the method is similar.

In resection of the bones alone the incision goes 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.

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. This is an important point, and one which surgeons often lose sight of while operating. 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 done? 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.

The performance of excisions and amputations, as well as of conservative operations on the extremities, has been very much simplified by Esmarch's method of preventing hæmorrhage. This useful and simple procedure consists in applying a rubber tube round the limb above the site of operation. Before putting it on, however, the limb should be held vertically for some time (Bruns has shown that in this way a limb is rendered practically as bloodless as by the application of an elastic bandage), then a gauze bandage is wound loosely round the limb, preferably round the upper third of the upper arm and the lower third of the thigh, as in these situations there is less thickness of muscle, and no nerves are exposed to direct pressure. A strong indiarubber tube of the best quality is wound round the limb over the bandage, and fastened by a simple loop without making a knot, so that it can be quickly loosened at any moment: it should not be drawn too tightly, as there is a risk of causing paralysis of the musculo-spiral nerve in the case of the arm, of the posterior tibial in the case of the leg.

As regards after treatment, in contradistinction to simple arthrotomies, it is obvious that in excisions the limb should be at once immobilised in a plaster bandage, so that the new articular ends may be kept firmly in contact in good position. Where there is any difficulty in maintaining them in position, it may be necessary to pass a silver wire through the ends in such a way as to retain them in the desired position without ultimately preventing the proper movement. Arbuthnot Lane has made use of this plan with very good results in old-standing affections of the hip-joint. Healing occurs rapidly, and if the wound remains aseptic the patient may begin passive movements in fourteen days in the case of the upper extremity, while in the case of the lower extremity he may be allowed to go about with the limb in plaster.

The sooner movement is begun the better will be the result, even if it be only very slight movement inside a well-padded plaster case. To obtain early restoration of function it is essential to get rid of the sensitiveness of the sawed ends of the bone as soon as possible. Where ankylosis is aimed at, as in the knee, firm fixation is the best means of attaining this object, and the patient can quite well have the leg put in plaster a fortnight after the operation. To obtain firm union the bones must fit accurately together, and the apposing surfaces should be as broad as possible: with this object the bones at the knee are sawn in a curved direction (or in an angular fashion, according to Tavel), which prevents any slipping; or they can be wired or nailed together, but these precautions are only of value when the bones are not softened.

To obtain, rapidly, comparative insensitiveness in the ends of the bones in cases in which a movable joint is aimed at, 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: 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 do, however much he may desire to. It is essential, too, that the movements of the muscles should be begun early, if the function of the joint is to be restored quickly. 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.

In tubercular conditions, after arthrectomies and excisions, the entire surface of the wound should be rubbed with iodoform powder, and if cavities exist they should be stuffed with iodoform gauze, or drained with glass tubes inserted through special openings.

U. LOWER EXTREMITY

269. Excision of the Phalanges and Metatarsal Bones (Fig. 157). From the rules given for making incisions in the fingers and toes, it is evident that only lateral incisions placed somewhat towards the dorsum are permissible, in order to avoid the nerves and tendons. In the case of the phalanges and their joints, the operation does less injury and the cicatricial contraction is less marked if two small lateral incisions are made. For the metatarsal bones it is sufficient to make a dorsal incision along the extensor tendons parallel to the branches of the musculo-cutaneous nerve. In order to obtain sufficient access the incision must extend over the adjacent joints. The head of the bone should always be exposed first, because its ligamentous connections are easier to separate than those at the base.

270. Excision of the Tarso-Metatarsus and Anterior Tarsus (Fig. 158). This is a very important operation in infective diseases (especially tubercle) 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. 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.

The excision is performed by means of two dorso-lateral incisions. 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 aspect 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 abcesses and advanced disease in the soft parts exist on the dorsum of the foot, it is better 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

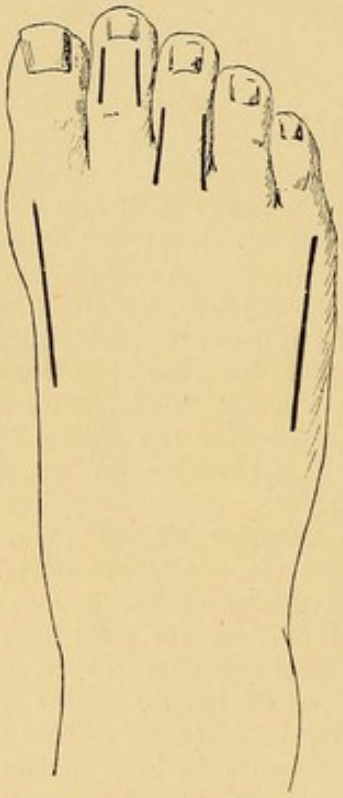


FIG. 157.—Excision of the phalanges. Resection of the 1st and 5th metatarsal bones.

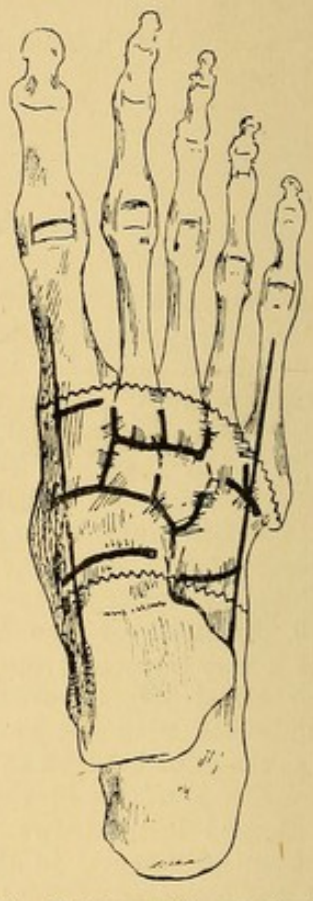


FIG. 158.—Excision of the anterior tarsus (usual arrangement of the synovial cavities).

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. In the last case on which we operated by means of a dorsal flap an extremely useful and movable foot was obtained.

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 must be taken not to injure the plantar arch and the external plantar nerve.

The shortened foot is extremely useful both for support and movement.

271. Excision of the Mid-Tarsus (Figs. 159, 160, 161). 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, and passes obliquely downwards and backwards towards the outer border of the heel. 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 dividing 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 slitting up their sheaths the tendons are drawn aside with blunt hooks. The capsule is divided over the head of the astragalus, and the joint opened.

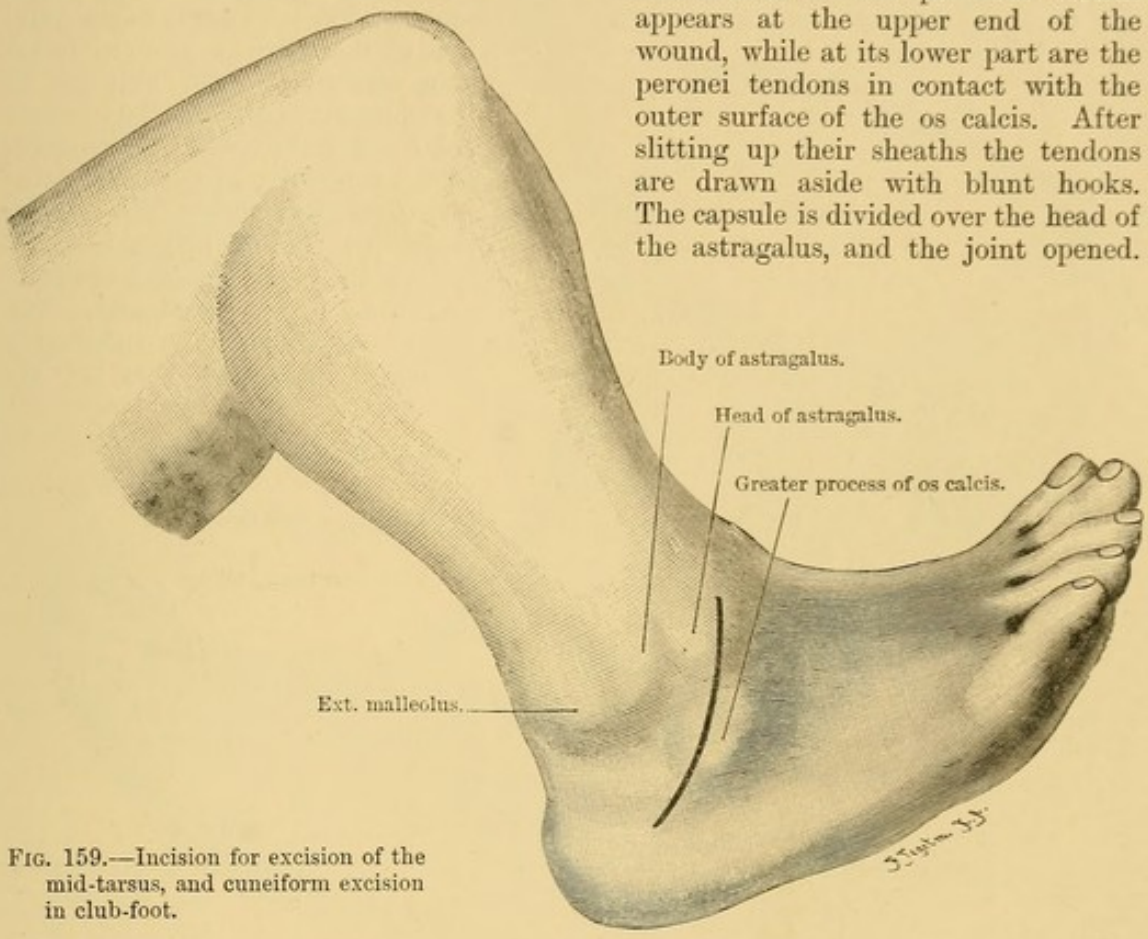


FIG. 159.—Incision for excision of the mid-tarsus, and cuneiform excision in club-foot.

The attachment of the capsule is then separated from the neck of the astragalus as far as the groove on its under surface. After exposing and drawing downwards the upper border of the extensor brevis digitorum the calcaneo-cuboid joint is opened. 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 no cavity remains, 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 make sure of a good result it is generally necessary to divide the tendo Achillis.

The important points to be attended to in order to obtain a good result are,

to ensure 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.

272. Excision of the Astragalus (Fig. 162). 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 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

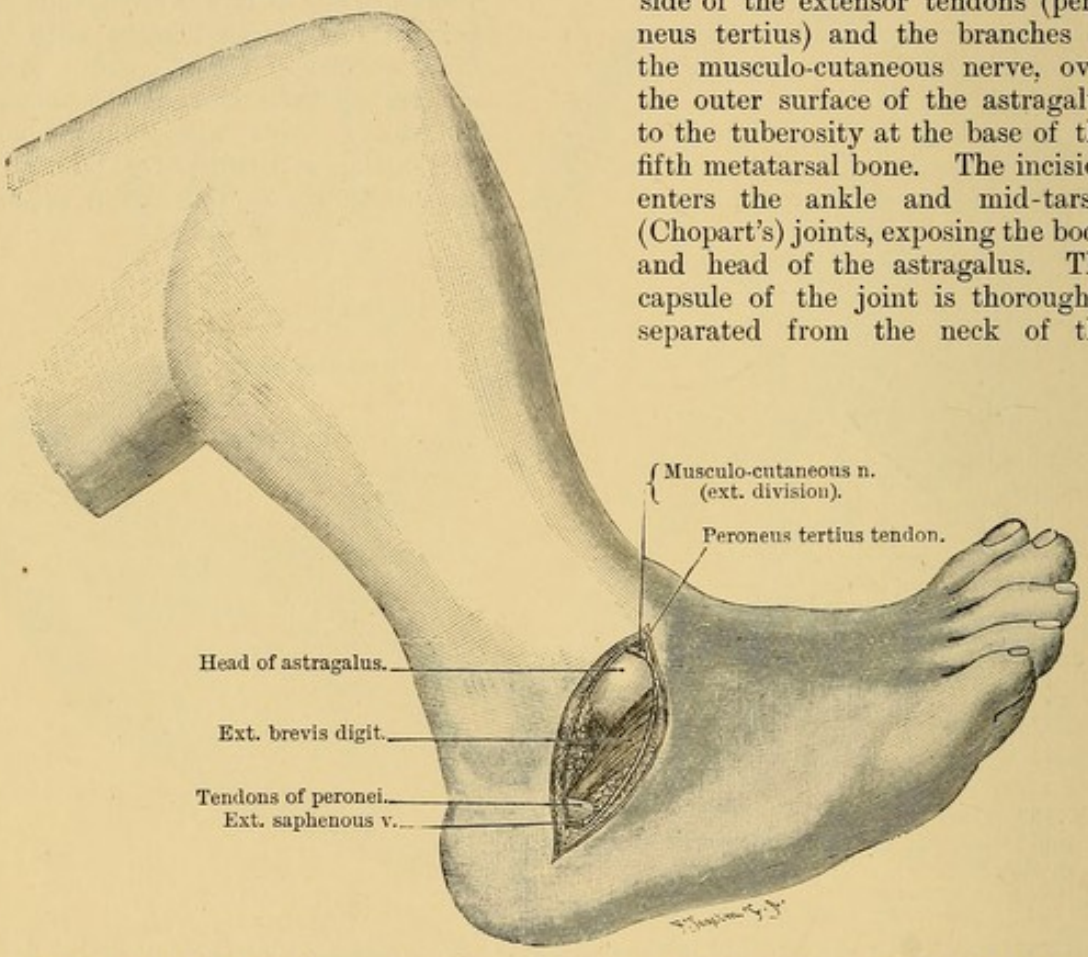


FIG. 160.—Excision of an osseous wedge in club-foot. First stage: exposure of the head of the astragalus by dividing the capsule, the tendons and muscles being avoided.

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 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 forcibly inverting 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.

273. Excision of the Os Calcis (Figs. 163 and 164). 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.

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 drawing upwards the peroneal tendons, the interosseous calcaneo-astragaloid ligament is cut across, and the dorsal and plantar calcaneo-cuboid ligaments are detached from the ex-

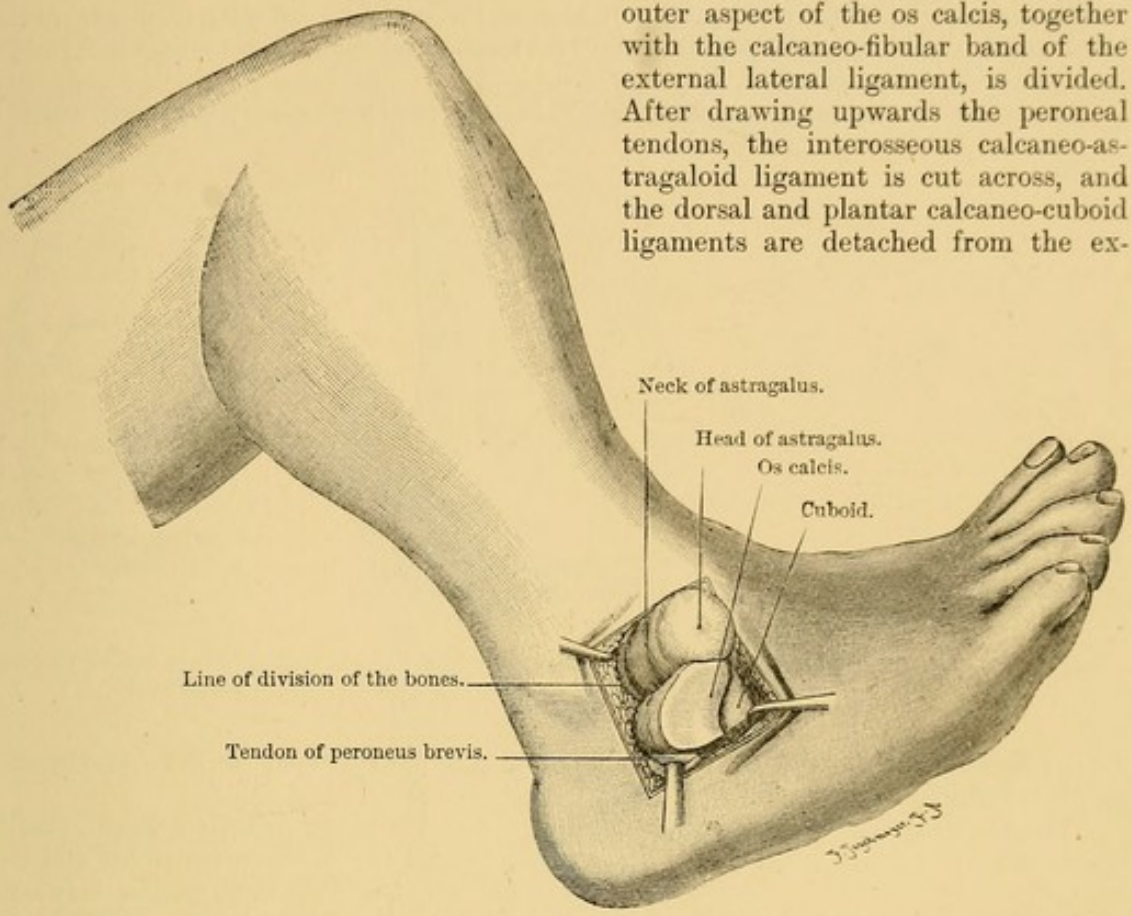


FIG. 161.—Excision of an osseous wedge in club-foot. Second stage: joint surfaces of head of astragalus and greater process of os calcis exposed. The place at which the bones are divided is indicated by a serrated line.

ternal 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, also all the other bones of the tarsus. He asserts that the scar does not in any way interfere with walking.

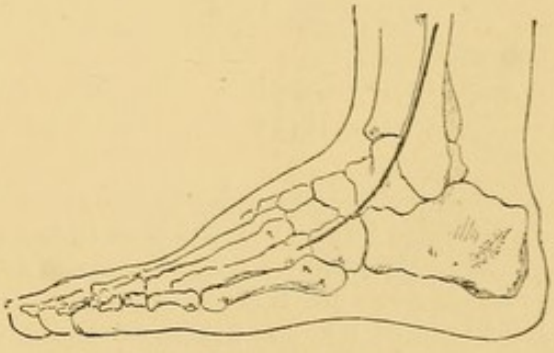


FIG. 162.—Excision of the astragalus (external incision).

274. Excision of the Calcaneo-Astragaloid Joint, and Excision of the Posterior Tarsus (Fig. 165). Excision of the joint between the astragalus and os

calcis is performed by Annandale by two lateral curved incisions. It can also be done by the method above described for excising the os calcis, or by a modification of the method for excision of the posterior tarsus now about to be described.

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 about to be described, it is a necessary condition that there should

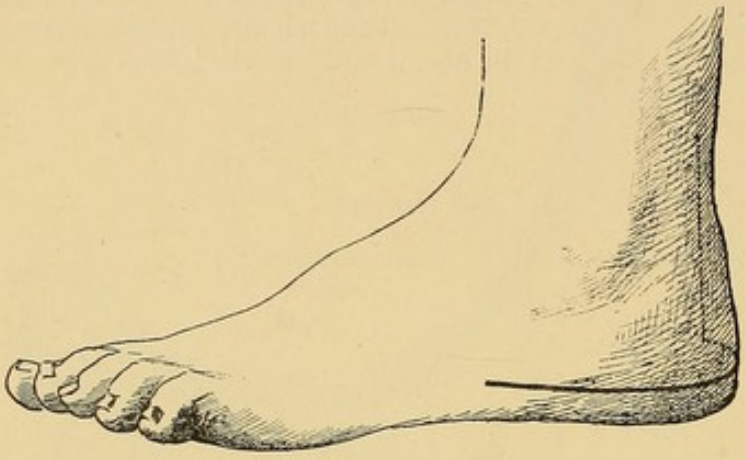


Fig. 163.—Excision of os calcis.

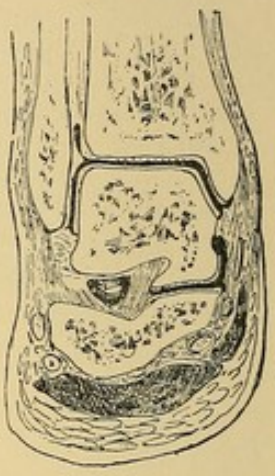


Fig. 164.—Coronal section through the ankle-joint (Henle).

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 opening the sheaths of the peronei tendons and displacing the latter forwards, as has been described in excising 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.

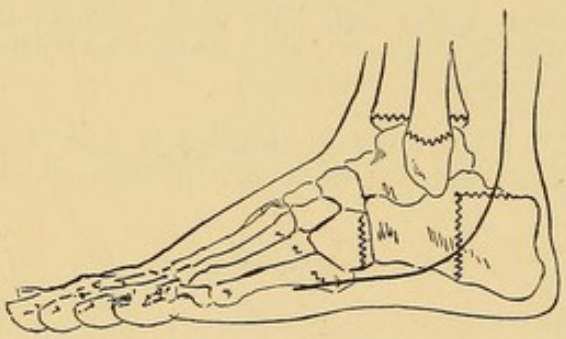


Fig. 165.—Resection of the posterior tarsus.

275. Excision of the Ankle-Joint (Figs. 166, 167, 168). 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 be a good one, must give free access to the ankle-joint and to the astragalo-calcanean articulation. It is still better if it gives an opportunity of examining the tendon sheaths, especially of the peronei.

Vogt makes an antero-lateral longitudinal incision; König and Riedel, bilateral incisions with chiselling off of the malleoli; Meinhardt Schmidt, the same together with a posterior incision; Hüter, an anterior transverse incision, which had been previously employed by Sabatier, Heyfelder, and Hancock; Liebrecht, a posterior transverse incision; Wackley and Textor, 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.

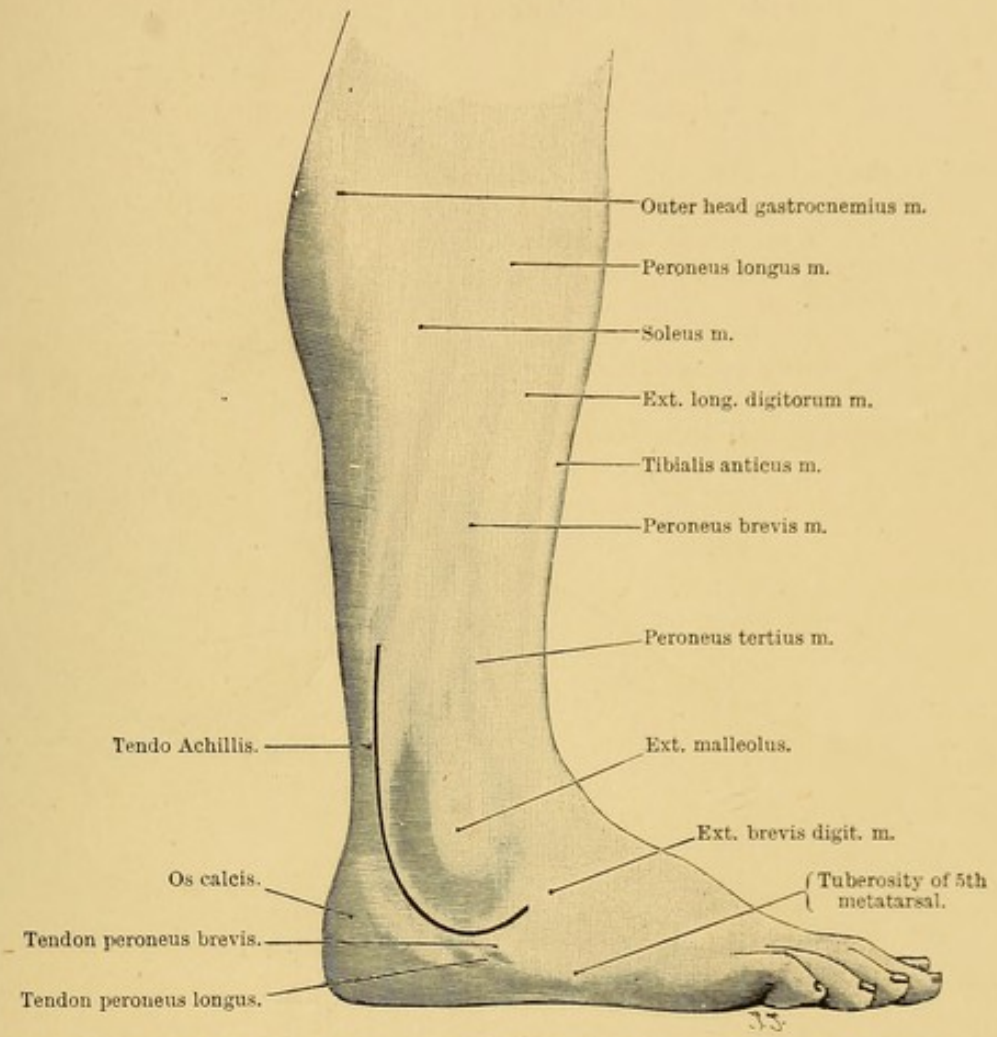


FIG. 166.—Incision for arthrotomy of ankle on right side.

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 that one first recommended by Albanese on Catterina's initiative, and later by Donenstein (Figs. 166, 167).

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 give more room, but each is

secured with silk in order to be sutured later. 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, the same being done at the posterior surface of the tibia 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 head of the astragalus looks downwards and the sole of the foot upwards, as shown in Fig. 168. If the bone is softened the internal malleolus is not infrequently broken in doing this, but it is just in such cases that this accident does no harm.

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-

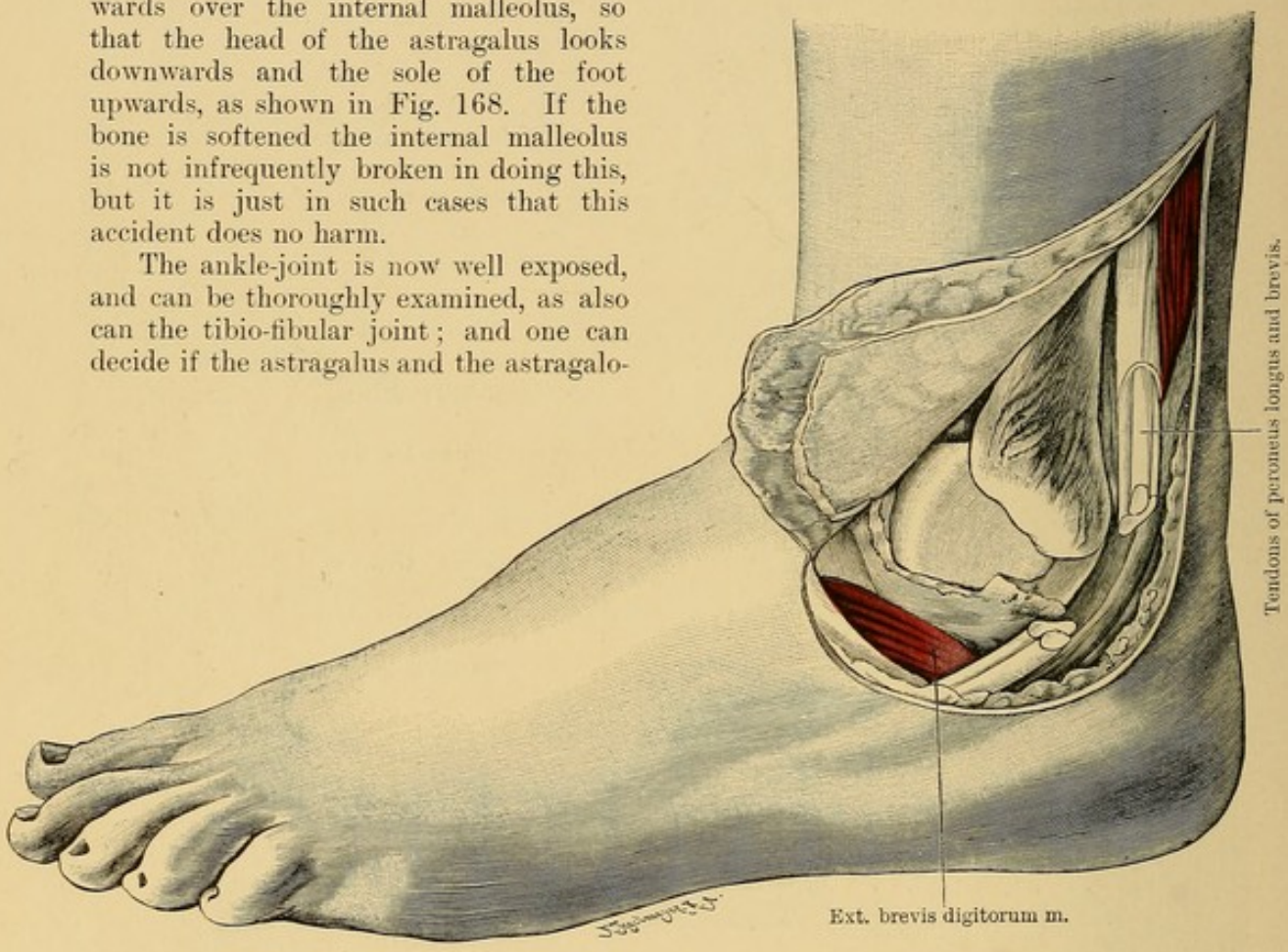


FIG. 167.—Excision of ankle by curved incision. The skin and fascia are retracted, the external malleolus exposed subperiosteally: the capsule is detached from the astragalus (the outer aspect of which is exposed), and the peronei tendons are divided.

calcanean joint are so involved that removal of the whole astragalus is necessary. In tubercular affections it is often desirable to do this to be sure of getting rid of all the disease, and there are no special difficulties in connection with it.

If the astragalus need not be excised, 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.

The method above described preserves 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 kept on until the wound is thoroughly healed. If the wound heals by first intention the patient can begin to get about in two or three weeks. Later on it is advisable to maintain the good position of the foot by wearing a Scarpa's shoe.

276. Total Excision of the Tarsus (Figs. 169 and 170). Wladimiroff and

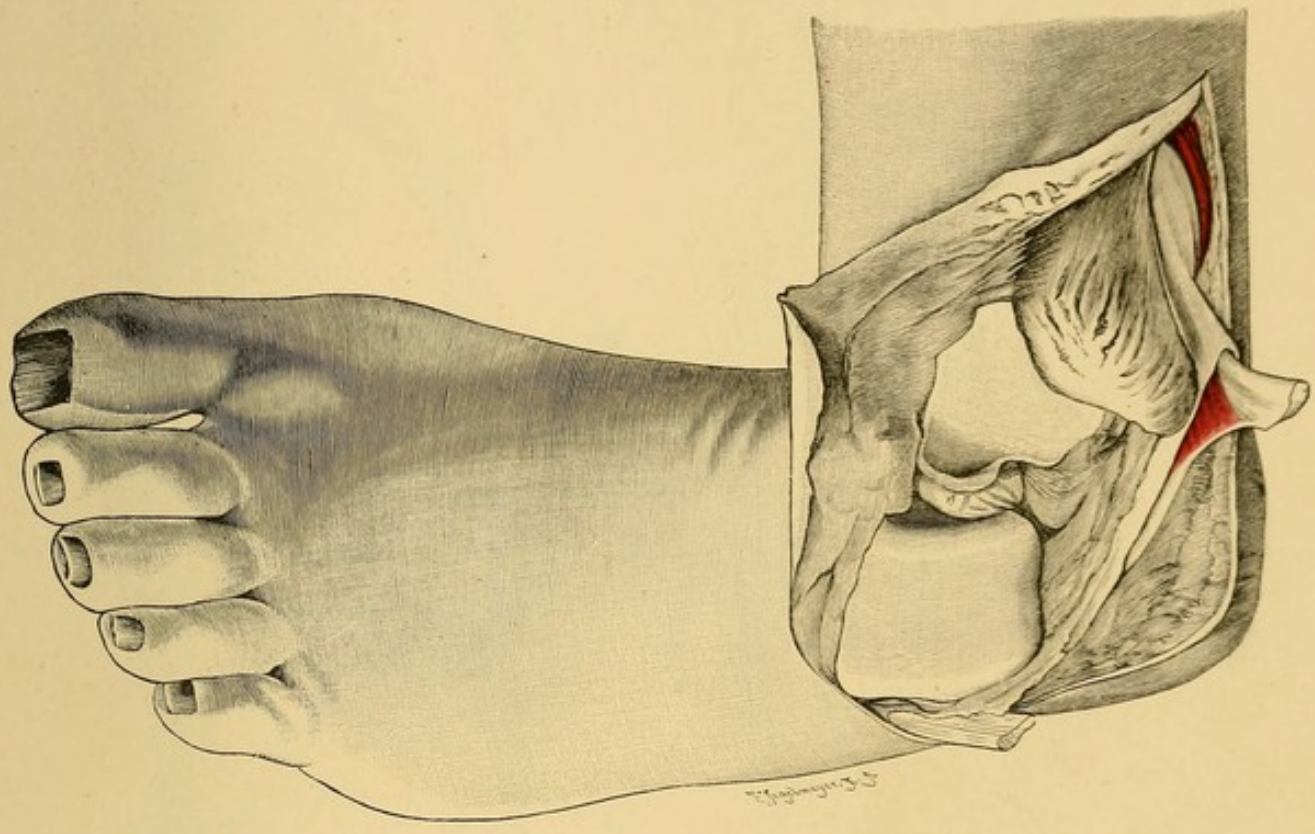


FIG. 168.—Excision of the ankle. The capsule is detached from the tibia and fibula and from the astragalus, and the foot dislocated inwards. The head of the astragalus and the articular surface of the tibia are well exposed.

Mikulicz have added to our means of preserving the foot by a method of operation which they have employed for disease of the posterior tarsus. We regard their method as superfluous for disease of the posterior tarsus when the soft parts of the sole and heel can be retained. The method, however, is especially valuable in disease affecting all the bones and joints of the tarsus. 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,

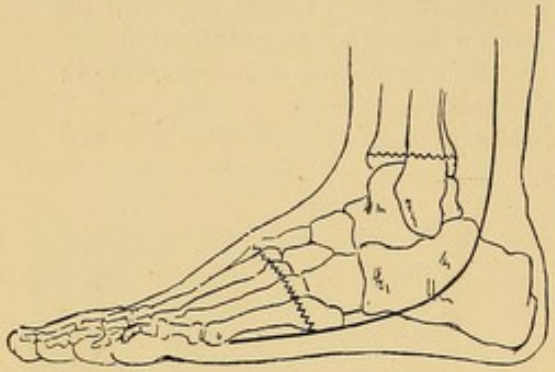


FIG. 169.—Resection of the entire tarsus (Wladimiroff, Mikulicz).

FIG. 171.—Resection of the lower third of the leg.

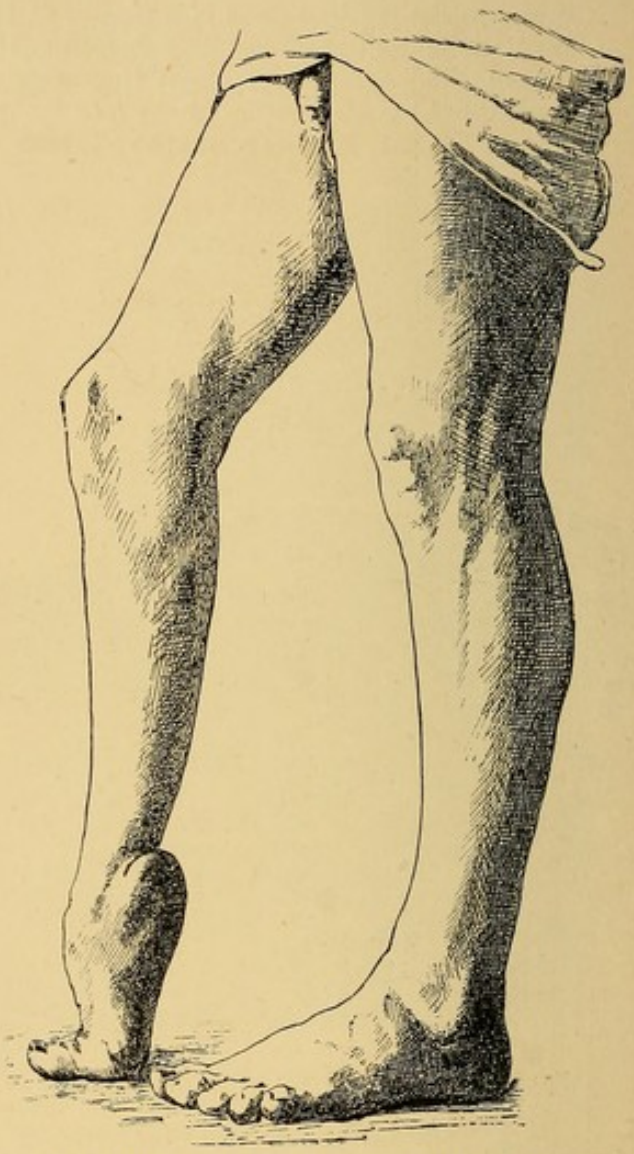


FIG. 170 shows the result after complete resection of the tarsus (from a photograph of a case operated on by the author).

a postero-lateral curved incision (Fig. 169), beginning a hand-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.

277. Resection of the Lower Third of the Leg (Fig. 171). 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.

278. Excision of the Tibia. In a case in which the middle third of the diaphysis of the tibia had to be resected on account of necrosis, we removed the diaphysis of the fibula from the other leg and inserted it into the hollowed-out remains of the tibia.

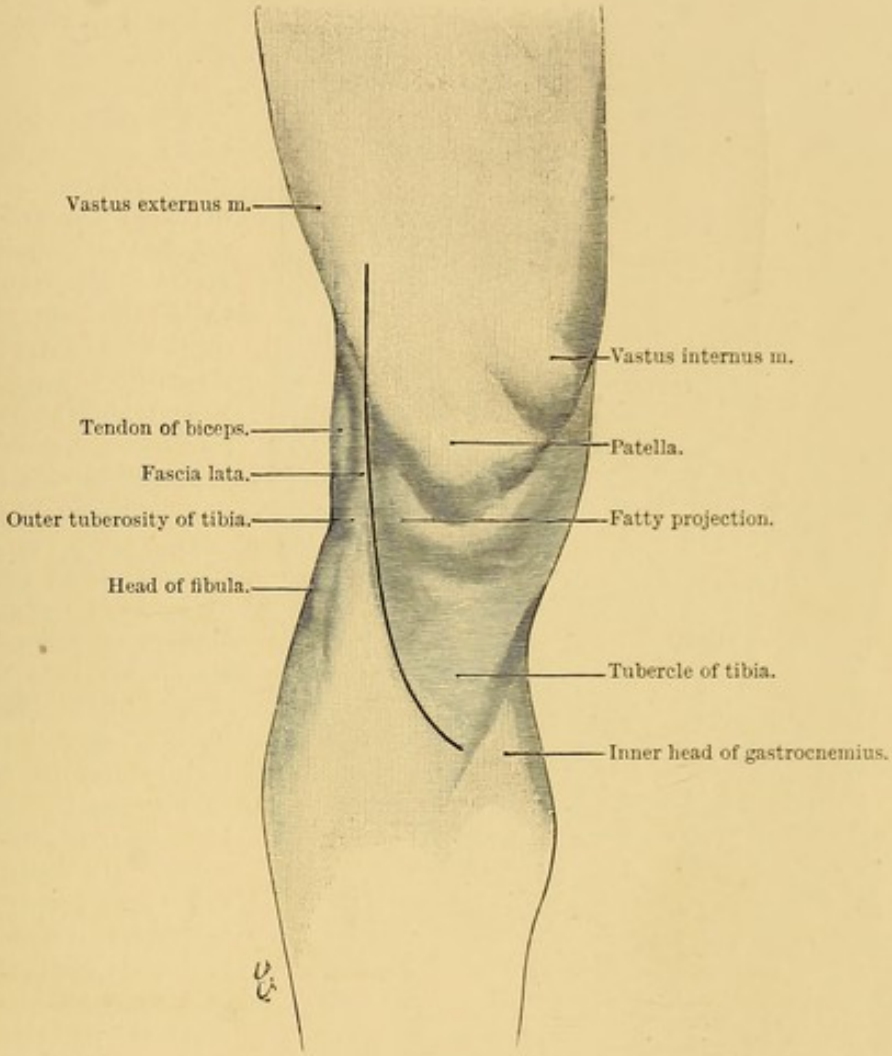
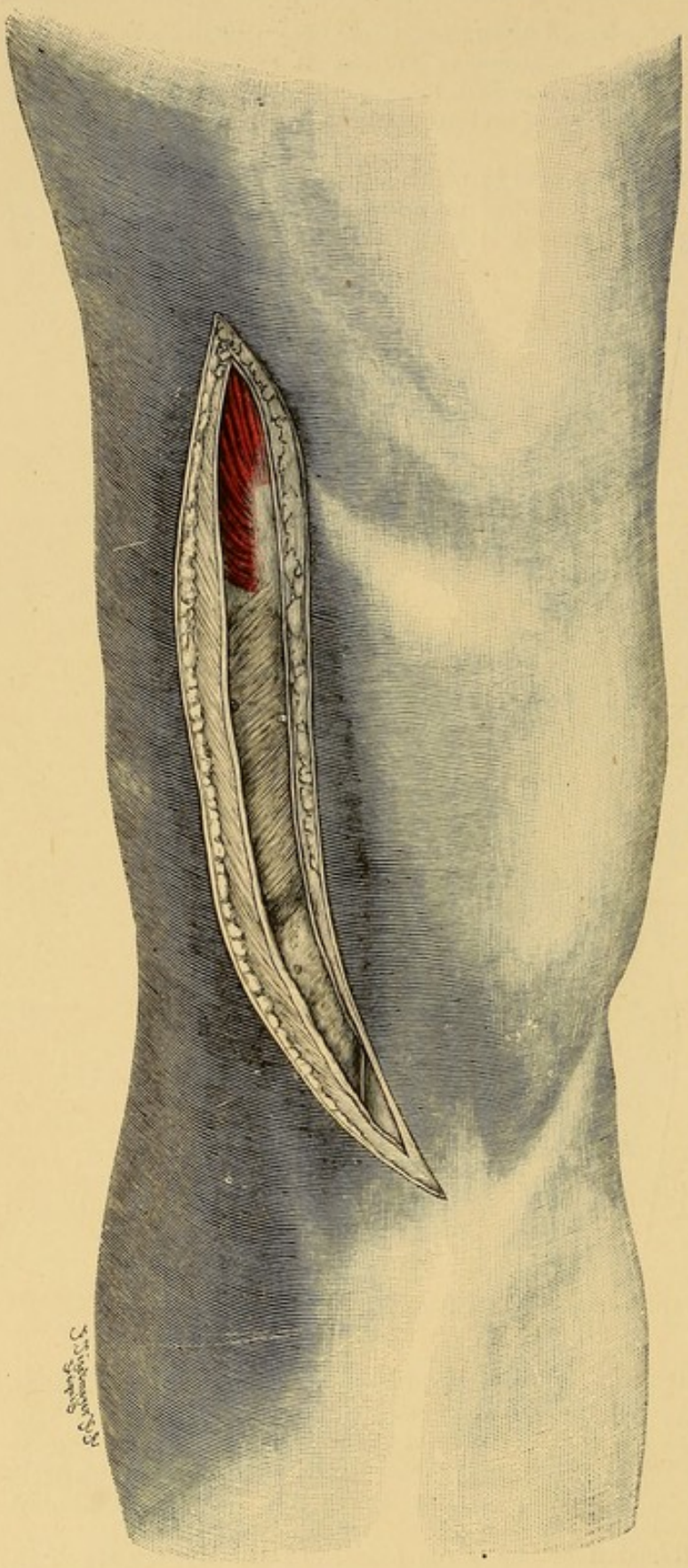


FIG. 172.—Incision for arthrotomy of knee.

279. Excision of the Fibula. The diaphysis, and indeed the entire fibula, may be removed by an incision behind the whole length of the peronei muscles, 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.

280. Arthrotomy and Excision of the Knee (Figs. 172 and 173). 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 method.

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 of Ollier in always aiming at entire removal of the diseased tissue.

But we always endeavour to keep the quadriceps extensor apparatus intact, so that we may be free to continue the operation in whatever direction seems necessary, and our method of excision falls into line with the methods of arthro-

FIG. 173.—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.

tomy. We need only lay special stress on the way in which the bones are to be sawn through.

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. 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 is required is to introduce a suture which penetrates deeply through the skin and fascia, drainage tubes being introduced 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 a permanent water-glass bandage is applied, as if it were a subcutaneous fracture. 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.

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. 172, 173), which begins over the vastus externus, a handbreadth 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.

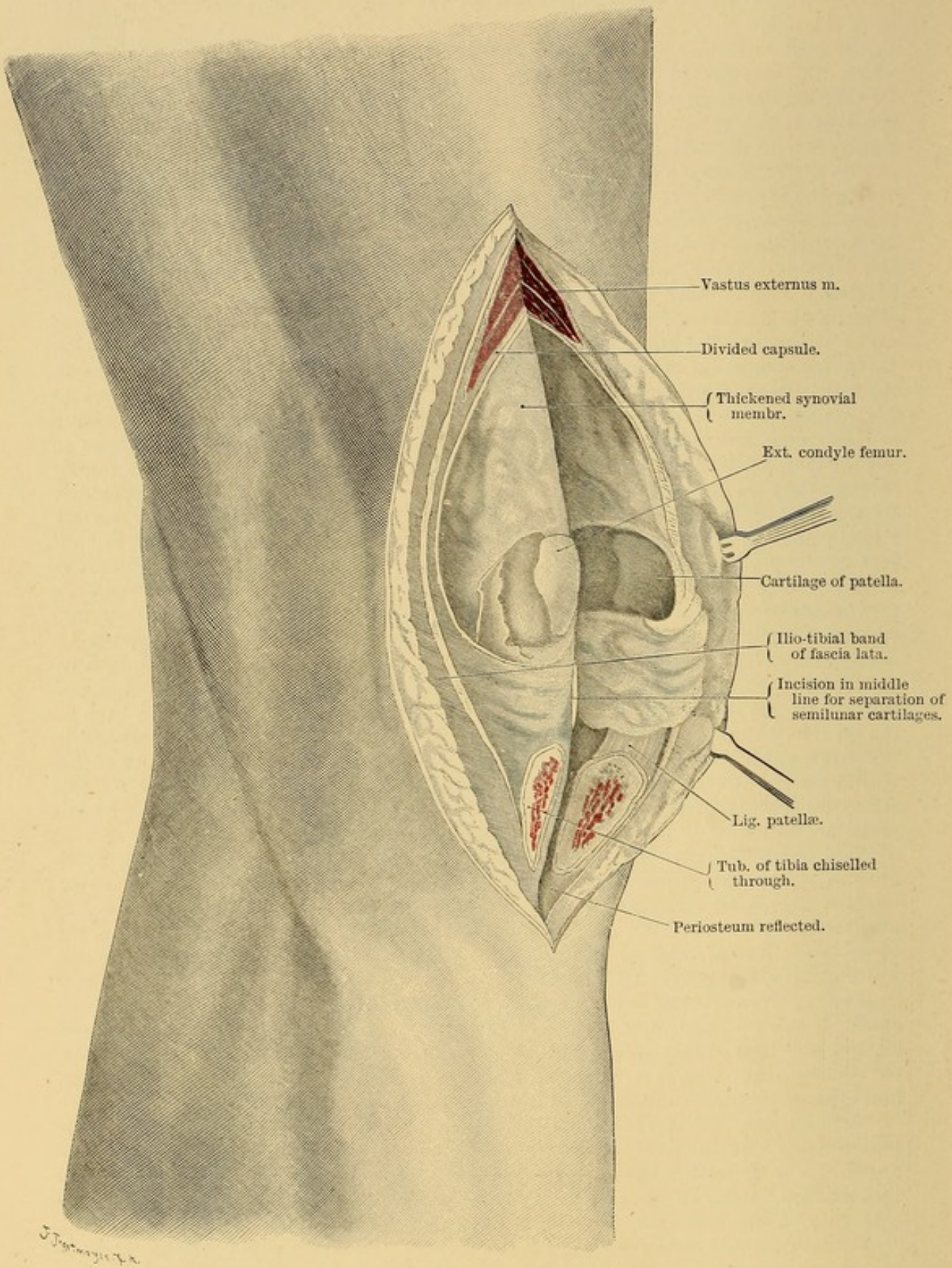


FIG. 174.—Arthrotomy of knee. The joint has been opened and the patella, with the quadriceps tendon and ligamentum patellæ pulled inwards; also the tuberosity of the tibia, which has been chiselled through, and is seen retaining its normal connection with the patellar ligament above and the periosteum below.

The patella should now be dislocated over to the inner side (Fig. 174), 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. 175).

If it be necessary to remove the ends of the bones, the upper attachments of the crucial ligaments are separated from the intracondyloid 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

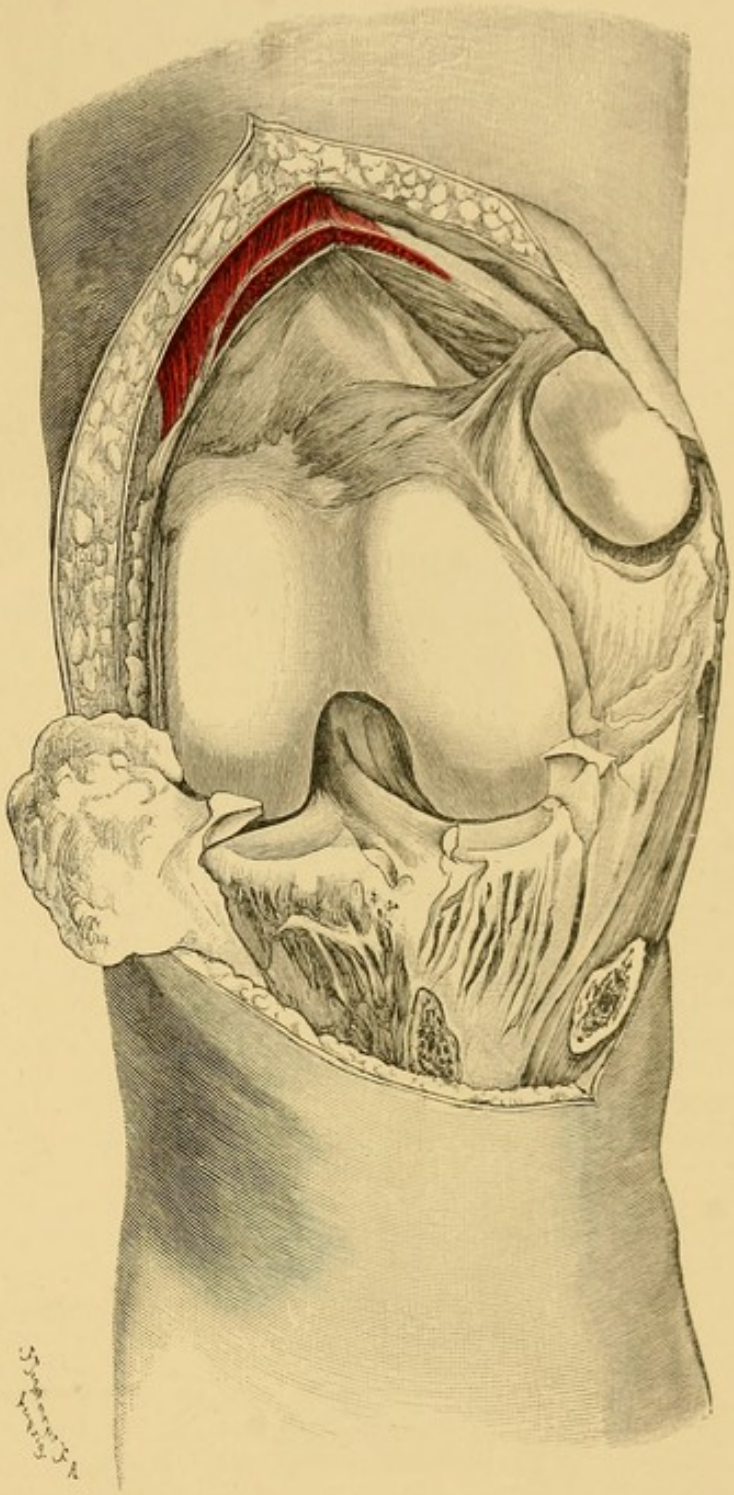


FIG. 175.—Arthrotomy of the knee by an external curved incision, giving a complete exposure of the joint. The capsule has been split upwards into the lower muscular fibres of the vastus externus, and downwards as far as the tubercle of the tibia, which has been chiselled off, still retaining its connection 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.

epicondyles, are more extensively separated from the bones. In the case of the

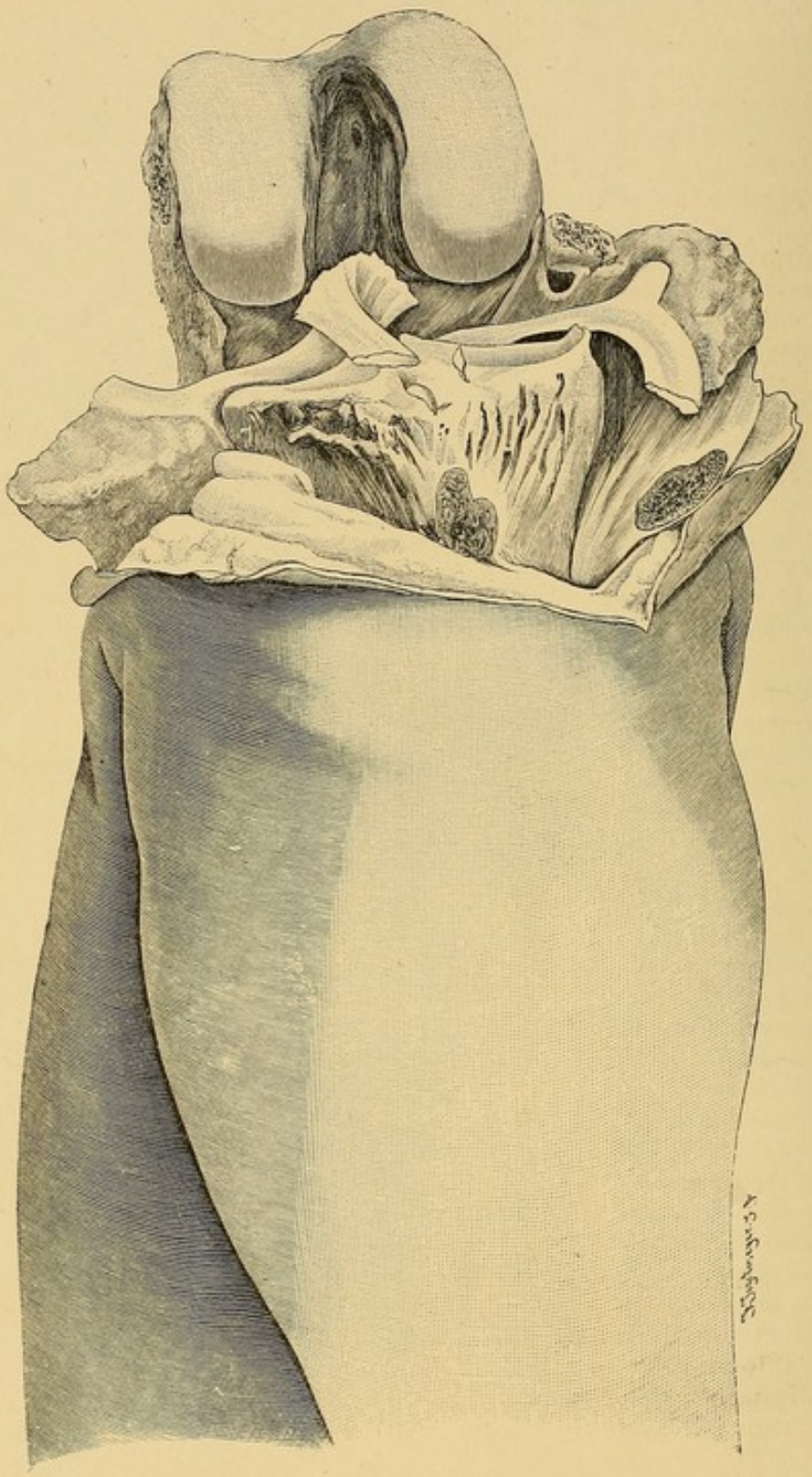


FIG. 176.—Excision of knee. Tubercle of tibia and semilunar cartilages detached as in Fig. 175 ; the attachments of the lateral ligaments are chiselled off through the epicondyles of the femur, and the crucial ligaments are separated from the intercondyloid notch of the femur and the upper surface of the tibia in continuity with the capsule.

femur it is especially important, after separation of the periosteum and capsule as far

as the epicondyles, to detach these bony processes, together with the lateral 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. 176).

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.

If the capsule is so diseased throughout that one is certain beforehand (*e.g.* in fungating 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, 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.

The entire capsule is then divided along the edges of the articular cartilage of the femur, tibia, and patella. If the tibia be diseased, it is separated subperiosteally from the fascia covering it. 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.

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; or the iodoform tampons are introduced and the wound is sutured, openings being left through which they can be removed after eight to ten days.

By thoroughly destroying the granulations, scraping out the sinuses, and rubbing in iodoform a primary suture may, as a rule, be employed. In all cases it is absolutely necessary at first to place the limb in the extended position by means of a plaster of Paris bandage, which should extend from the ischial tuberosity to the malleoli.

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.

281. Excision of the Patella. This is an important operation for primary disease of the patella 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).

282. Osteotomy and Cuneiform Resection of the Tibia (Fig. 177). 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 of the tibia to the edge of the calf muscles. After separating 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.

283. Supra-Condyloid Osteotomy of the Femur (Fig. 177). 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.

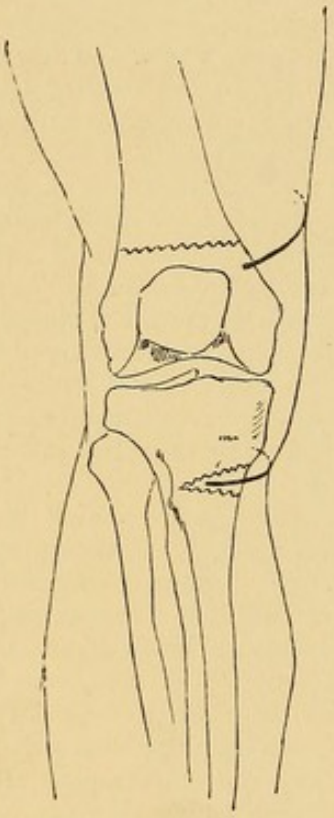


FIG. 177.—Osteotomy of the femur. Cuneiform osteotomy of the tibia.

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 developing 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 internal superior 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.

284. Osteotomy and Subtrochanteric Cuneiform Resection of the Femur (Figs. 178 and 179). 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

FIG. 178.—Subtrochanteric osteotomy.

FIG. 179.

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.

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.

285. Excision of the Diaphysis of the Femur. The outer side of the shaft of the femur may be cut down upon in its entire length, from the base of the great trochanter, where the transverse terminal branch of the external circumflex artery passes under the vastus externus, to the external condyle, where the superior external articular artery winds transversely around the bone. The incision passes between the posterior border of the vastus externus and the biceps, no structures of any importance being injured.

286. Excision of the Hip-Joint (Figs. 180, 181, 182). 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. The incision passes through the skin and fascia between the tensor fasciæ femoris and the sartorius, and then down to the capsule of the joint external to the rectus femoris. For a description of the operation for congenital dislocation of the hip the reader should consult the works of Hoffa and Lorenz, to whom we are indebted for the details of the method. When it is desired to freely expose the joint the posterior incision gives much more room, especially if the following method be employed:—

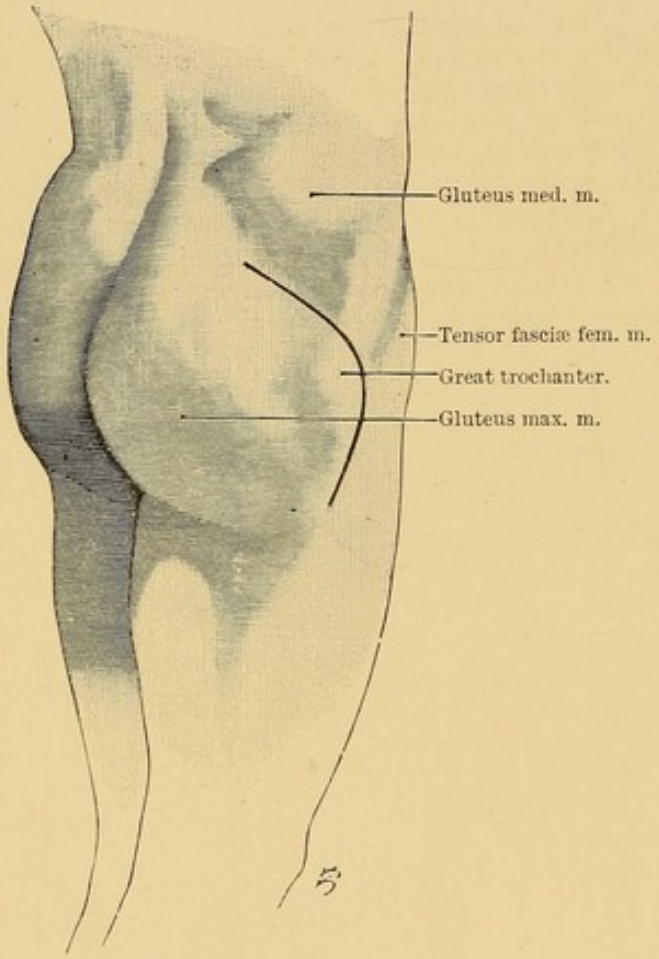


FIG. 180.—Incision for arthrotomy of hip.

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. 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. 181).

The upper and back part of the incision divides the fibres of the gluteus maximus, 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.

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. This space is opened up, and the broad tendon of insertion of the gluteus medius

(attached to the outer side of 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 lower 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

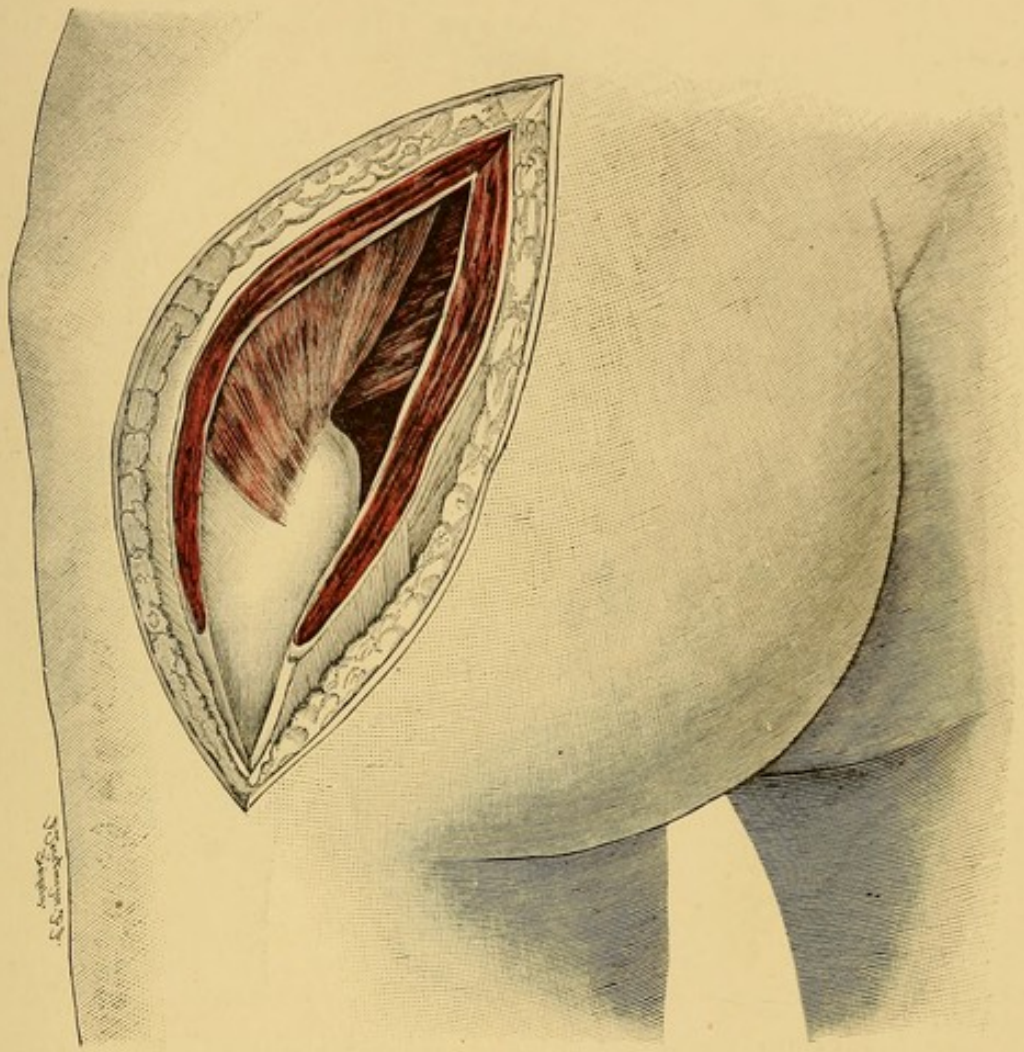


FIG. 181.—Arthrotomy of hip. The gluteus maximus and the dense fascia over the trochanter has been divided. The insertions of the gluteus medius and minimus are exposed.

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, the limb being rotated inwards (Fig. 182).

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

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 to be ligatured where it winds round

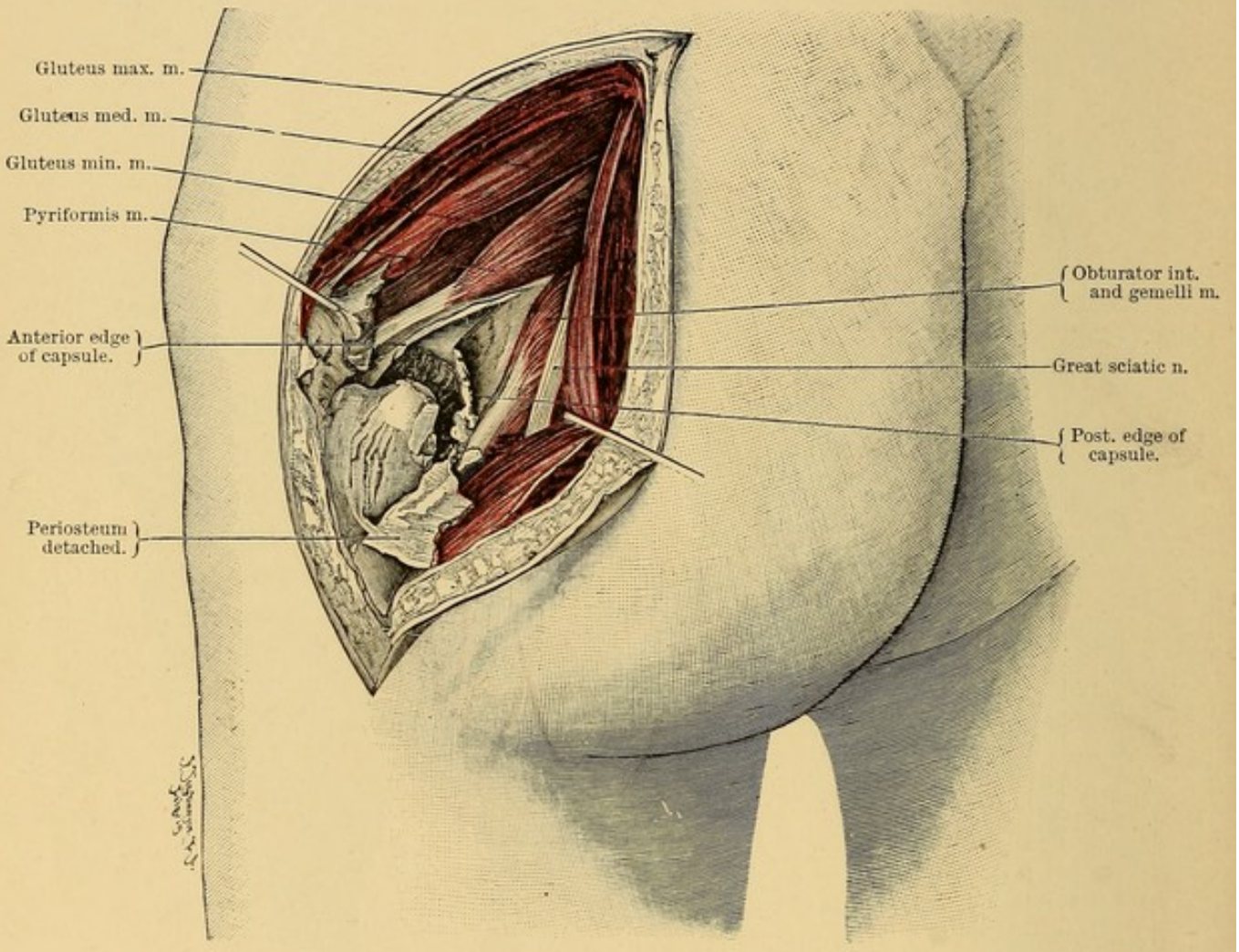


FIG. 182.—Arthrotomy of the hip. The capsule has been opened, the insertions of the gluteus medius and minimus, together with the pyriformis and periosteum, are detached in an upward and forward direction; the capsule, along with the periosteum and tendinous insertions of the obturator internus, gemelli, and obturator externus, is separated downwards and backwards.

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 until one is satisfied that the whole joint has been cleared out.

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 a part of the 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 of 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.

If it is necessary to get a more extensive view of the posterior part of the pelvis, or to resect portions of the innominate bone, Sprengel's method of making the incision along the iliac crest and then downwards along the tensor fasciæ femoris so as to turn down the entire gluteal muscles, will be found very useful. If necessity arises, Sprengel carries the anterior incision downwards external to the anterior crural nerve, and in this way he has cured many obstinate cases of suppuration in the innominate bone. An advantage of this incision is that the operation can be done subperiosteally, the soft parts being reflected and retained in their continuity along with their accompanying nerves and vessels. But our principle of carefully working between the parts supplied by different nerves must be adhered to, for which reason the anterior incision should be carried downwards between the tensor fasciæ femoris and the sartorius, as the latter, along with the subjacent rectus, is supplied by the anterior crural nerve.

287. Excision of the Innominate Bone (Fig. 183). 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 in the hip-joint.

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 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 arteries being grasped with forceps.

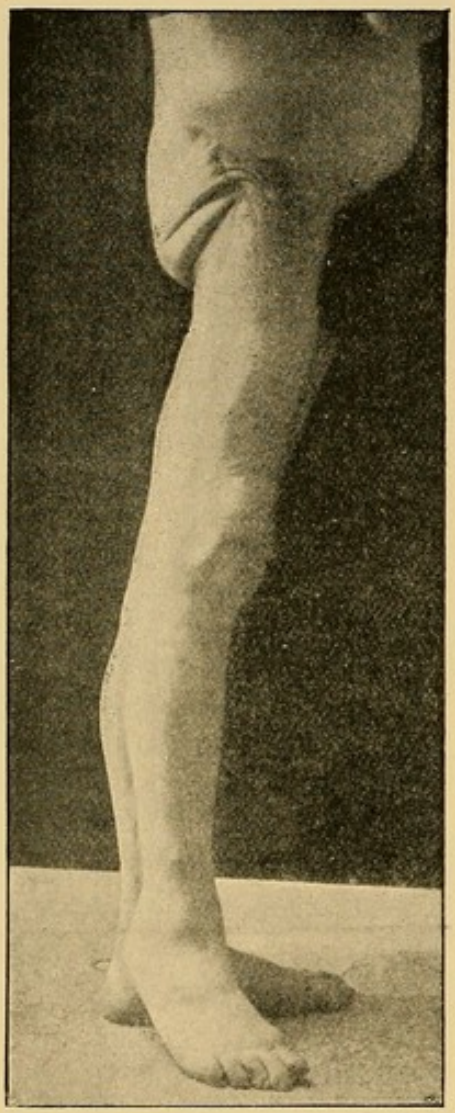


FIG. 183.—Excision of hip and innominate bone for a tumour of the pelvis.

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 attachment 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 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.

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.

V. UPPER EXTREMITY

288. Excision of the Phalanges, Metacarpal Bones, Inter-Phalangeal and Metacarpo-Phalangeal Joints (Figs. 184 and 185). 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

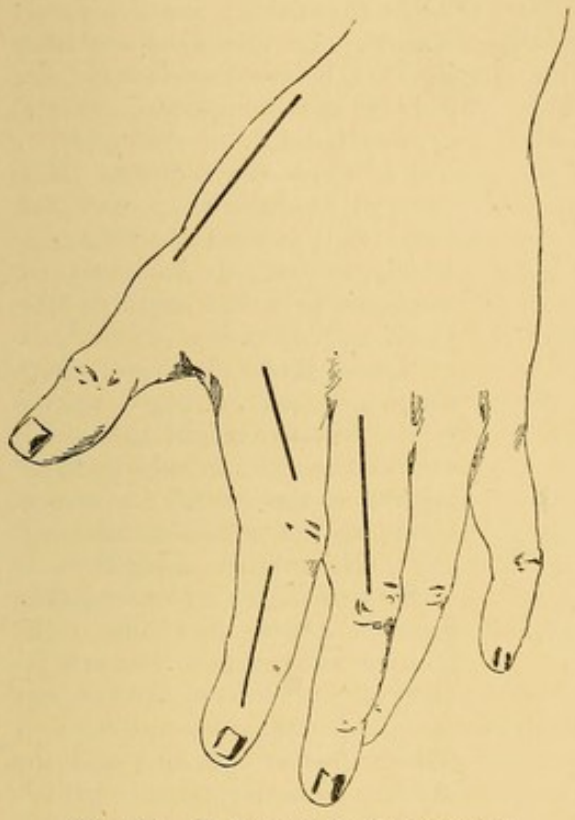


FIG. 184.—Excision of the phalanges and 1st metacarpal bone.

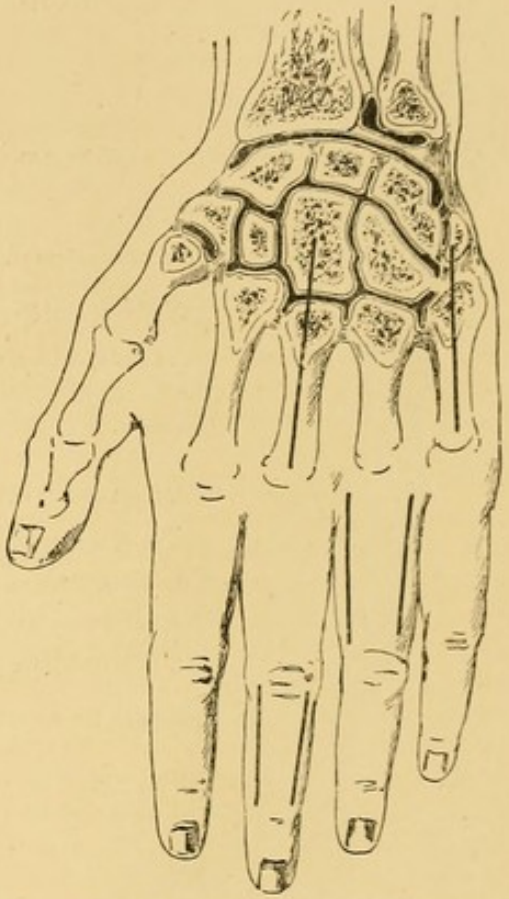


FIG. 185.—Excision of the phalanges and metacarpal bones. (Coronal section of the wrist, after Henle.)

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.

289. Excision of the Wrist (Figs. 185, 186, 187, and 188). 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.

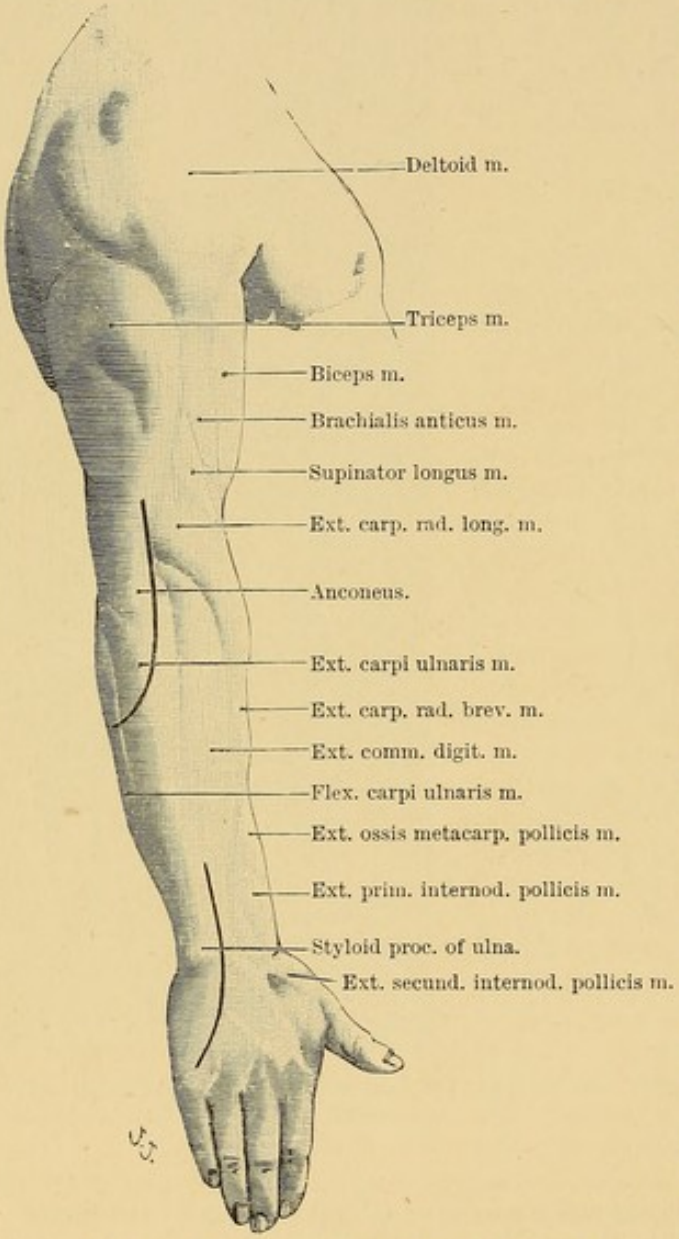


FIG. 186.—Arthrotomy of the elbow and wrist.

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 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. 186, 187, and 188). 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. 187).

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 radio-carpal 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 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 the extensor tendons come to lie upon the radial side of the radius (Fig. 188). 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

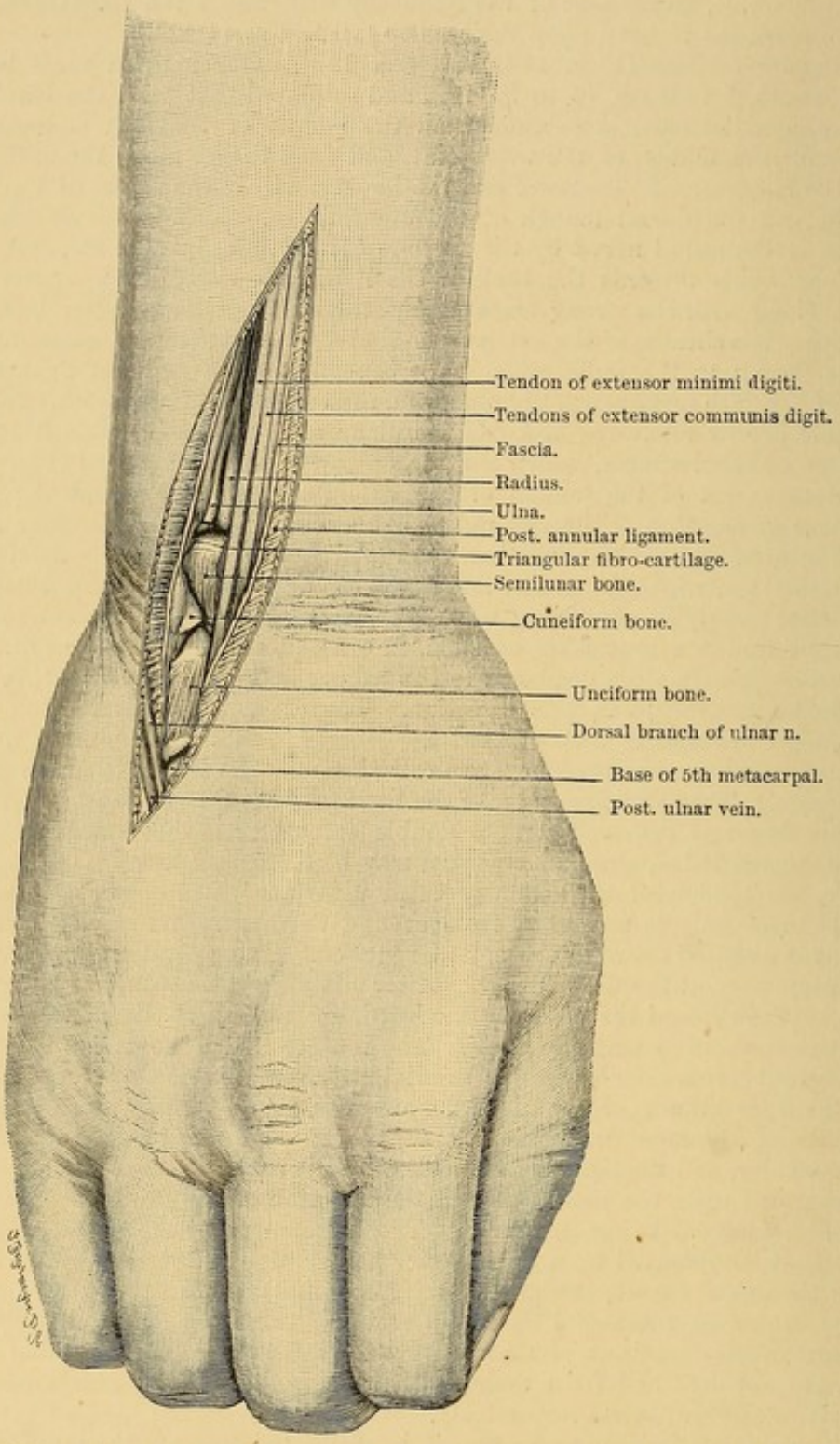


FIG. 187.—Excision of the wrist by the dorso-ulnar incision carried through the capsule.

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

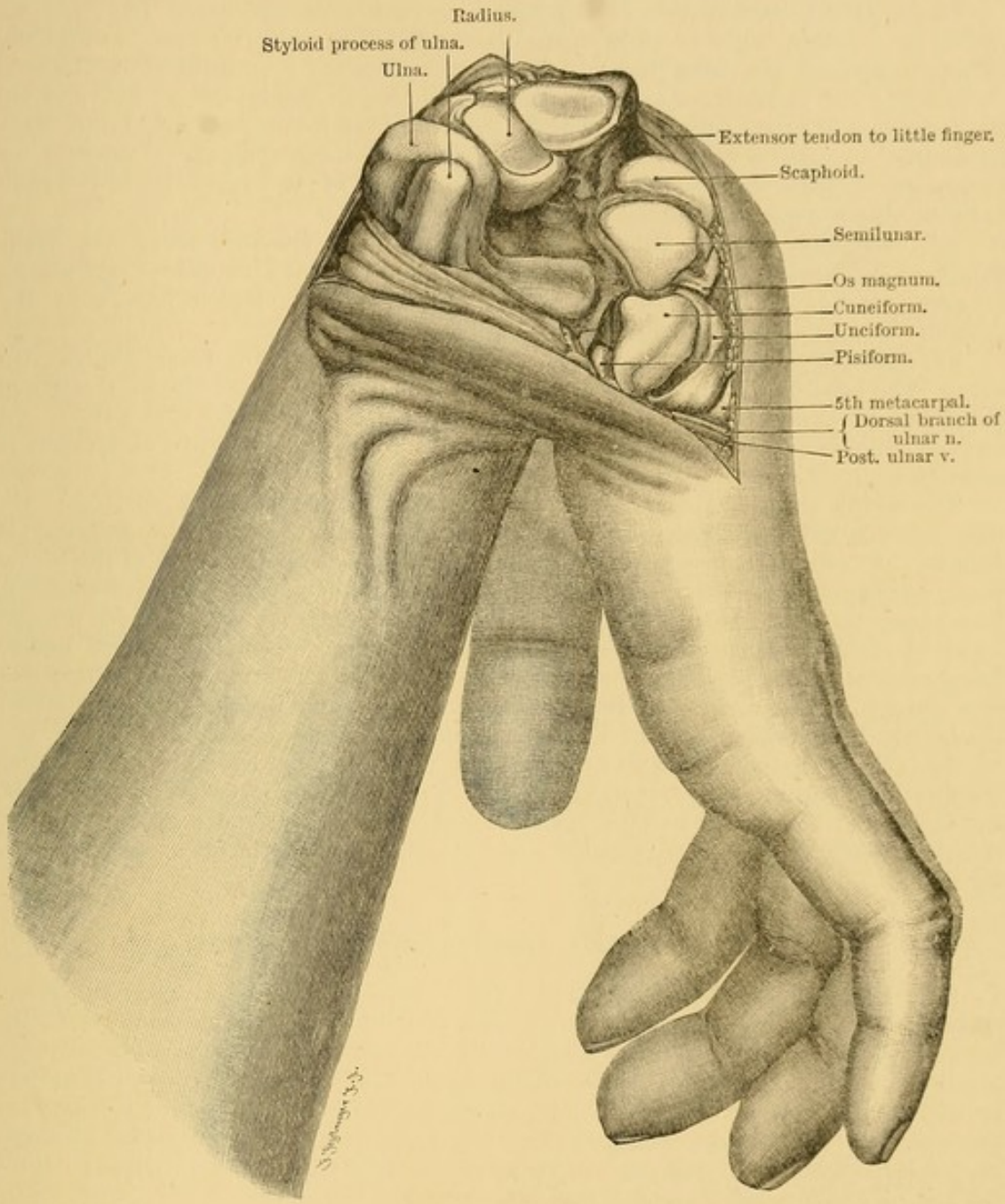


FIG. 188.—Excision of the wrist by the dorso-ulnar incision. Second stage: the wrist-joint is dislocated and the posterior ligament detached from the bones of the forearm.

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.

290. Excision 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.

291. Excision 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.

Method of freely opening the Elbow-Joint

292. Excision of the Elbow (Figs. 189, 190, and 191). 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.

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 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. 189) 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 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 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 from below by means of a chisel and drawn forwards. The

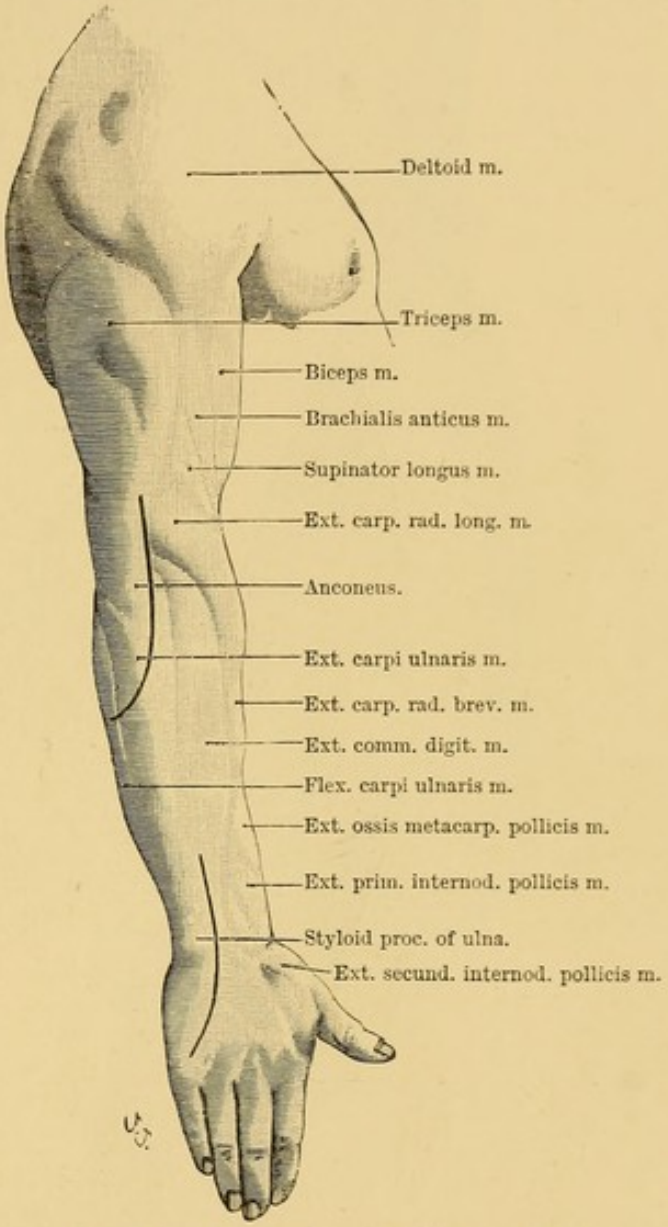


FIG. 189.—Arthrotomy of the elbow and wrist.

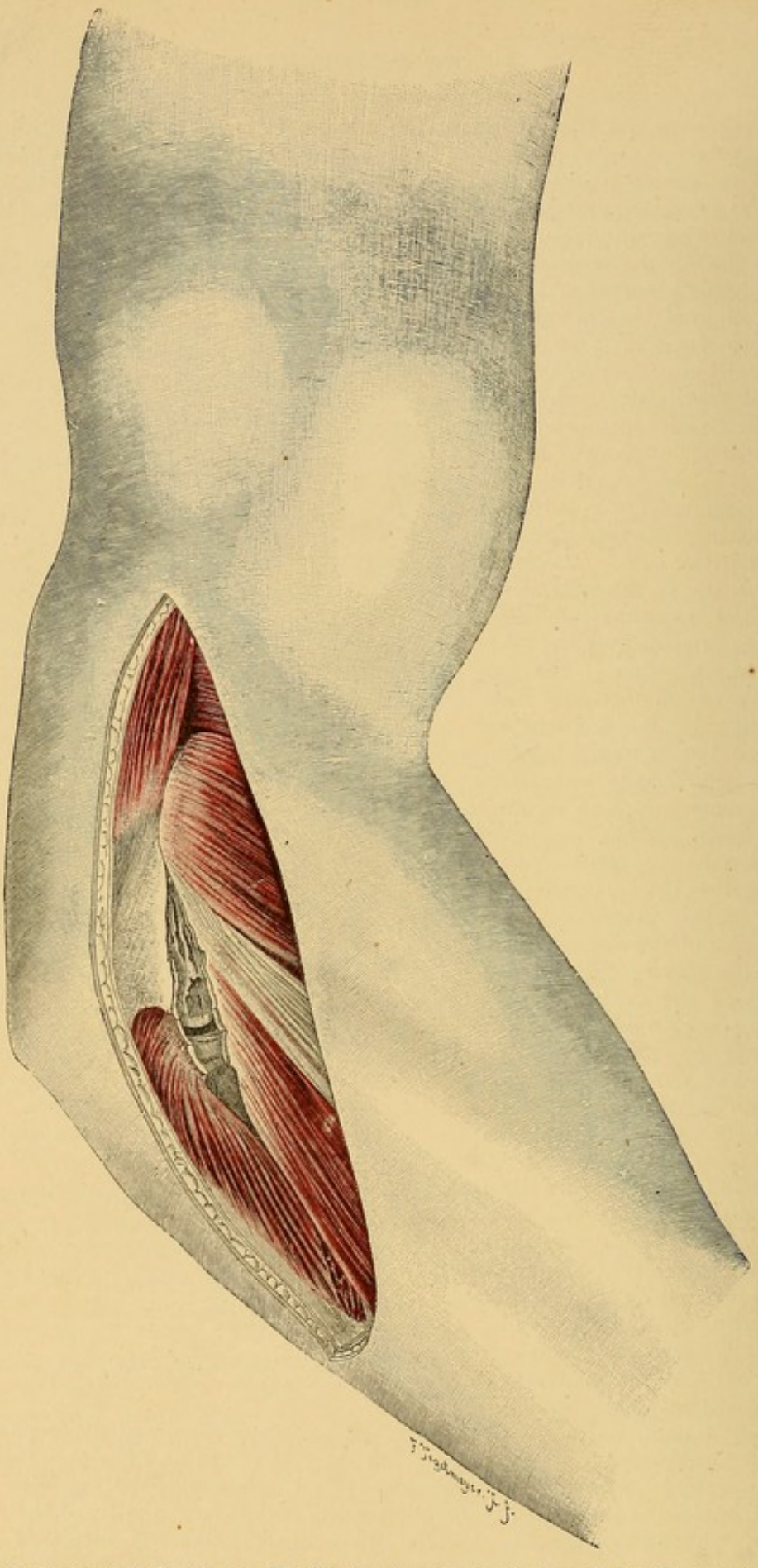


FIG. 190.—Arthrotomy of the elbow. The incision has been made through the skin and fascia down to the bone, in the interval between the triceps (posteriorly) and the supinator longus and extensor carpi radialis longior (anteriorly); lower down it has been carried through the capsule down to the head 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.

joint has now become so movable that the forearm can be completely dislocated inwards (Fig. 191). 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

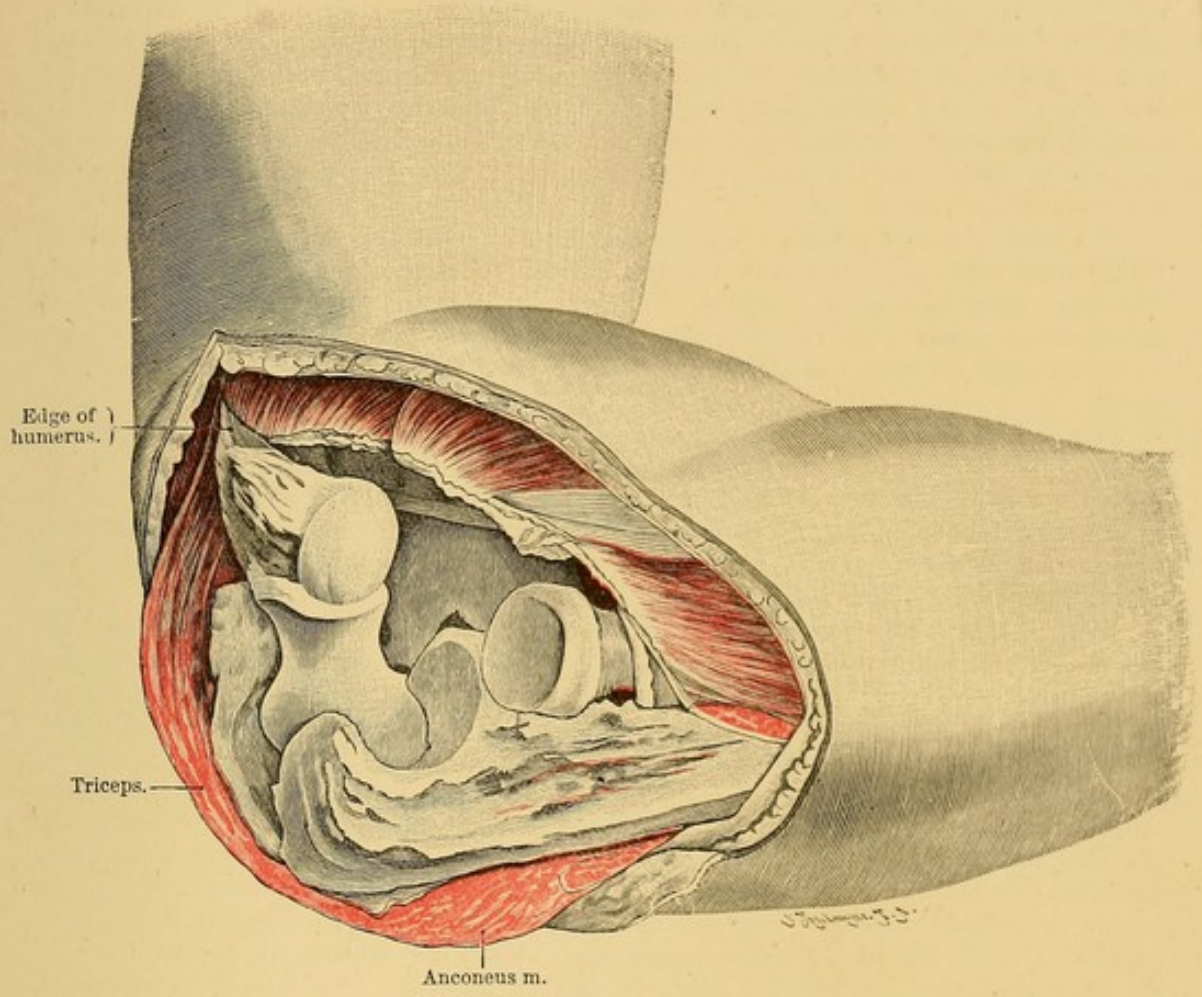


FIG. 191.—Arthrotomy of the elbow after the forearm has been dislocated inwards. The outer surface of the ulna is exposed with the anconeus detached from it. The cut surface of the anconeus is seen below. In the upper part of the wound the supinator longus is seen detached subperiosteally (or subcortically) from below upwards, as are also the extensor carpi radialis longior and brevior, extensor communis digitorum and extensor carpi ulnaris.

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; in this particular case 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.

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 such 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.

293. Excision 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.

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.

294. Excision of the Shoulder-Joint. (*a*) *From the front*—when the disease involves the head of the bone (Figs. 192 and 193).

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.

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.

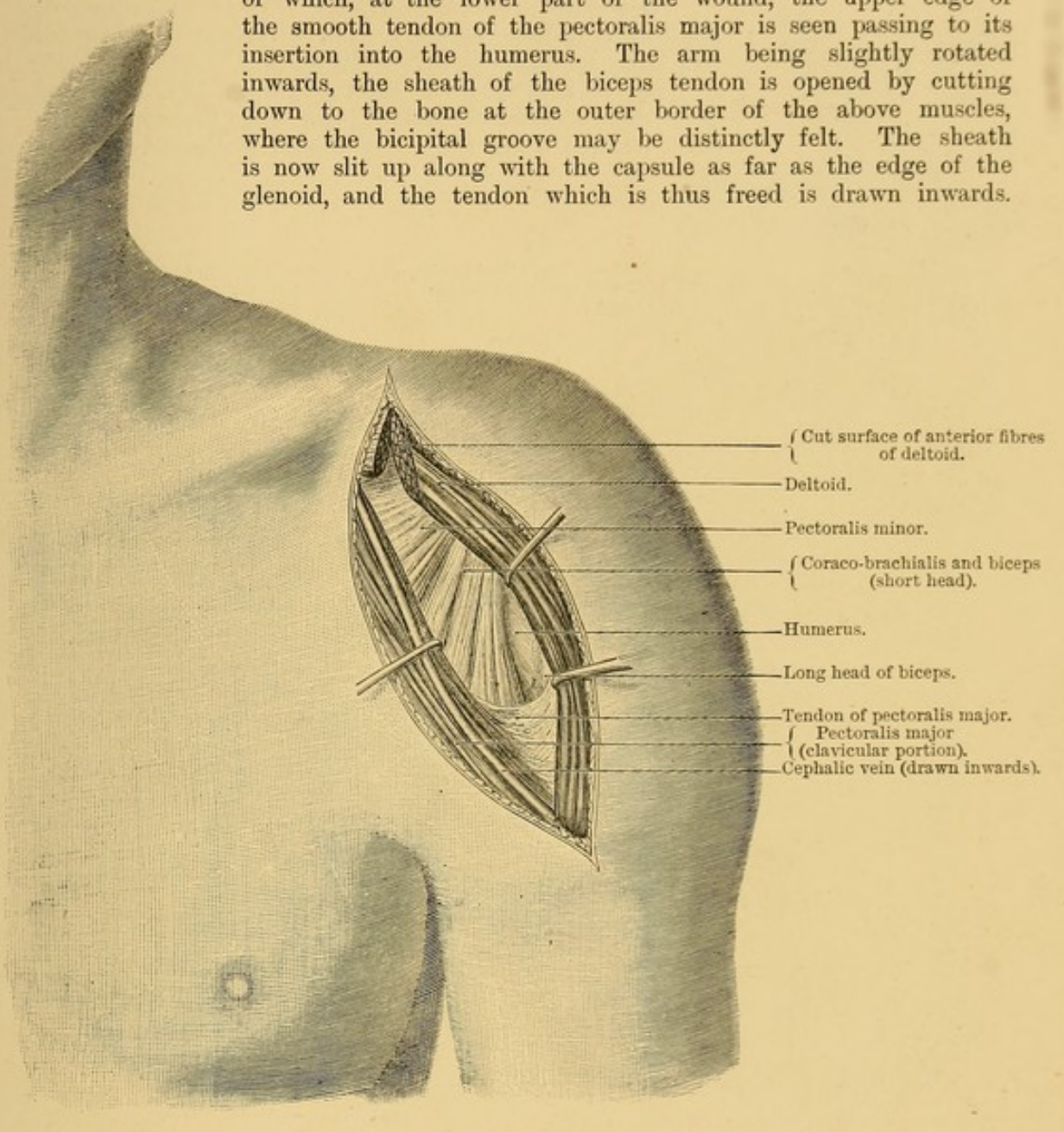


FIG. 192.—Excision of the head of the humerus by the anterior oblique incision (called by Esmarch, Ollier's method).

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 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.

(*b*) *Resection from behind* (Figs. 194 to 198) 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. 194, is carried from the acromio-clavicular joint over the top of the shoulder and along the upper border of the acromion to

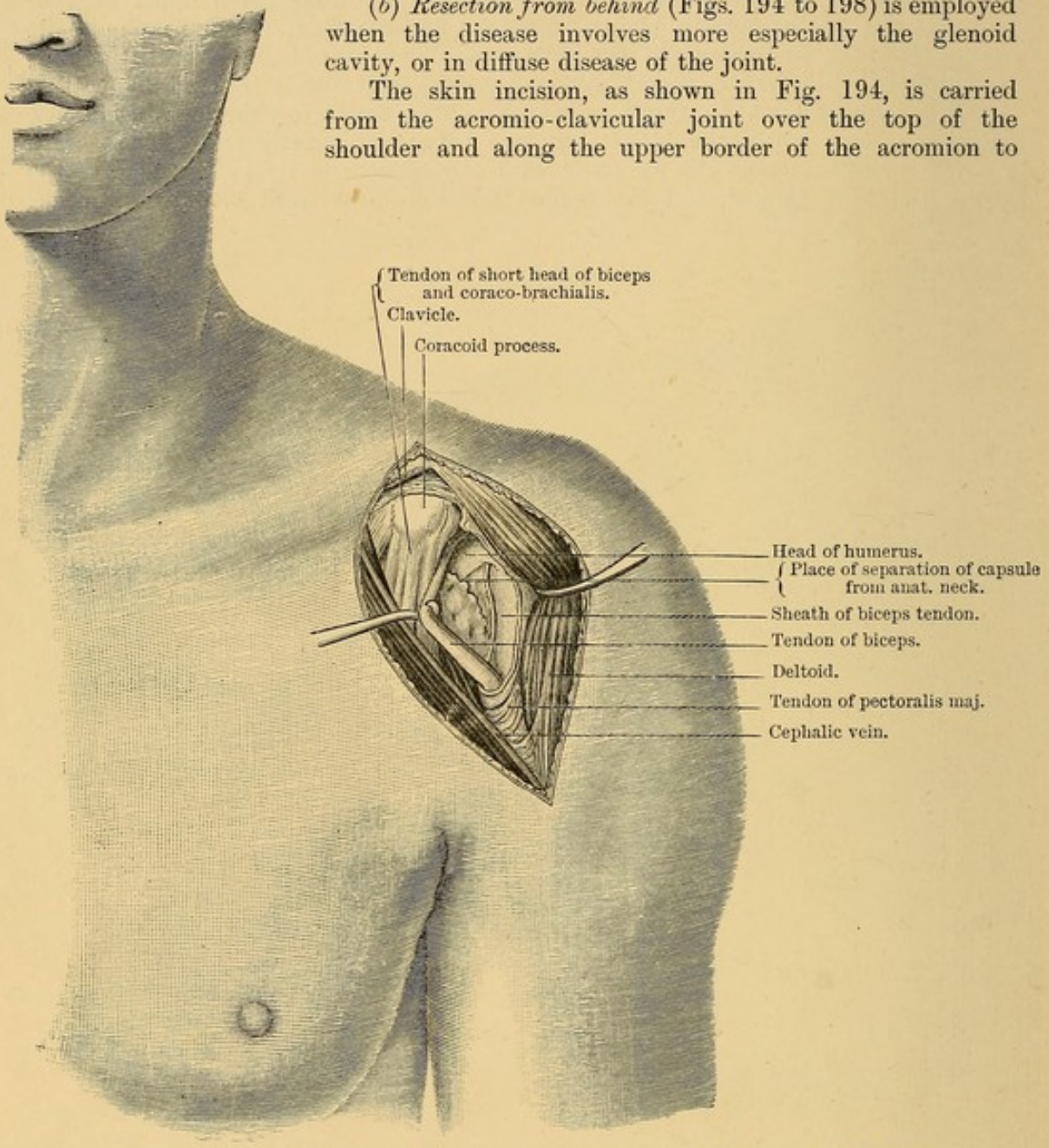


FIG. 193.—Excision of the head of the humerus by the anterior incision. Second stage: the biceps tendon is lifted out of its sheath, and the joint is opened.

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 now 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.

In a similar manner 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, and, 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; 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 very firm union subsequently.

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 arm being rotated outwards, a longitudinal incision is carried down to the bone in the coronal plane. Commencing at the upper part of the posterior lip of the bicipital groove, 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.

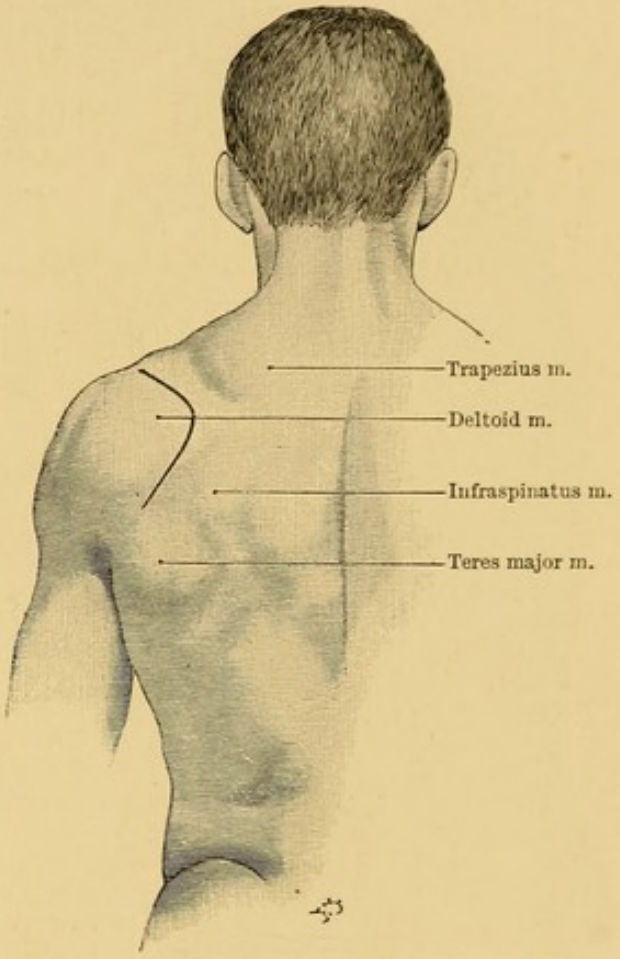


FIG. 194.—Arthrotomy of the shoulder by posterior curved incision.

In this way the entire head of the humerus and the glenoid fossa can be freely

exposed, and if it is not necessary to do 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 come out from under the teres minor can be preserved: indeed, if the operation be properly performed there need be no fear of injuring them.

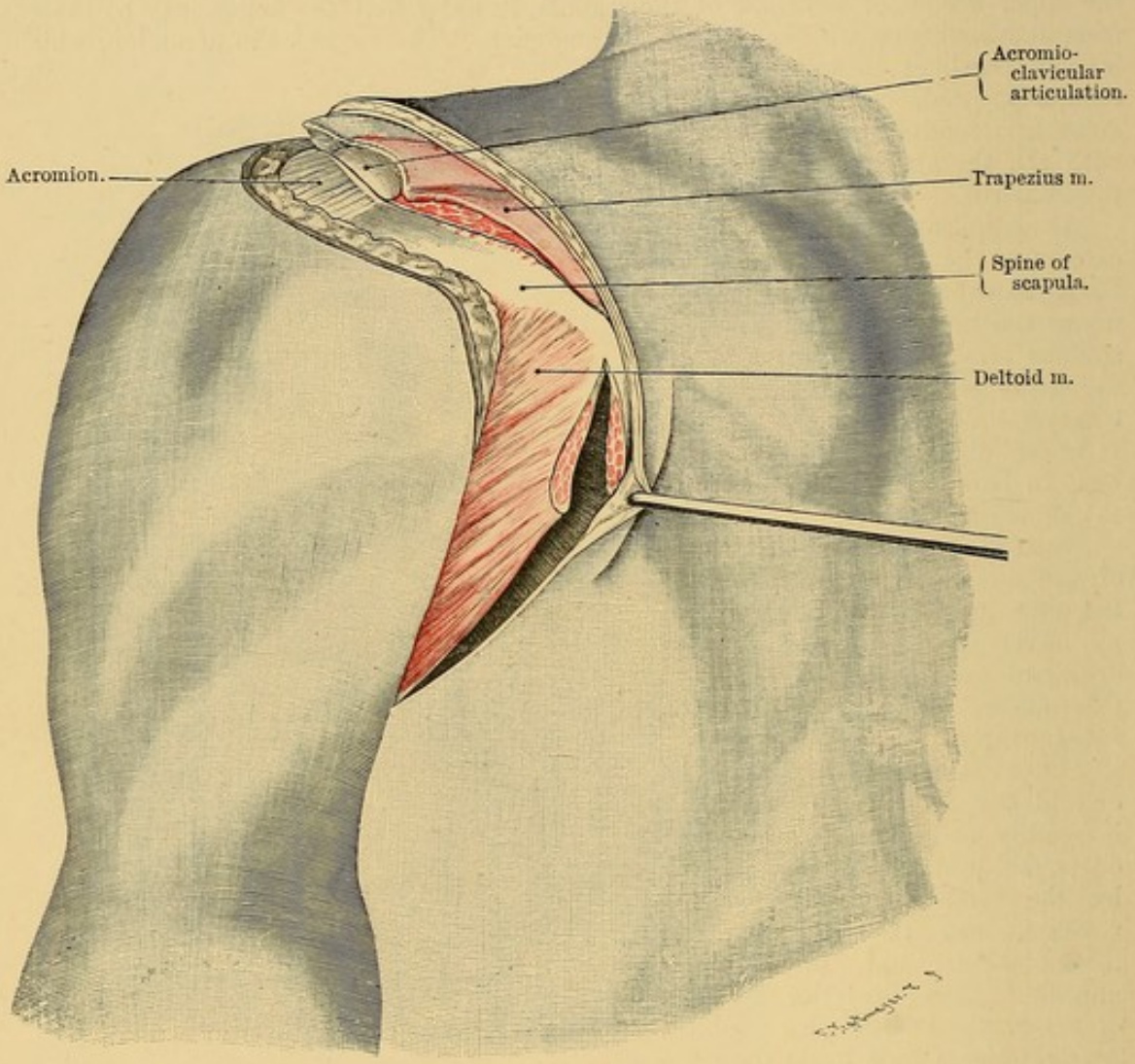


FIG. 195.—Arthrotomy of the shoulder by the posterior curved incision. The acromio-clavicular joint is opened and the trapezius is detached from the upper border of the spine of the scapula. The deltoid is exposed along its lower border, and its attachment to the spine is divided posteriorly, and at this point, after detaching the supra and infraspinatus muscles, the chisel is inserted to divide the spine of the scapula.

When the head has been thoroughly cleared, and especially if it be excised, an 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 of 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.

The excellent results to be obtained by our method are shown in Fig. 198. It

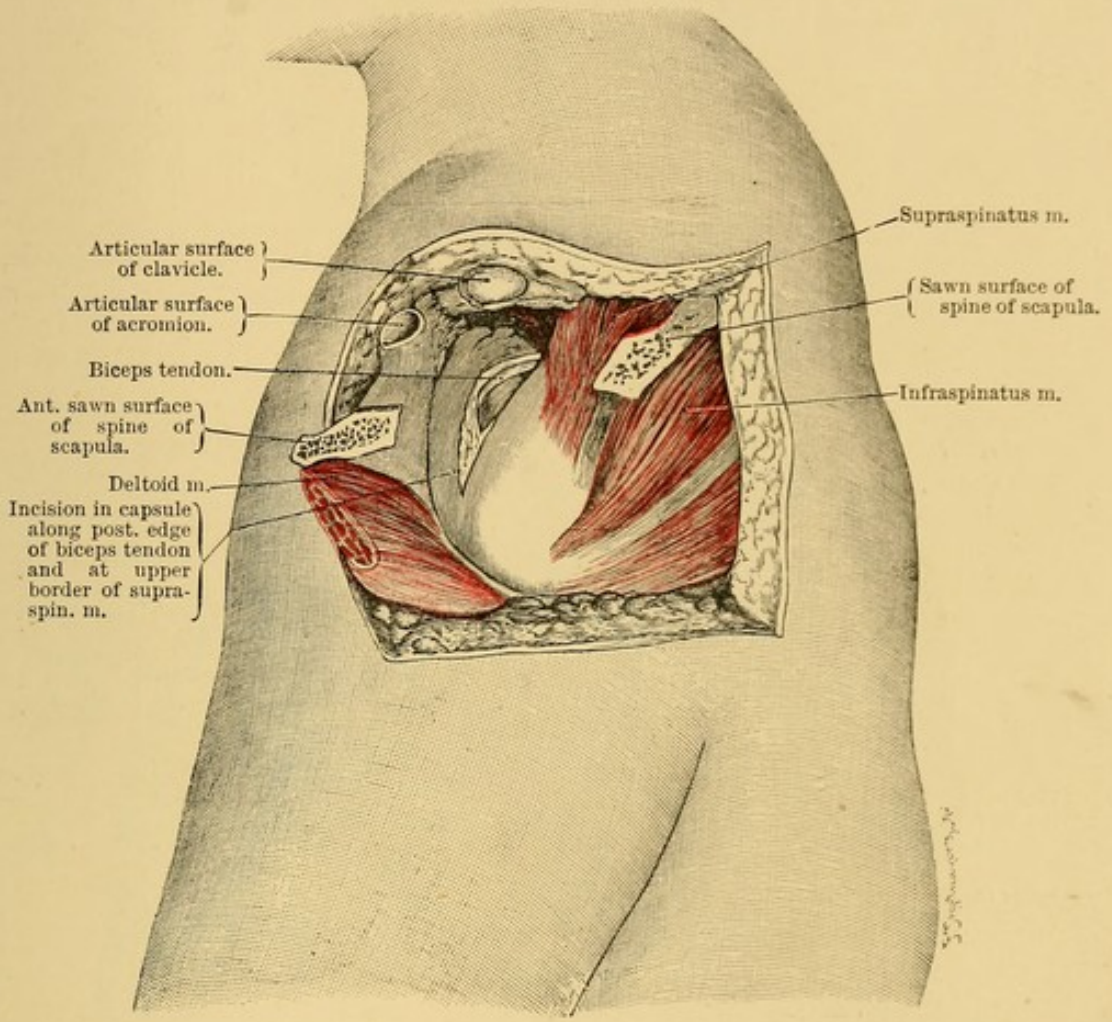


FIG. 196.—Arthrotomy of the shoulder. The flap, consisting of skin, deltoid, and acromion, has been thrown forwards; the capsule has been incised immediately behind the long tendon of the biceps, at the upper border of the supraspinatus.

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.

295. Excision of the Clavicle, of the Acromio-Clavicular, and of the Sterno-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 nerve, 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.

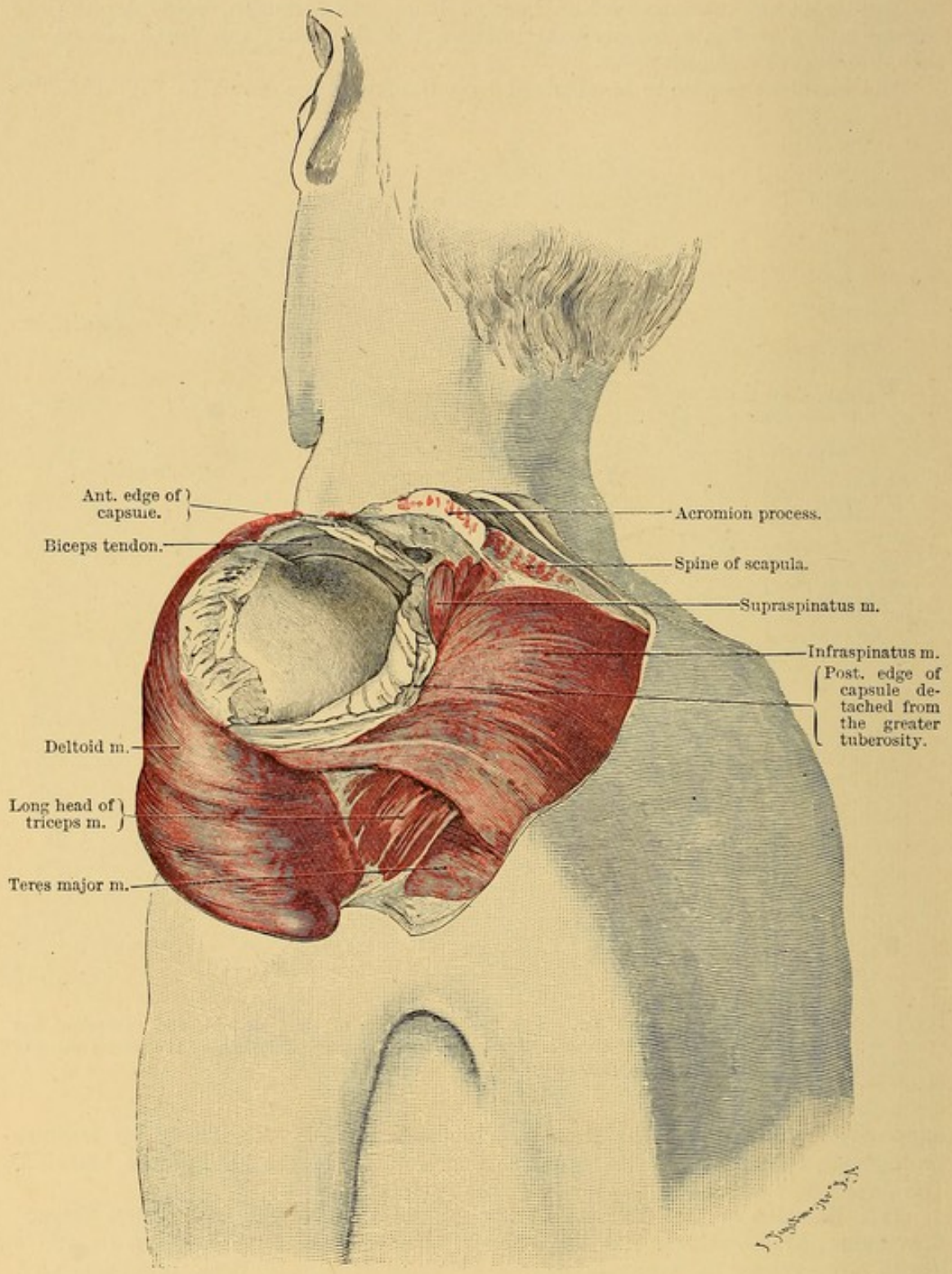


FIG. 197.—Excision of shoulder from behind. The deltoid is separated from the acromion and the spine of the scapula; the bone is not yet divided. The capsule has been incised at the upper border of the supraspinatus, and has been stripped backwards off the head of the humerus along the greater tuberosity.

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 nerve 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 divided. 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.

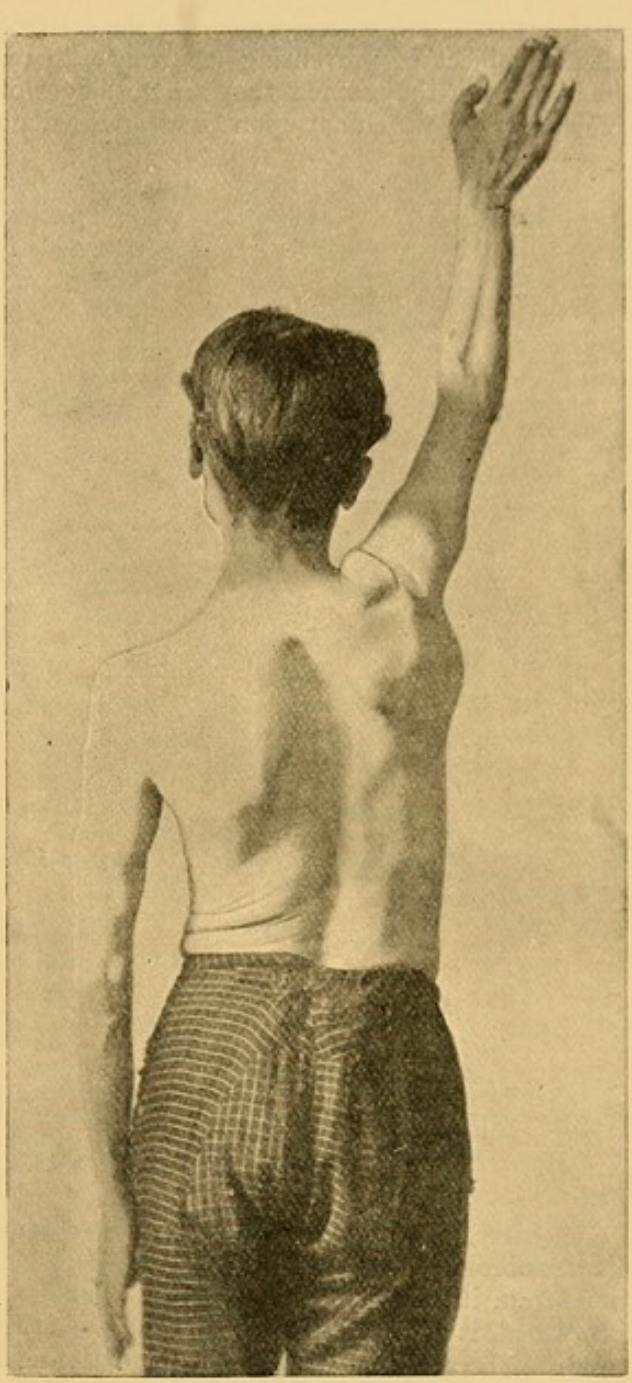


FIG. 198.—Excision of the shoulder for tubercular disease, with fracture and rotation of the head of the humerus.

In excising 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 done 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.

296. Excision of the Scapula (Fig. 199). *Complete* excision of the scapula was first performed by Langenbeck (Gies) in 1855. Ceci has shown what

excellent functional results can be obtained after its complete removal. In tumours of the scapula it is essential that the operation be thorough, without at the same time inflicting unnecessary injury on the surrounding parts. When the periosteum can be retained an endeavour must be made to preserve it, together with the overlying muscles, with the object of obtaining as much regeneration as possible. In tumours, on the other hand, where preserving the periosteum is out of the question, it is better, with the object of preventing recurrence, to remove the muscles as well, because in the absence of the scapula they are no longer of any use. The muscles to which we refer are those which act upon the scapula alone, or which pass from it to the arm.

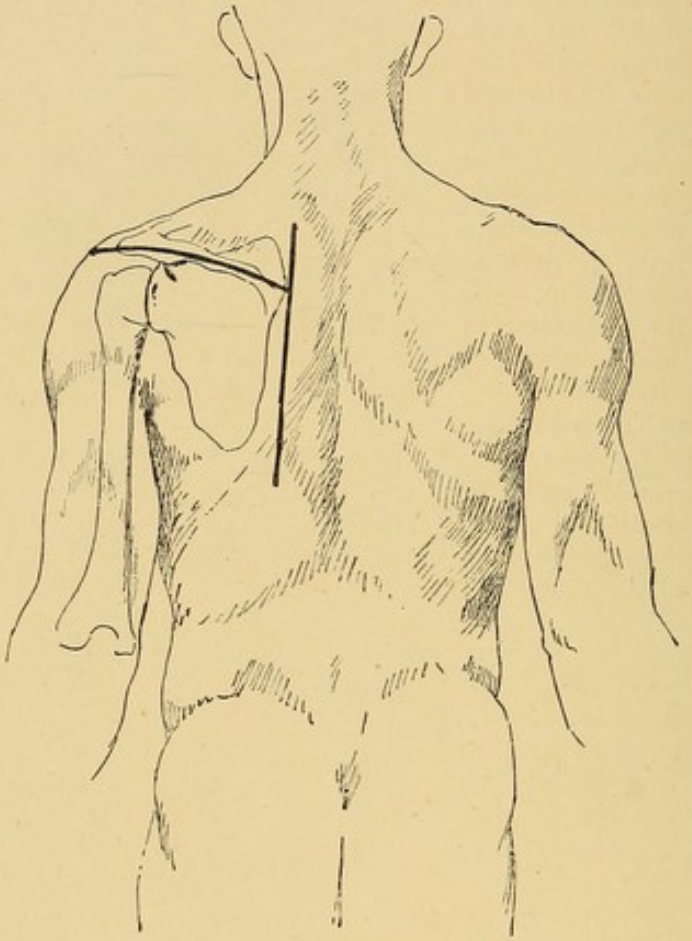


FIG. 199.—Excision of the scapula.

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 it 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. 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.

SECTION V

AMPUTATIONS AND DISARTICULATIONS

W. 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. 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 providing 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.

Evolution of the Methods of Amputation

Their indications. 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 made to cover the stump without any tension. If this cannot be done with a transverse incision alone, a single (or two) longitudinal incision is added, also down to the bone. This simple process has in course of time undergone such numerous 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 got by placing over it the periosteum and the soft parts entire, with as little injury as possible: the soft parts are divided down to the bone, and the periosteum is stripped off it 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. 200 to 202 a general view of the evolution of the more complicated incisions from the simple circular methods.

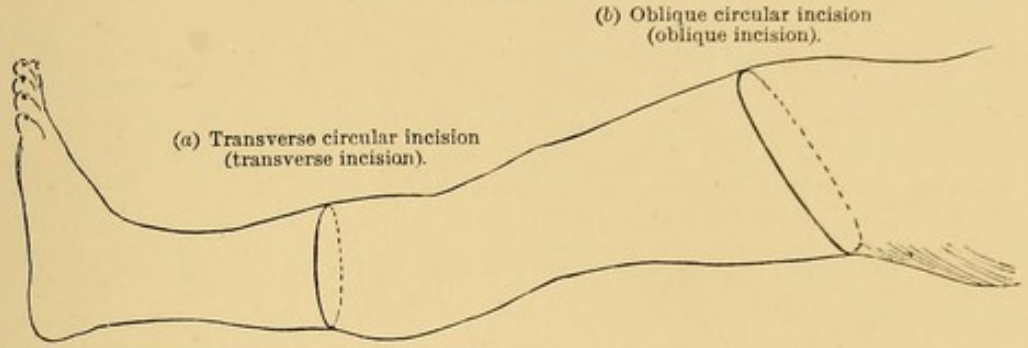
The circular method is the oldest, and consists in carrying a transverse incision right round the limb in a plane at right angles to its long axis. If the plane is oblique to the axis of the joint an oval incision results (Fig. 201). From the transverse circular and oblique circular incisions, better termed merely transverse and oblique, 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 *ordinary horse-shoe flap* results.

The *transverse circular incision*, or shortly the *transverse incision* (Figs. 200 and 205), is the fundamental type of one method of amputation. It originated as a single incision from Celsus, as a double incision from Cheselden and Petit (Schede). The sawing of the bone higher up was introduced by Louis and Boyer. According

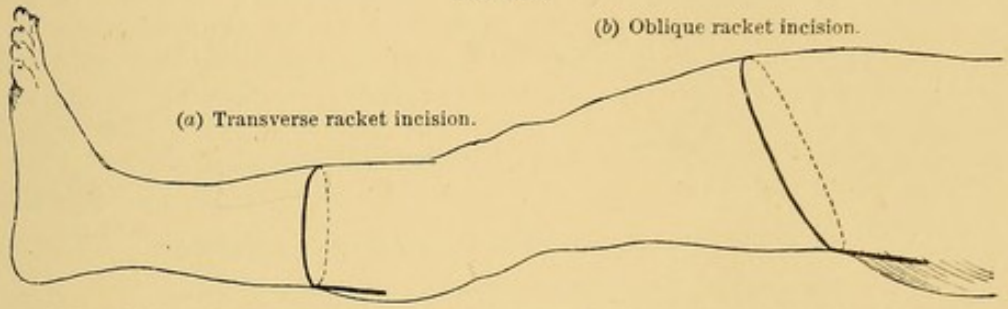
METHODS OF AMPUTATION.

FIG. 200.



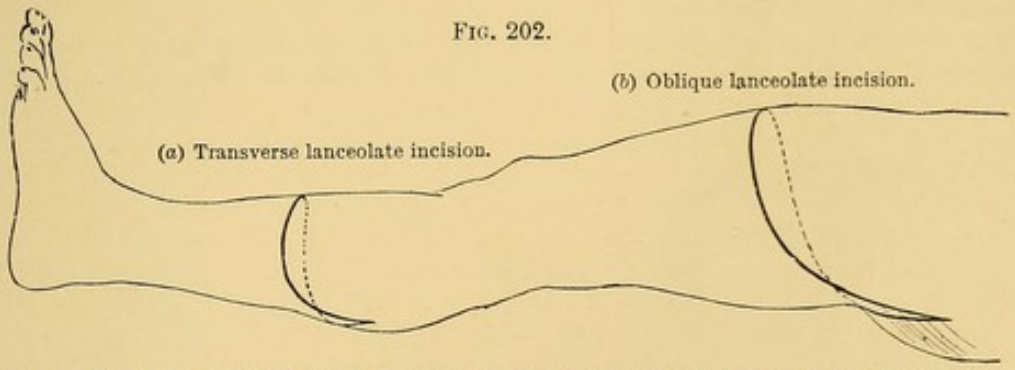
I. Fundamental type: circular incision.

FIG. 201.



II. Addition of a longitudinal incision, to simplify the operation: racket incision.

FIG. 202.



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]

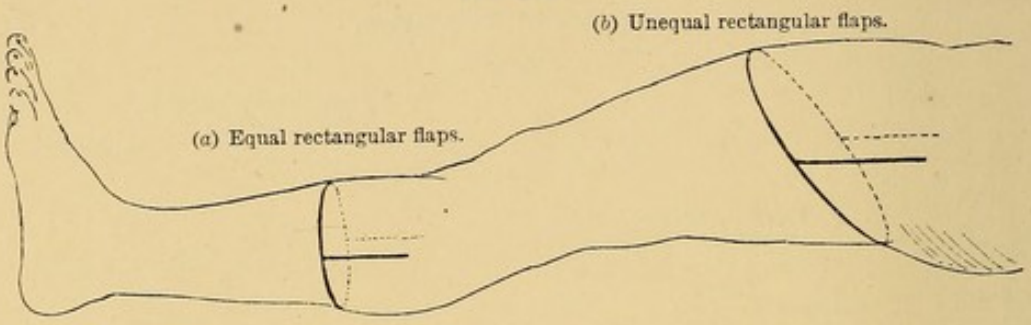
to Freres' description, Celsus divided the soft parts on one side and separated them from the bone, in fact practised what, with some modification, has been lately recommended by Bruns and Neudörfer. The present circular method was introduced by Bell and Hay (Treves).

While it is simple in execution, it has a number of disadvantages which prevent

[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. 200).

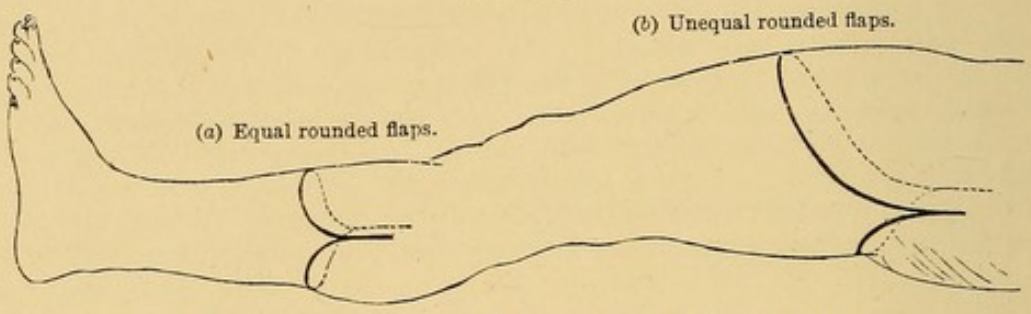
it being universally employed. (1) Since in an amputation one endeavours to preserve as much as possible, the oblique incision is preferable whenever there is more healthy skin on one side than on the other, or when the skin on one side is more adapted for a covering. (2) The separation of the skin to a sufficient extent is difficult where the limb to be amputated is conical. (3) In the transverse circular

FIG. 203.



IV. Two longitudinal incisions added to the circular incision: rectangular flaps.

FIG. 204.



V. Angles of the rectangular flaps rounded off: rounded flaps.

incision the cicatrix comes to lie upon the end of the stump, which is not the case with the oblique incision. Figs. 205 and 206 sufficiently illustrate the different positions of the lines of suture.

It is evident, therefore, that on the above grounds the *oblique circular incision* has a far wider range of employment, because it is applicable to most cases, is easily

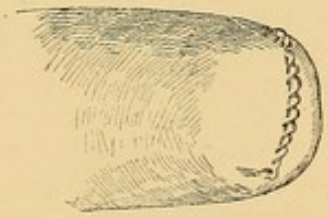


FIG. 205.—Position of the line of suture by the transverse circular incision.

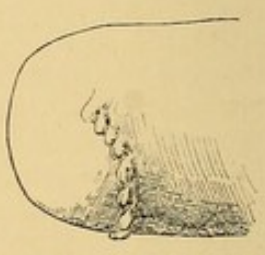


FIG. 206.—Position of the line of suture by the oblique incision.

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. If only one longitudinal incision is added, then we have the racket incision; if two longitudinal incisions are made, then two rectangular flaps are formed.

By rounding off the corners, the racket incision is converted into a lanceolate incision, and the rectangular flaps become rounded.

The *racket* (Fig. 201) and *lanceolate incisions* (Fig. 202) give better access to the deeper tissues with less sacrifice of skin (and less sacrifice of the soft parts generally), and are therefore to be preferred in difficult disarticulations. They are specially valuable when 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 racket is preferable to the lanceolate incision when the longitudinal part of the incision divides the soft parts down to the bone, and when the soft parts are to be separated subperiosteally. In other cases the lanceolate incision is more rapid.

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 subperiosteally, the soft parts being then divided transversely at a lower level. This is practically a racket incision. This method can be quite well performed subcortically instead of subperiosteally, the former being indeed preferable.

The flap methods (Figs. 203, 204), in the form of skin flaps (Lowdham), of skin and muscle (Ravaton), and the transfixion flaps (Vermale) are better when the skin or the other soft parts demand special attention upon one or both aspects of the limb. 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.

Performance of the different Methods

The transverse circular method (Figs. 207, 208, 209). 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 periosteum is divided and separated up to the level at which the bone is to be sawn through. The height at which the bone is sawn across above the skin incision is equal to fully half the diameter of the limb. The periosteal tube should always be long enough to completely cover the sawn surface of the bone. When a disarticulation is being performed, the joint-capsule, which is practically a continuation of the periosteum, is to be treated in the same way: it is separated upwards from the bone as far as the line of the joint (Ollier, Socin).

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. In this way a broad apposition of all the soft parts is ensured.

The oblique or oval incision (Figs. 210, 211, 212). The "elliptical" method is attributed by Treves to Sharp and Soupart. 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, the proximal one parallel to the surface. The upper end lies at the level where the

periosteum is to be divided; the lower end lies at a distance below it equal to the diameter of the limb. After dividing the skin and fascia, the lower ellipse of skin is seized with the left hand (Fig. 212) and drawn upwards, and the muscles are divided down to the bone, *the edge of the knife being directed towards the bone* so that a flap is formed which increases in thickness towards its base. The periosteum is divided transversely where the incision reaches the bone, and, as in the transverse circular

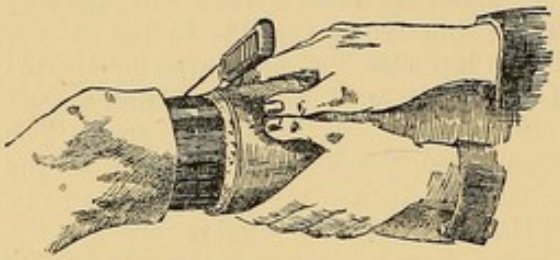


FIG. 207.—Transverse circular incision: method of retracting the skin, and position of the knife.

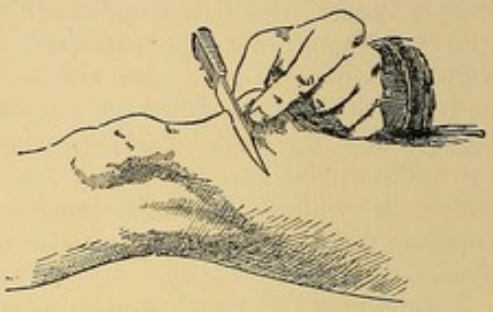


FIG. 210.—Oblique incision: the lower end made by cutting across a fold of skin raised up between the finger and thumb.

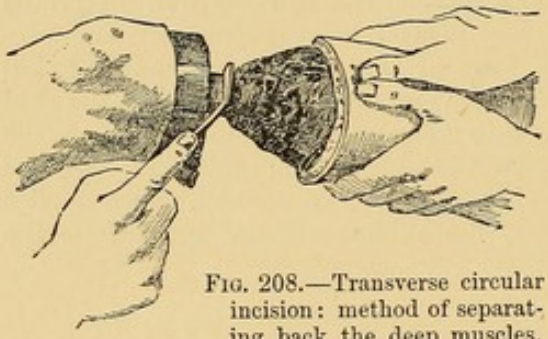


FIG. 208.—Transverse circular incision: method of separating back the deep muscles, together with the periosteum, with the periosteum detacher (raspatorium).

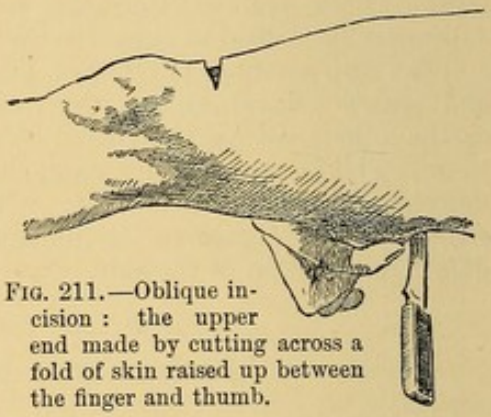


FIG. 211.—Oblique incision: the upper end made by cutting across a fold of skin raised up between the finger and thumb.

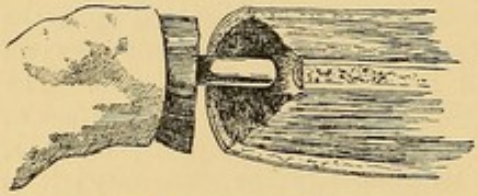


FIG. 209.—Transverse circular incision. Sagittal section, to show the hollow cone which is left after sawing through the bone.

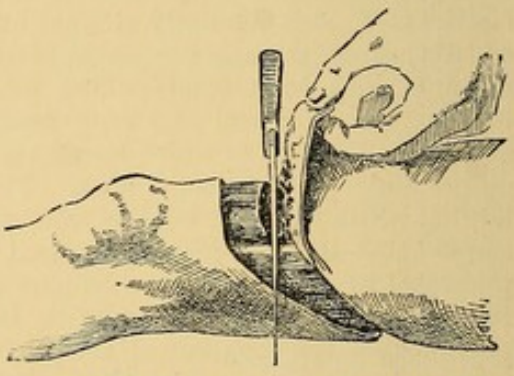


FIG. 212.—Oblique incision: position of the knife in order gradually to carry the incision deeper through the soft parts of the flap.

incision, is separated upwards so that it may cover the sawn surface. The musculo-cutaneous flap is now folded over the wound.

If for any reason the muscles and tendons cannot be retained, then, after making the skin incision, the lower end of the skin flap is seized and dissected up from the subjacent tissues to the level at which the periosteum is divided, the edge of the knife being kept vertical to the muscles and never directed towards the flap. After

dissecting up the skin, 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. 201, 202). 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. It extends 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 makes the longitudinal portion of the racket incision first, so that after chiselling through the bone he may shell it out subperiosteally up to the level of the circular incision.

Lastly, the circular incision through the skin is added, the latter retracted, the muscles divided down to the bone, the periosteum separated upwards as far as where the bone is to be divided (in disarticulations as far as the joint), and the sawing across (or the disarticulation) is completed.

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, especially in the shoulder, hip, and thumb. The longitudinal, which is added to the circular, incision allows the parts to be divided down to the periosteum or capsule of the joint (the muscles and nerves together with the vessels being avoided), and the whole of the soft parts around the end of the bone (or around the periosteal tube) to be so retained that the stump, although boneless, may still possess a certain degree of mobility. The racket incision also allows the larger vessels to be ligatured, and if necessary divided, before making the circular incision, or before removing the limb.

The racket incision is the type of the subperiosteo-subcapsular method of Ollier.

The lanceolate incision, in which the angles of the racket incision are rounded off, is the more convenient and elegant modification of the latter, where rapidity of execution is of more importance than the careful preservation of all the soft parts.

The circular methods with two lateral incisions, or *the double flap methods* (Figs. 201 and 202), 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 result. If it is placed obliquely the flaps are of unequal length. Teale, for example, employs 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 the two curved incisions are made to 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 is divided in a curved direction, first on the one and then on the other aspect of the limit. 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. The periosteum is divided circularly and separated up as far as the place where the bone is to be sawn. 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 covers the main part of the wound surface. The relation of the skin incisions to the seat of amputation—that is to say, to the level at which the bone is sawn or to the line of disarticulation—is estimated, in the case of the lanceolate and flap methods, in the same way as for the simple transverse or oblique circular incision.

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 method produces a very clean wound, and is very rapid, but it has lost its importance since the introduction of anæsthetics and of Esmarch's prophylactic arrest of hæmorrhage.

After removing the limb the vessels are ligatured with fine silk. The nerve trunks are sought for, drawn forwards, and cut across. When the wound surfaces cannot be sutured into complete apposition in their whole extent, a glass drain (with large lateral openings) is introduced as directly as possible into the cavity which is left through a small special opening.

Deep interrupted sutures are used to bring the muscles together, and an accurate continuous suture is used for the skin. Still more accurate union is obtained if the individual layers of the soft parts are separately brought together by means of buried sutures ; first the periosteum, then the deep and superficial muscles, the tendons, and lastly the skin.

Normal Process for Amputations

Modern surgery seeks not only to ensure healing by first intention in an amputation, as in every other operation, but also to leave a functionally useful stump. A stump to be functionally useful must be capable not only of bearing weight and pressure, but also of movement. But in satisfying these demands we only fulfil part of our endeavours. The first essential for the usefulness of a stump is freedom from pain ; the second, good nutrition, so as to prevent atrophy of the muscles and bone.

If in recent times we have obtained more useful stumps than formerly, we are indebted, in the first place, to asepsis. Smooth and painless cicatrices can only be got when the wound heals accurately and without infection, for it is the thick, dense cicatrices resulting from an inflammatory condition of the wound that are painful. The worst of all, however, are the irregular hypertrophic inflammatory scars with overgrowth of bone. For this reason, as well as because of the dangers of infection and the discomforts of delayed union, we should do all in our power to ensure healing by first intention.

We shall not here again consider the treatment of wounds, but we may refer the reader to the chapter on the subject at the beginning of the book. We would again point out, however, how important it is that clean incisions should be made, whose edges can be accurately fitted together. Numerous experiments under the direction of Tavel have clearly proved that lacerated and irregularly torn wounds are much more prone to be infected by a definite number of organisms than are those which are cleanly cut. Consequently, as absolute freedom from germs in the wounds which we make cannot at present be attained, the chances are that a clean and properly conducted amputation will heal without reaction, while one in which the technique is poor will suppurate. Thorough arrest of hæmorrhage and proper drainage always help to ensure a good cicatrix.

But even though we avoid infection and escape a hypertrophic, needlessly thick, dense cicatrix, every stump is not a serviceable one. The cicatrix even of a wound which has healed by first intention will remain sensitive if it is exposed to special mechanical injuries, such as traction, or pressure, conditions met with in cicatrices on the trunk which are injured by the movements of the body and the pressure of

clothes. Pressure and traction are to be avoided, especially when an artificial limb has to be worn.

The cicatrix is exposed to most pressure if it lies between the bone and the artificial limb, or any external object. The muscles and tendons inserted into the cicatrix exert most traction on it if it is fixed to an immobile structure, especially to bone. To avoid painful pressure the scar should, therefore, not lie under the end of the bony stump in any case where it is to be utilised to bear weight or pressure. The only incisions which meet this indication are the oblique incisions and their modifications, as illustrated above. It is only by dividing the soft parts deeper on one side than the other that one can get a cicatrix placed where no pressure can be exerted on it.

It should be noted that this applies not only to the skin, but also to the deeper soft parts, the fascia, muscles, tendons, and periosteum. These layers must also be divided obliquely if the scar is not to lie on the pressure surface. We grant that scars vary in sensitiveness, those of muscle being less sensitive than those of skin; but, again, a scar in periosteum behaves quite differently, because of the great sensitiveness of this membrane, which, moreover, is easily stimulated to permanent proliferative changes by mechanical irritation. It has already been noted that the cicatrices on the ends of nerves (the most sensitive parts of all) are best kept out of the region of the stump by division of the nerve higher up.

Therefore the united surfaces of the soft deeper parts (including the periosteum) should not be situated directly over the end of the stump. This is a point which up till now has not been specially attended to in the periosteo-plastic method. But even although the operation be properly performed by means of the oblique method, there still remains a possible source of pain in the stump, dependent on the shape of the bone. If sharp corners and edges are allowed to remain, which are driven into the soft parts by the weight of the body, there will always be a painful stump. Fortunately this is less likely to occur if the scar does not lie under the bone. It has been rightly pointed out that in Syme's amputation of the foot, a stump capable of bearing the weight of the body is provided if the malleoli are not sawn off. This can only be obtained if one distributes the pressure on the less prominent bony parts. No one would be able to walk if supported only on the apex of the most prominent point, the external malleolus.

In the face of this fact it can be easily understood why, by the older methods, we so often got serviceable stumps at the epiphysis (as Hirsch has shown, but for a different reason) and so rarely in the shaft of a bone. The epiphysis can easily be rounded off, and this should always be done, so that the pressure from below may be distributed equally over a large surface. We maintain expressly that by this means painless and very useful stumps may be obtained in amputations above the malleoli and through the condyles of the femur without any osteoplastic operation, provided care be taken that the soft parts covering the stump are movable and do not contain a scar.

In the case of the shaft of a bone it is extremely difficult to attain this rounding off. We have to do here with a tube with a hard exterior, and if we do round it off we simply transfer the edges from the outer surface of the bone to the medullary surface. But the main point is that a really well-rounded stump in the shaft is technically very difficult to get. We have not yet got sufficient evidence as to how far a carefully rounded section through the shaft, which is covered with scarless periosteum and scarless soft parts, is really adapted to bear weight without giving pain.

Hirsch must be recognised as having called attention to the fact that stumps which have been stripped of periosteum are quite useful. In his method, as in the most ancient methods, Hirsch does not preserve the periosteum. He makes no osteoplastic nor even a periosteo-plastic covering, but leaves the end of the bone bare of periosteum, and it is interesting to learn that at the Surgical Congress in Berlin, 1901, his method found eloquent supporters. Bunge, from Eiselberg's clinic, declares that it is injurious to cover the stump with the sensitive periosteum, and that, on the contrary, it should be removed, as the stump will then be much more useful, because

less sensitive. On the same grounds Bunge scrapes out the medulla, so that this sensitive part may not be pressed upon.

Bier is convinced that it is harmful to operate subperiosteally, because of the resulting overgrowth of bone. But as he prefers the osteoplastic to the older methods, it follows that it does not signify much whether the periosteum is retained, or whether bone is replaced over the sawn surface. The point is that a good stump may be formed in various ways, provided the end of the bone is rounded, broad, and smooth, and has no corners or edges to exert pressure on sensitive parts. But another point which has been too long neglected is that it is essential that the stump should retain the good shape given to it at the operation.

For if one wishes to prevent injurious growth from the medulla, or from the bone itself, the stump must be subjected as early as possible in the functional relationships to which it will later be exposed. The irregular overgrowths which are sometimes described will then not occur, because functional activity determines the direction of cicatrisation.

If the wound heals rapidly by first intention, strong and serviceable stumps can be assured, be they aperiostal, subperiostal, or osteoplastic, by taking care that the skin-cicatrix, the fascial scar, the stump of the nerves, and the muscle-cicatrix are away from the seat of pressure. This can be effected by the oblique oval method of incision, by making the end of the bone broad and round, by causing it to press against portions of muscle and skin which are only slightly sensitive, and by accustoming it early and carefully to gradually increased pressure. The best stumps are always those in which the skin and periosteum covering the face of the bone retain their normal relationship to each other, as in Bier's or Pirogoff's osteoplastic operation, especially if the skin is already accustomed to pressure, as in Gritti's operation and Küster's modification of Pirogoff's amputation.

Few methodical experiments were made to ascertain the effect of direct pressure on diaphyseal stumps, till Bier pointed out that in forming stumps by his osteoplastic method much depends upon allowing the bone to become functionally active as early as possible, because direct pressure prevents it from becoming atrophied, and, we should like to add, also from becoming hypertrophied.

The great difficulty in rounding off the cortex of a bone is one reason for employing the osteoplastic method of amputation. Since (according to Schede) Walther in 1813 performed operations by the periosteo-plastic method, Ollier has developed this procedure. The osteoplastic method of Pirogoff, which Gritti first used successfully for diaphyseal stumps, has, after many years (thanks to Bier's establishment of the principle underlying it), been far more extensively adopted. Bier departs from the principle of avoiding a bony cicatrix at the lower end of the stump, because he considers that in such a cicatrix is sensitive, and therefore impairs the power of the stump to endure pressure. Bier, therefore, covers every sawn extremity of bone not merely with periosteum, but with a flap of bone so arranged that its lower surface is one which is normally covered by periosteum. The bony flap adheres to the sawn surface, but even if it should not and remain movable, Bier has seen no harm follow to the usefulness of the stump. Even if the sawn extremity of the bone is covered by a scar it is of no moment, so long as there is a layer of bone between it and the soft parts.

We consider two points in Bier's contributions as of special importance: firstly, the rounding off of the bone, demonstrated by the X-rays, by the osteoplastic method; and, secondly, the painlessness of the stump even when there is a fibrous scar on the surface, provided it has no close connection with the soft parts of the stump. We have already spoken of the importance of the first point in obtaining a painless and useful stump. We now come to the consideration of the second point.

Besides the necessity of preventing pressure on the scar, we have directed attention to the necessity of preserving the scar from traction. The scar is pulled on by the movements of a stump only if it cannot follow those movements, and this especially happens if it is adherent to the firm resisting bone.

If, therefore, in addition to the normally adherent periosteum, the normally movable soft parts, especially the sensitive skin, become adherent to the sawn surface of the bone, pain will naturally occur on movement. But if one covers the sawn surface with periosteum, retaining its normal relation to the soft parts, adhesion of the latter in the course of cicatrisation is prevented. As already seen, this adhesion happens only when one has separated the soft parts from their normal relation to the flap of periosteum. In this lies the chief value of the periosteo-plastic method, and to a considerable extent of the osteoplastic method. The latter is preferable to the former in all cases where the shaft is divided, because it makes it easier to obtain a rounded-off stump. The layer of bone which is applied to the sawn shaft does not require always to have a very regular surface as long as it has no sharp corners or edges.

Bier has called attention to the necessity of accustoming a stump to pressure early, and using it soon, so as to prevent atrophy of the bone and soft parts. Atrophic stumps are sensitive, just as are atrophic limbs on which no operation has been performed. But it is of equal importance that the growth of the end of the bone should be prevented from forming projecting angles, and thus interfering with the functions of the stump. It is because there is so little danger of exostoses and hyperostoses forming on the end of a bone where the amputation has been done by Hirsch's aperiosteal method that the stumps are so efficient in bearing weight. Bier's requirement, therefore, applies especially to periosteo-plastic stumps, but also to all stumps in which primary union gives opportunity for early use.

The principle of preventing hypertrophy of scars, pressure and traction on a scar, and atrophy of the soft parts, allows us to formulate the following procedure for a normal operation :—

An oblique incision (combined, if necessary, with a longitudinal one in the form of a racket or lanceolate incision) through skin and fascia. After retracting the elastic skin the muscles are divided obliquely down to the bone. The periosteum is also to be divided obliquely. The periosteum is then separated, along with the superficial layer of the cortex of the bone, by means of a sharp raspatory or chisel, or, when possible, a flap of bone having a movable periosteal hinge is made by means of the saw; lastly, if only a thin shell of the cortex has been raised up along with the periosteum, the end of the bone is simply rounded off, while, if a distinct flap of bone (osteoplastic method) has been sawn up, the end of the bone must be sawn in a curved direction so as to fit it.

The periosteal or bony flap is sutured over the sawn surface of the bone to its periosteum. The stumps of the muscles or tendons are sutured to each other or to the surface of the bone at a distance from the sawn surface. Lastly, the skin and fascia are sutured. But in cases where a periosteal flap, or a flap of bone and periosteum, cannot be obtained in normal relation to the other soft parts, it is better to remove the periosteum entirely from the end of the stump, to scrape out the medullary cavity (according to Eiselberg and Bunge), and to round off the edges of the bone as dentists do.

In disarticulating, care for the shape of the end of the bone is unnecessary: the upper cartilaginous surfaces should be preserved, as they are insensitive and used to pressure. In addition, the points which we have emphasised in excisions are to be borne in mind, viz. to retain the attachments of the tendons, muscles, and ligamentous capsule to the cortical layer of bone subjacent to them. In other words, the subcapsular method is to be added to what we have just described as the normal, so that the disarticulation is performed by what may be termed the periosteo-plastic-subcortical method.

X. LOWER EXTREMITY

1. Amputations at the Foot

The main rule to observe in amputations at the foot is to arrange the incisions so that there will be no cicatrix in the sole. The longer flap must always be taken from the plantar aspect. A second rule, except in amputations of individual toes, is that portions of the foot are always to be removed transversely to its long axis (Major).

Two main types of operations are recommended in performing amputations and disarticulations of the foot. In the anterior part of the foot, where it is broad and flat, larger flaps should as a rule be taken from the sole, as shown in Figs. 216, 217, illustrating disarticulation at the tarso-metatarsal and intertarsal joints. The dorsal incision should be convex, and have enough skin to allow the flaps to be sutured without tension. This is analogous to the incision in the posterior part of the foot in Pirogoff's osteoplastic amputation of the foot, with this difference, that the plantar flap in the latter includes a portion of the os calcis. But for the posterior part of the foot, which is higher and narrower, a different incision is as a rule preferable. This, which is illustrated in Figs. 222, 223, 224, greatly simplifies the operation, and gives a very good covering. In disarticulating the foot at the ankle and at the astragalo-calcanean joints an internal flap is taken. This can also be carried out very successfully by the osteoplastic method, as is shown below in the description of Tauber's modification of Pirogoff's osteoplastic operation. These are the two normal methods of amputating the anterior and posterior part of the foot.

Lastly, the osteoplastic methods, such as those of Lewschin and Spassokukozkii, are becoming more and more popular, especially when the flap must be taken from the dorsum. Further, we may employ the method of Mikulicz, in which portions of the metatarsus are retained in a well-nourished flap.

297. Removal of a Toe with and without its Metatarsal Bone (Fig. 213). 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 is made. The dorsal part of the incision extends down to the bone, which is removed subperiosteally.

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.

298. Disarticulation of all the Toes (Metatarso-Phalangeal Disarticulation) (Fig. 214). 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 toes being now markedly bent towards the sole, 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 are cut across as high up as possible.

299. Amputation through the Metatarsus (Fig. 215). 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 is also very serviceable as a 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.

An oblique incision is carried, with a single sweep of the knife, through the muscles down to the bone so as to avoid the branches of the internal and external plantar arteries. A small knife is then carried round each of the metatarsal bones: the periosteum is divided and retracted and the bones sawn across. The oblique circular

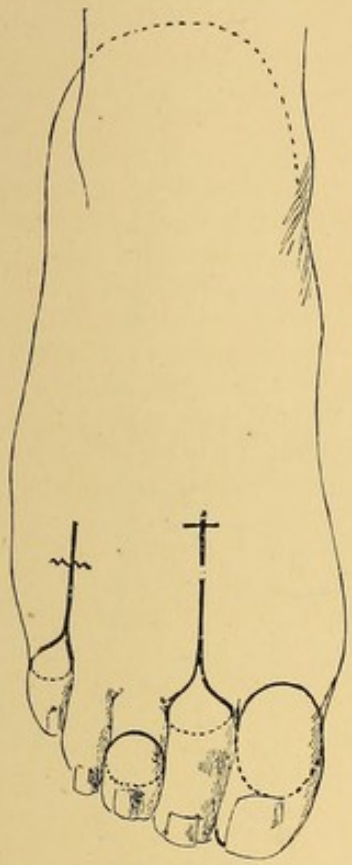


FIG. 213.—Disarticulation of the great toe at the metatarso-phalangeal joint, and of the 2nd toe along with its metacarpal bone: amputation through the 3rd toe, and through the 5th metatarsal bone.

FIG. 214.—Disarticulation of all the toes at the metatarso-phalangeal joints.

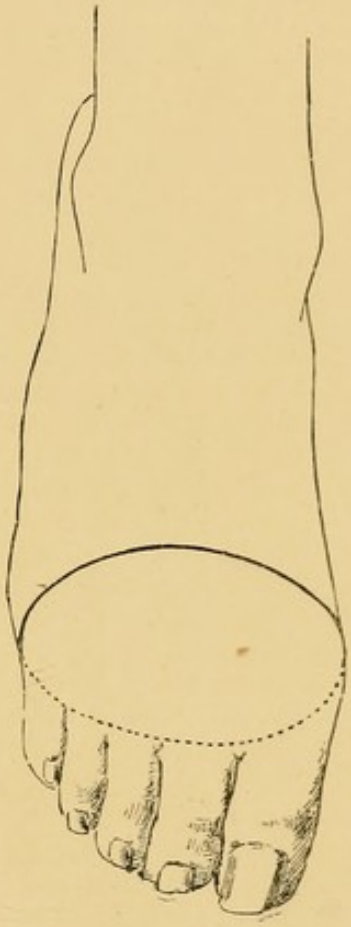


FIG. 215.—Amputation through the metatarsus.

incision is better than the transverse circular, as the scar in the former case is on the dorsum.

300. Disarticulation at the Tarso-Metatarsal Joints—between the metatarsus anteriorly and the three cuneiforms and cuboid posteriorly (Lisfranc's operation) (Figs. 216 and 217).

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, and, after retracting the skin, the periosteum is divided 1 cm. in front of the joint-line, 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: it has 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 strongest ligament is that between the internal cuneiform and the base of the second metatarsal (Fig. 217), and it is only after this has been divided that the joint can be

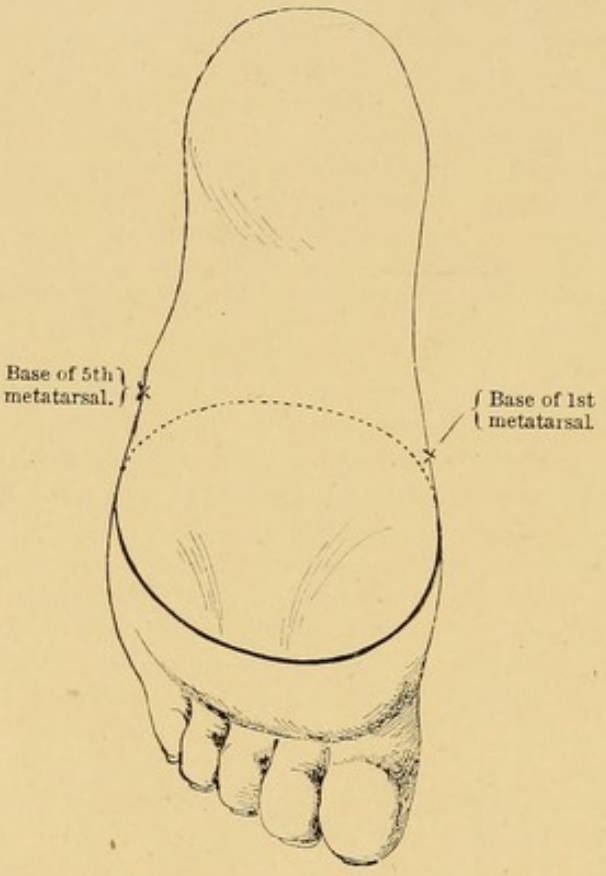


FIG. 216.—Disarticulation at the tarso-metatarsal joints (Lisfranc's operation).

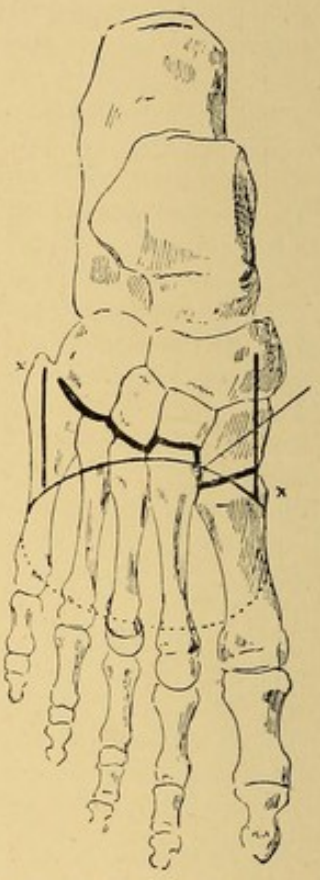


FIG. 217.—Line of the tarso-metatarsal joints; and incisions for Lisfranc's operation.

opened out. Removal 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.

301. Anterior Intertarsal Disarticulation (Jäger-Bona) (Fig. 218), 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, except that somewhat less skin is preserved. 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. 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.

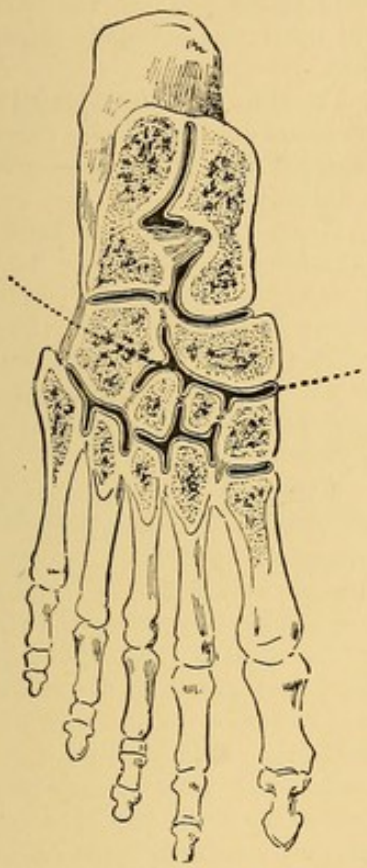


FIG. 218.—Anterior intertarsal disarticulation (Jäger). Horizontal section of the foot (Heitzmann).

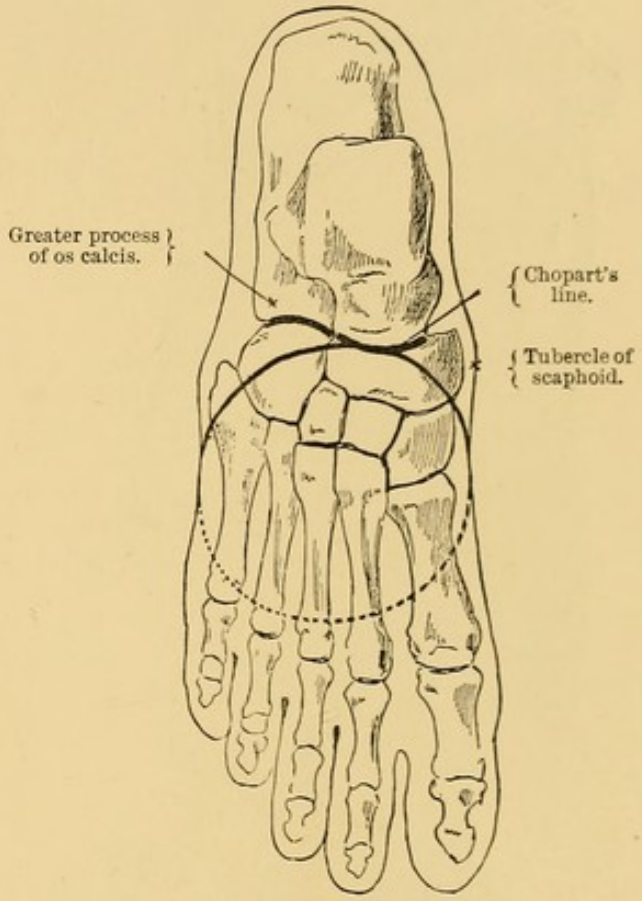


FIG. 219.—Posterior intertarsal disarticulation (Chopart's operation).

302. Posterior Intertarsal Disarticulation (Chopart's operation) (Figs. 219 and 220). 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 divide 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.

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, and the plantar reaching down to the balls of the toes.

The dorsal incision is carried down to the bone across the scaphoid, the periosteum being then stripped back along with a short flap. 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.

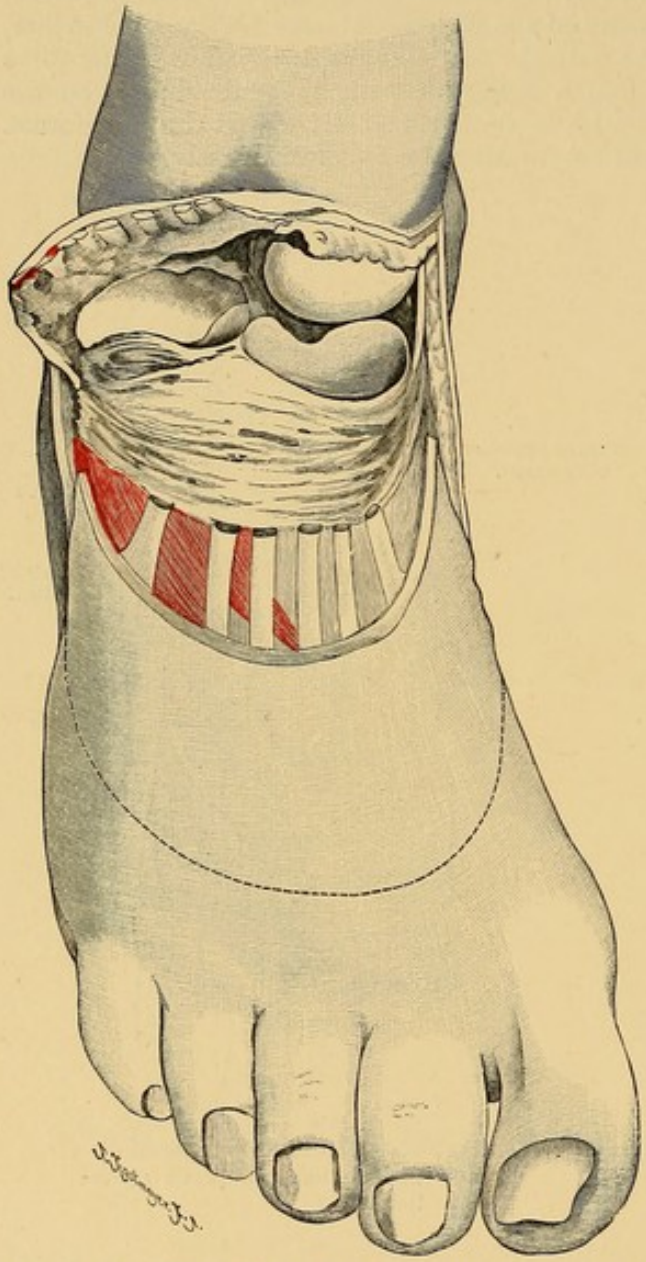


FIG. 220.—Posterior intertarsal disarticulation by a plantar flap and convex dorsal incision. The skin on the dorsum is retracted; the tendons are divided and the joint opened, exposing posteriorly the articular surface of the head of the astragalus and the os calcis. Anteriorly are seen the articular surface of the scaphoid and part of the cuboid.

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 peroneus 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.

303. Amputation through the Posterior Tarsus. When the soft parts are insufficient for a Chopart's 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.

304. Subastragaloid Disarticulation (Malgaigne, Textor) (Fig. 221). A racket-

[1] *Deutsche med. Wochenschr.* January 1899.

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

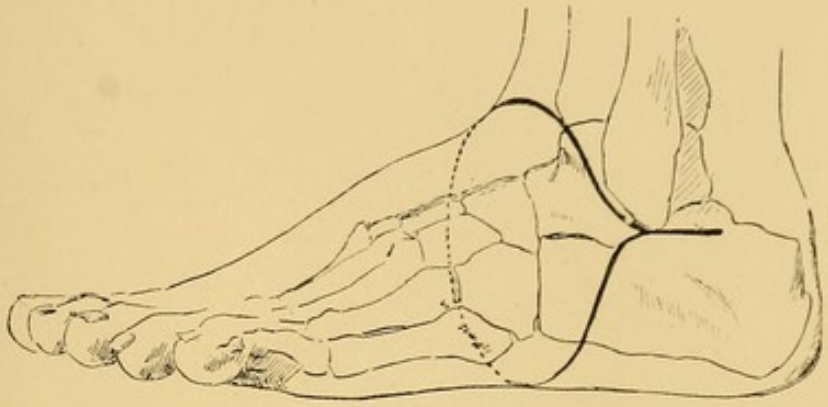


FIG. 221.—Subastragaloid disarticulation (Malgaigne, Textor).

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.

305. Subastragaloid Osteoplastic Amputation. This operation, introduced by

FIG. 222.—Disarticulation at the ankle-joint (Syme's amputation modified).

Hancock, consists in sawing off the tuberosity of the os calcis, and applying it to the 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.

306. Disarticulation at the Ankle-Joint (Syme's operation) (Figs. 222-225). This operation was performed by Syme by means of a flap taken from the heel. The 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. 222). This method resembles most the internal flap recommended by Farabœuf, and the methods of Roux and Verneuil. 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

FIG. 223.—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.

is dissected from above downwards from the internal flap by keeping close to the bone. The malleoli are cleared and the ends of the bones sawn off.

Tauber gives a similar incision in describing his modification of Pirogoff's amputation, but instead of separating the internal flap from the os calcis, he leaves it attached, saws off its outer half in the sagittal plane, then saws off the malleoli, and applies the sawn surface of the os calcis to the tibia and fibula.

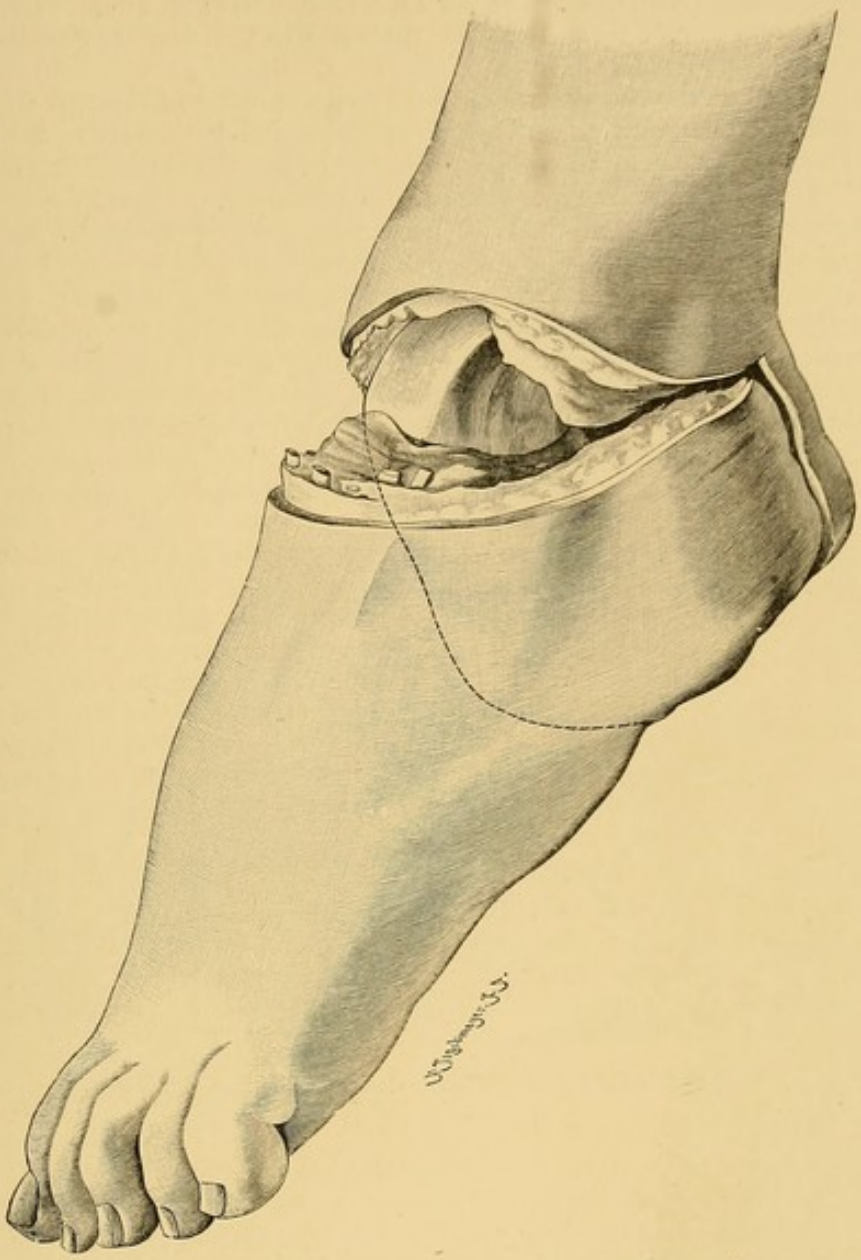


FIG. 224.—Disarticulation of the ankle by an internal flap (outer side). The joint is opened in front and externally; the head and outer surface of the astragalus and the tip of the external malleolus are exposed.

An internal heel flap was first employed by Richard Mackenzie, of Edinburgh (*Monthly Journal of Medical Science*, 1849, vol. ix. p. 951).

According to Bier, the articular cartilage should never be removed, so as to avoid having a bony cicatrix: indeed it is often better to leave the malleoli. If they have to be sawn off, Tauber's osteoplastic method should always be kept in mind. When, however, the os calcis is only partially diseased, and when the skin is available, a portion of the peripheral part of the bone may be used to cover and protect the sawn surface of the tibia.

FIG. 225.—Coronal section through the ankle-joint (Henle).

307. Osteoplastic Amputation of the Foot (Pirogoff) (Fig. 226). 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 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 divided, and the astragalus exposed as far back as its posterior surface. The tuberosity of the os

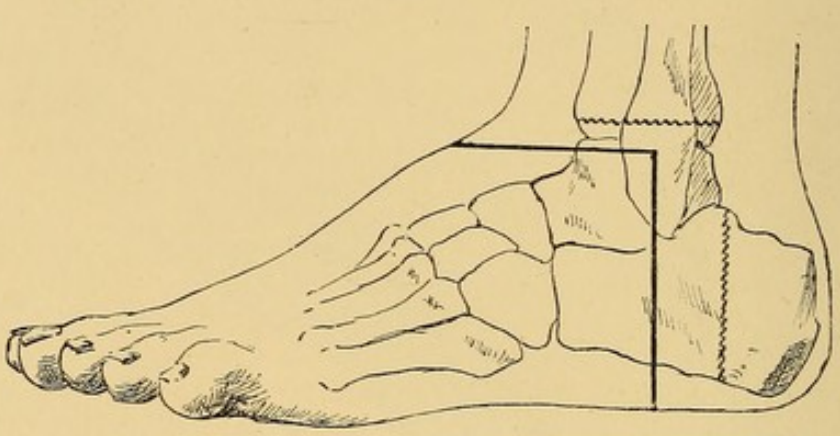


FIG. 226.—Osteoplastic disarticulation of the foot (Pirogoff).

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 along with the articular surfaces of the tibia and fibula. 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 desirable, 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 beginning (Fig. 221) horizontally below the tip of the external malleolus. Through

this horizontal incision access is obtained for sawing through the bone. This incision should be compared with the one described on page 400 under Tauber's operation.

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.

Ssabanejeff has also recently described a subastragaloid osteoplastic amputation.

308. Amputations through the Leg (Figs. 227-232). The incisions to be recommended are sufficiently indicated in the illustrations; and for the way in which the operation is performed reference must be made to the description of amputations in general.

On the other hand, the proper manner of performing Bier's osteoplastic amputation of the leg must be fully described. 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 Eiselberg, 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 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 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 which level the periosteum is separated still farther upwards and the soft parts divided circularly.

FIG. 227.—Amputation through the malleoli.

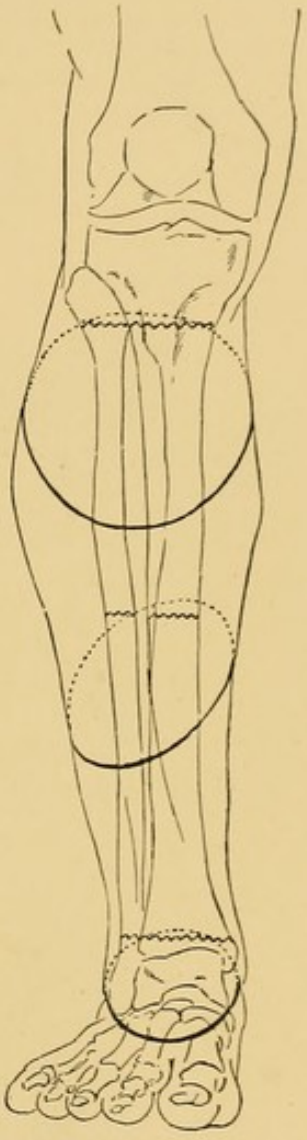


FIG. 228. — Amputations through the leg below the knee, in the middle third, and through the malleoli.

The bones are then sawn across and the osseous flap sutured over the sawn surface of the tibia.

In our experience 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.

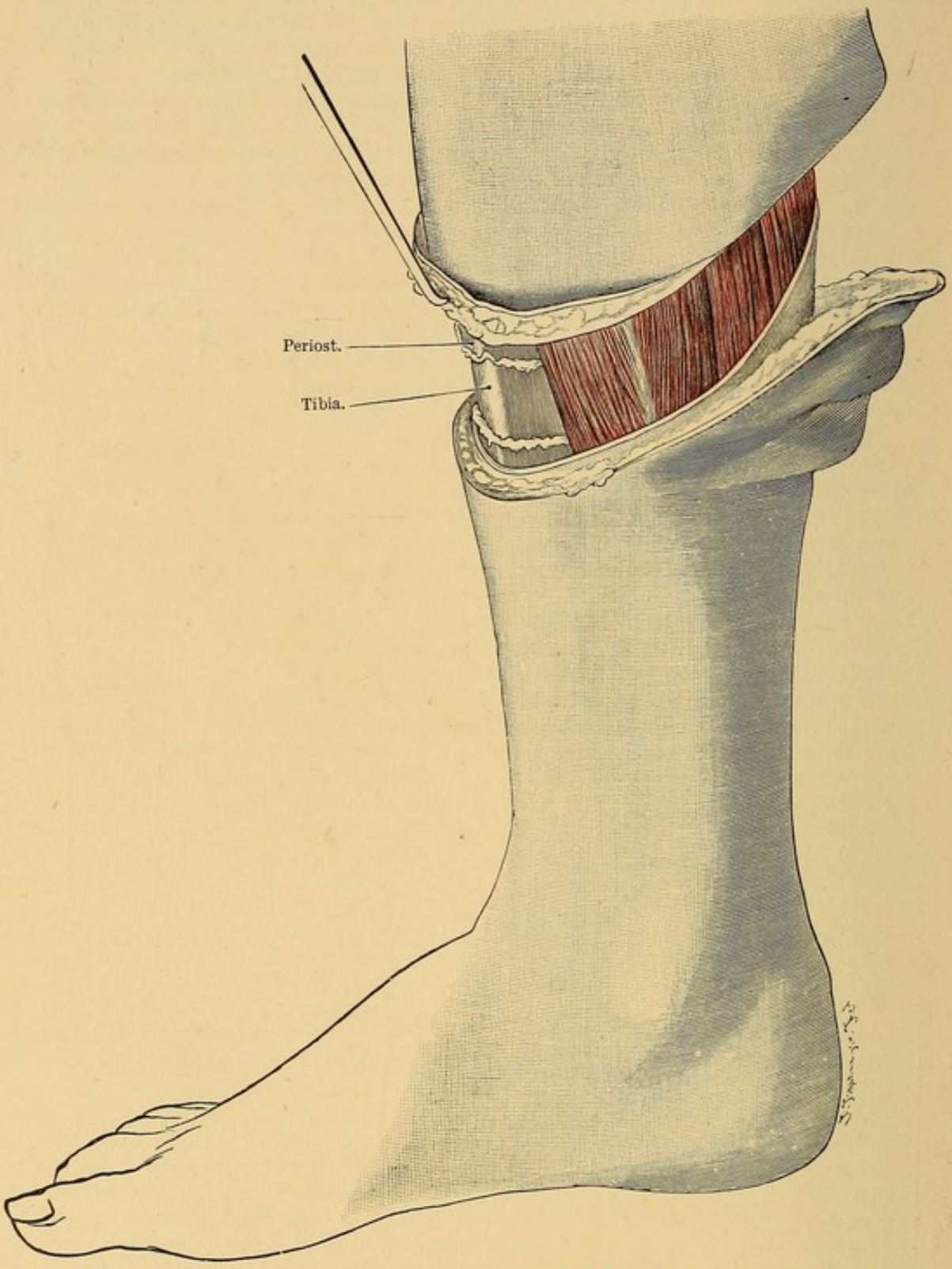


FIG. 229.—Osteoplastic amputation of the leg. An oblique incision is made through the skin and fascia, which are retracted; the periosteum of the tibia is divided and stripped slightly upwards.

It is desirable to retain the continuity of the deeper parts with the skin, otherwise necrosis of the latter frequently occurs. Figs. 229, 231, show how this may be done, the saw being still used. The disadvantage of the chisel is that it often causes con-

siderable 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. The oblique incision should be the one usually employed; and when amputating high up and low down in the leg, the flap should be placed anteriorly so as to cover over the convexly sawn epiphyseal extremities. Poncet has shown, after careful observation, that disarticulation at the ankle with a dorsal flap also provides a very serviceable stump. Lastly, Guyon's incision may be employed in disarticulating at the ankle, making an incision extending downwards as far as the lowest point of the tuberosity of the os calcis, thus obtaining a perfectly flat heel flap.

In the region of the shaft, on the other hand, the oblique circular incision is directed in such a way that the flap is placed antero-externally, so that the anterior border of the tibia (which should always be rounded off) does not press so much upon it. The periosteum of the inner surface of the tibia should be included in the flap, to act as a further protection against the bone. Farabœuf recommends an

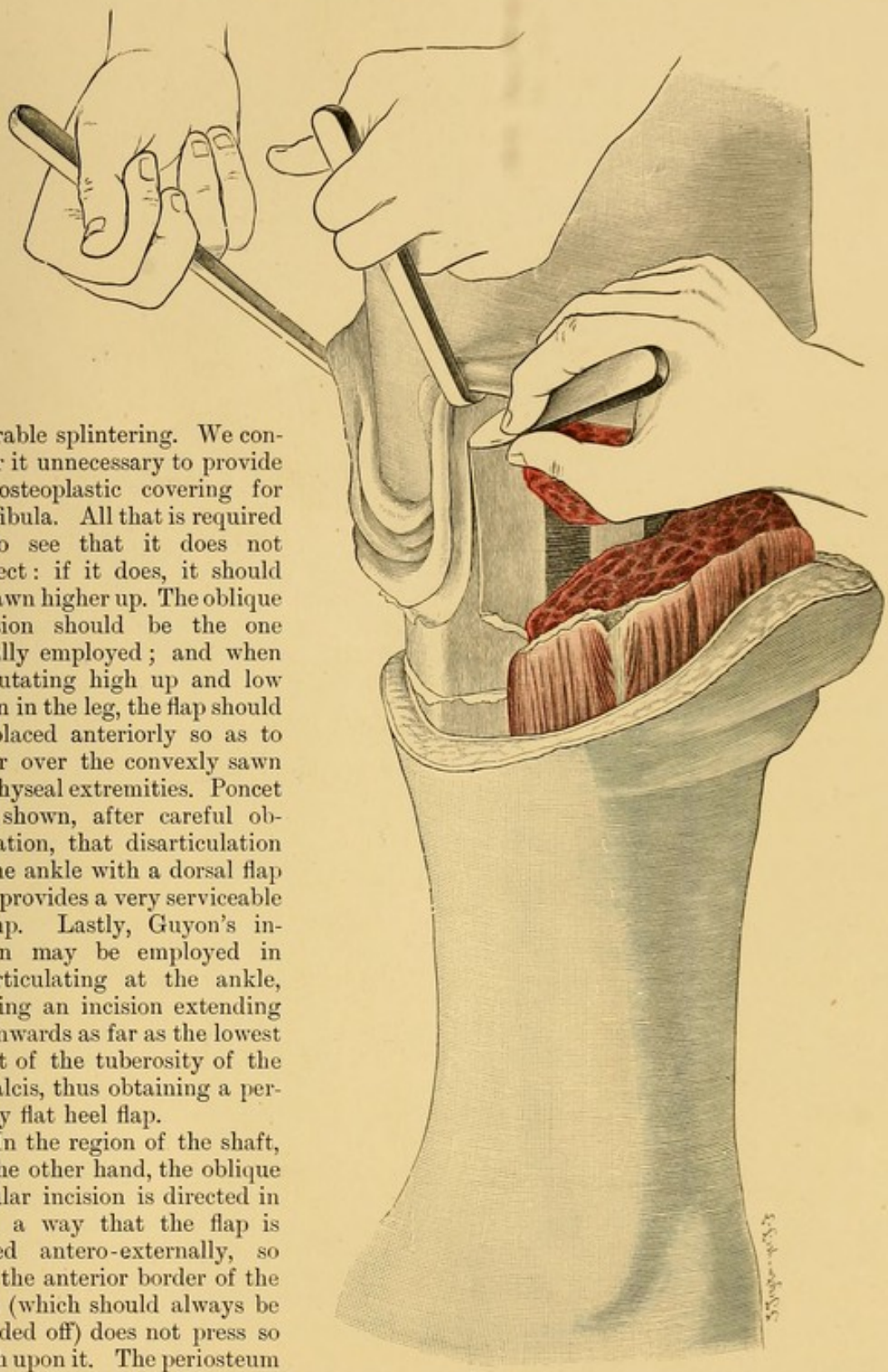


FIG. 230.—Osteoplastic amputation of the leg. The skin edges are retracted upwards; the periosteum is incised along the line at which the bone is to be sawn.

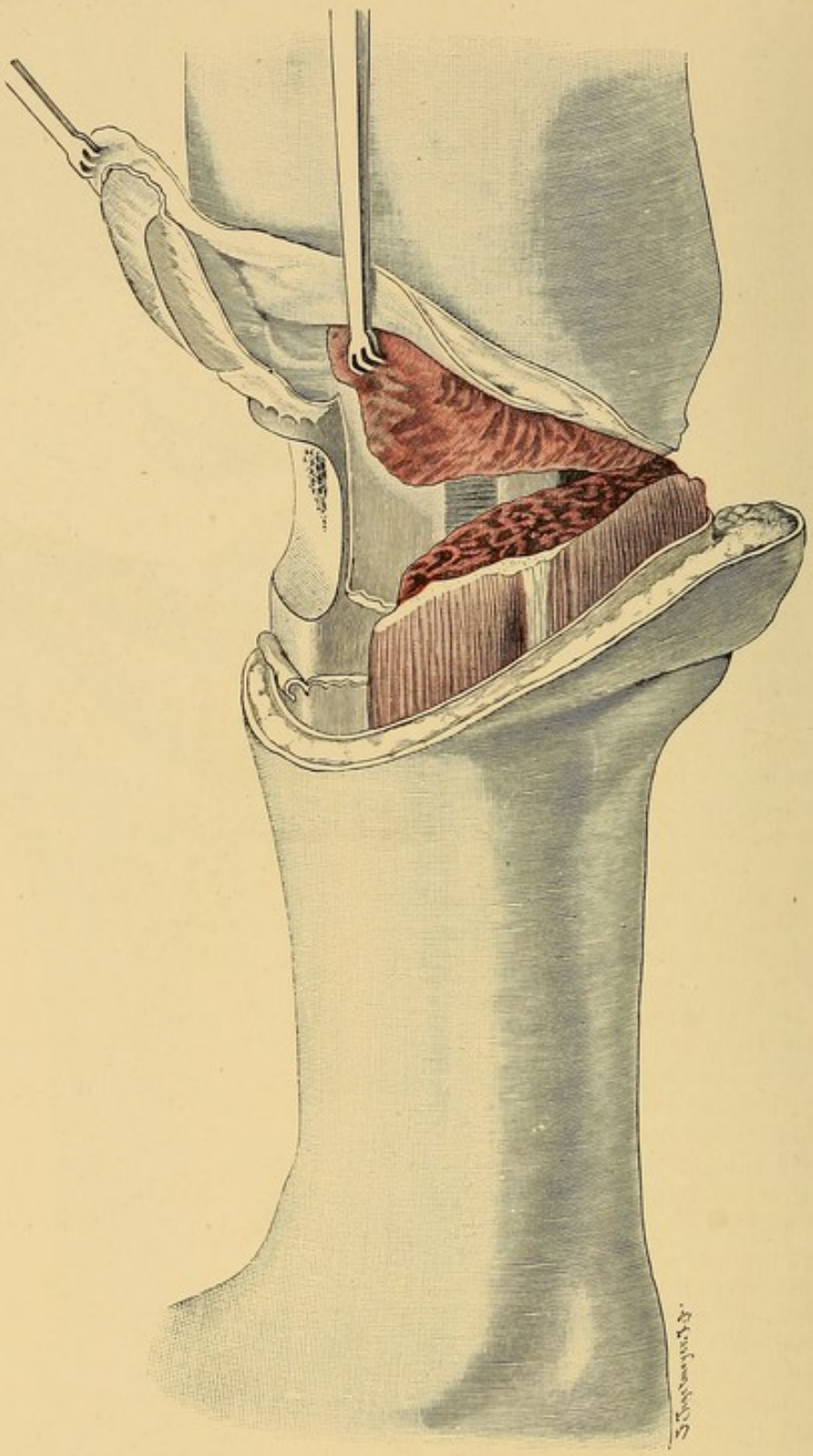


FIG. 231.—Osteoplastic amputation of the leg. A flap has been turned up consisting of skin, periosteum, and bone; the periosteum has been stripped rather higher than the base of the flap of bone.

antero-external flap, which includes all the soft parts down to the bone. Treves considers Hey's and Lee's plan of making a posterior flap of skin and muscle as excellent.

If it be desired to amputate through the muscular part of the leg, it is advisable to simplify the incision and to retain well-nourished muscles in the stump to ensure its mobility. Bruns has again recently recommended the circular method of Celsus (with two lateral incisions if necessary): a circular incision is carried through skin

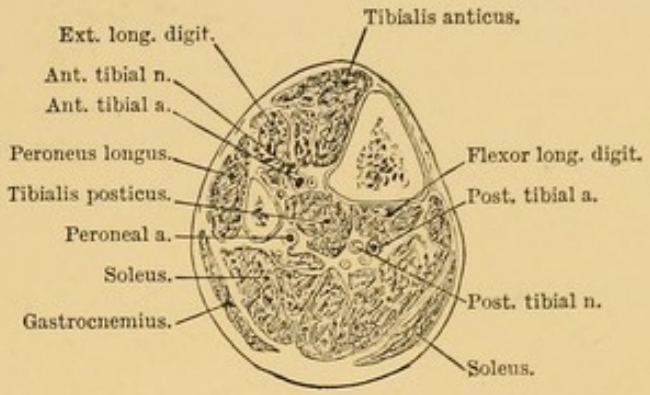


FIG. 232.—Transverse section through the leg above its middle (from a photograph).

and fascia, and these being retracted, the muscles are divided down to the bone, which is sawn across after the muscles have been retracted subperiosteally for a distance equal to half the diameter of the limb.

Teale makes a large anterior and a small posterior rectangular flap, both including all the soft parts down to the bone.

More recently it has been sought to obtain a cushion to cover the ends of the bones in the case also of amputations through the shafts of the bones of the leg, and so make it possible for the patient to bear his weight upon the stump. Ollier has employed a heel flap for amputations above the ankle, and Kummer has reduced the heel flap to a suitable length simply by allowing it to granulate and shrink before applying it to the stump.

Bier obtains a very useful stump by amputating the leg by the simple circular method, and then chiselling or sawing out a wedge of bone from the tibia above the stump, the base of the wedge being placed anteriorly: a sort of foot is formed, the pressure being borne upon the dorsal surface of the shaft of the tibia. This procedure may be adopted in amputating through less muscular parts of the leg.

The interosseous membrane adheres firmly to the bones, and is to be dissected back with a knife along with the periosteum. The muscles which lie between the bones must be cut across transversely so as to divide the vessels at the lower extremity of the flap.

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.

2. Amputations in the Region of 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: 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.

309. Disarticulation at the Knee (Figs. 233, 234). This is performed if the joint is in a healthy state, but amputation higher up is necessary if it is diseased. By

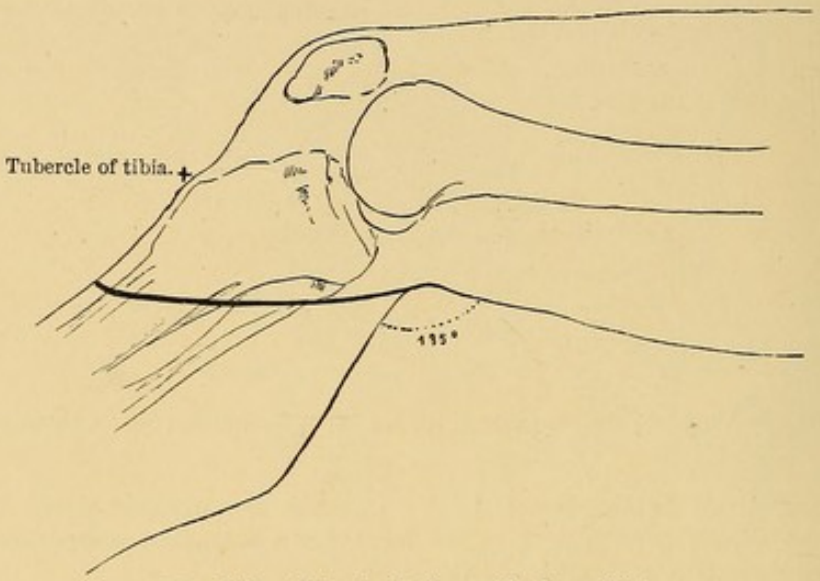


FIG. 233.—Disarticulation at the knee-joint.

retaining the capsule of the joint along with the synovial membrane (Socin) a freely movable covering for the stump is provided. Owing to the great breadth and thickness of the condyles there must be no lack of skin taken from the sides. For this

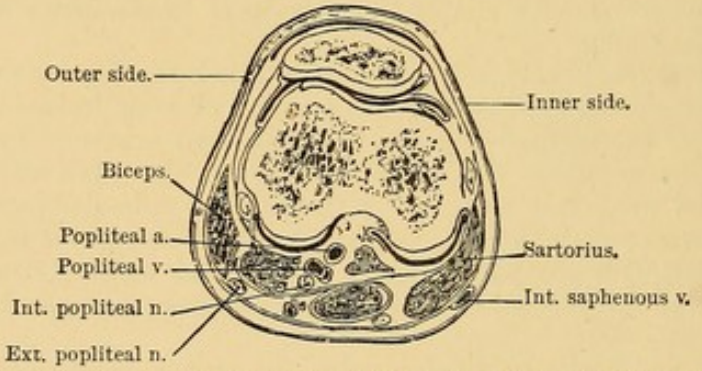


FIG. 234.—Section through the knee-joint at the level of the condyles of the femur.

reason the oblique incision is more suitable than any of the flap methods. An excellent stump is got if aseptic healing occurs.

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. 233). 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.

The method of making an anterior flap is not so good 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.

Miller, with the knee fully extended, makes a circular incision round the limb $2\frac{1}{2}$ 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 because there is no bony scar formed. When there is plenty of skin it is to be preferred to all other methods.

310. Amputations through the Thigh (Figs. 235-238) were formerly among the

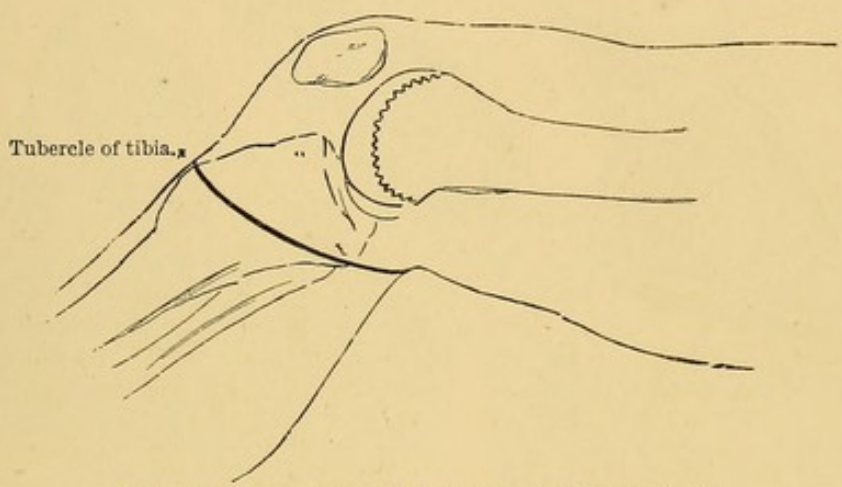


FIG. 235.—Amputation through the condyles (Carden).

most frequent amputations, and are so still. The oblique circular incision is to be recommended at all levels. Circular incisions may also be employed, but not at the lower end, on account of the bad position of the scar.

311. Amputation through the Condyles (Carden and Buchanan) (Fig. 235). 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 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 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, 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.

Lastly, Ssabanejeff has devised a form of *osteoplastic amputation* through the

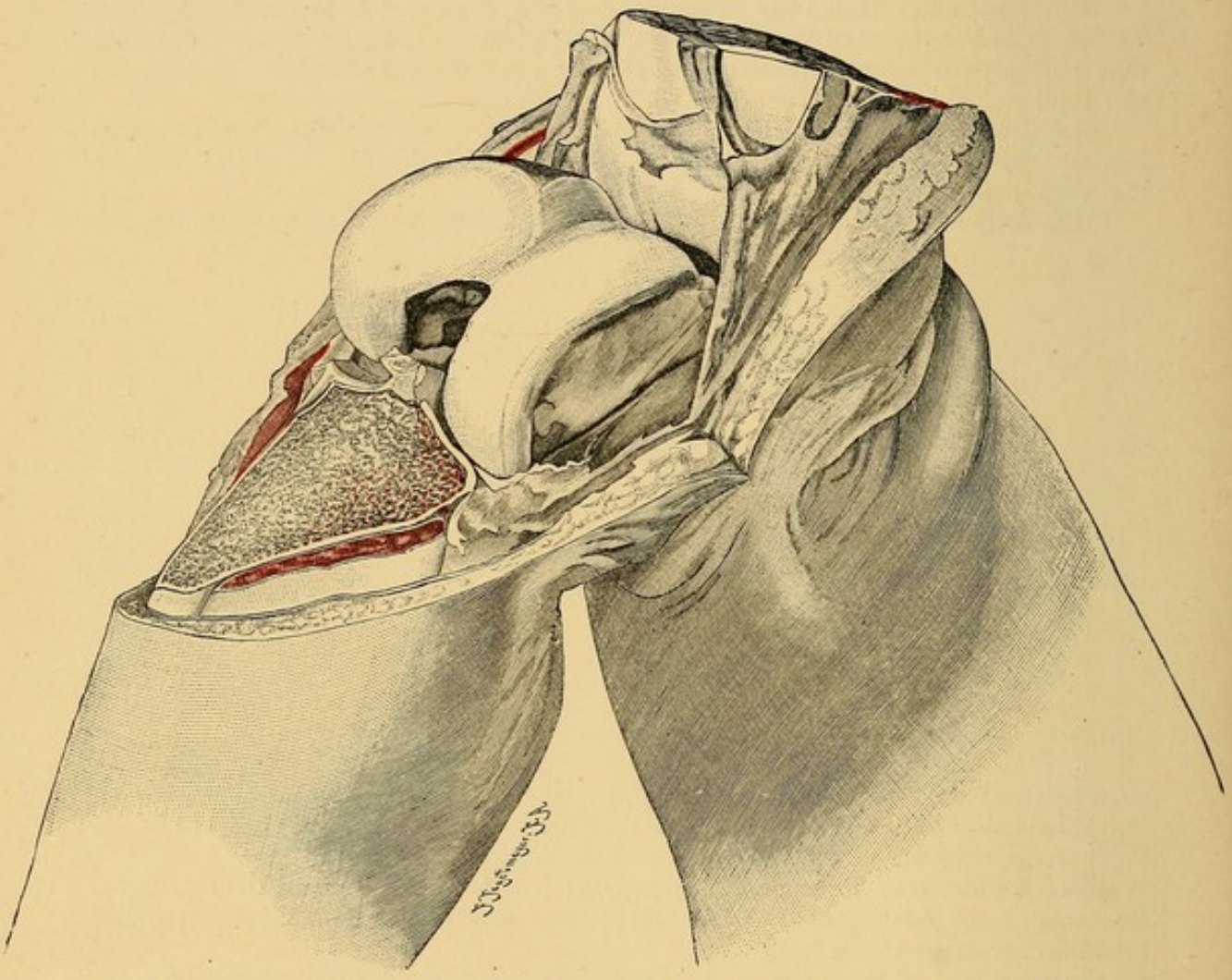


FIG. 236.—Osteoplastic amputation through the condyles of the femur (Ssabanejeff). An oblique incision has been made through skin and fascia as in Carden's amputation (Fig. 235). The tibia is sawn through obliquely upwards and backwards as high as the head of the fibula, and the flap containing the upper section of the bone is thrown backwards. The line of section through the condyles of the femur is shown.

condyles in which the anterior flap contains a piece of bone sawn from the anterior surface of the tibia. After retracting the anterior flap the saw is applied close to its edge and carried in an oblique, or, better, slightly concave direction into the anterior surface of the tibia, so as to remove from it a cap of bone (Fig. 236). The flap containing the piece of bone is reflected upwards as in the operation just described, and its bony surface is then applied to the oblique and slightly convex surface left by sawing through the condyles of the femur.

In this way the skin and bone 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 Djelitzin 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.

312. 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 the flap should be taken from the antero-internal aspect (Fig. 239), because if a purely anterior flap be made, the adductors pull the femur inwards and forwards and cause it

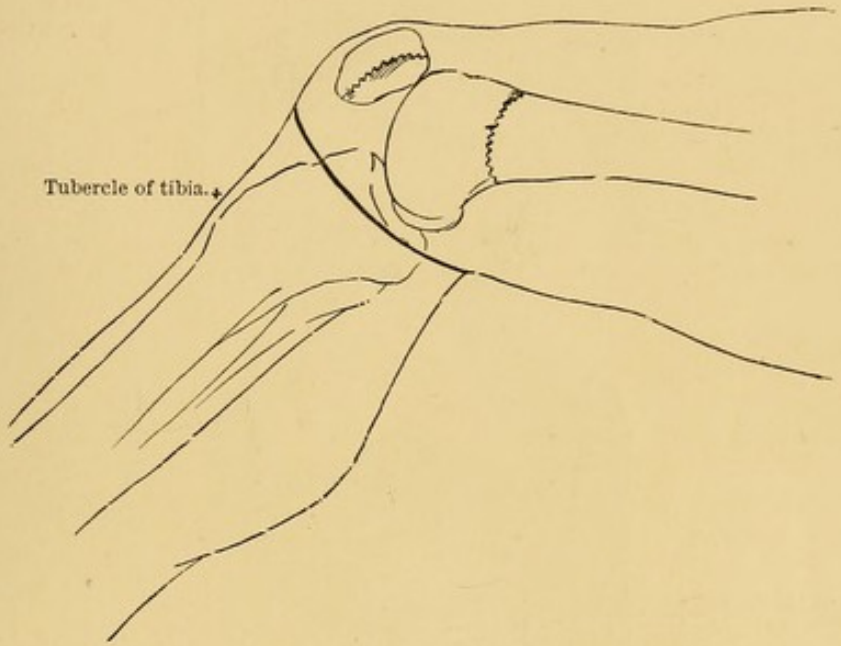


FIG. 237.—Osteoplastic supracondyloid amputation (Gritti).

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 modification of this common operation is *Gritti's osteoplastic supracondyloid amputation* (Figs. 237, 238). An oval incision is made with its upper end situated posteriorly above the prominence of the condyles, its lower end anteriorly two fingers' breadth below the patella. The ligamentum patellæ is divided close to the tibia so that it may be sutured to the periosteum of the femur, which is sawn through in a curved manner (convexity downwards) immediately above the condyles (or above the epiphysis), the periosteum being previously divided circularly 1 cm. lower. 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.

313. Amputation through the Middle of the Thigh (Figs. 239, 240). 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. In very muscular limbs the periosteum is separated upwards for several centimetres so that a sufficient skin covering may be obtained, and in order to provide a periosteal covering for the sawn surface of the bone.

314. Amputation below the Trochanters (Fig. 239) is performed by an oval incision in the same way as in disarticulating at the hip-joint. The longitudinal

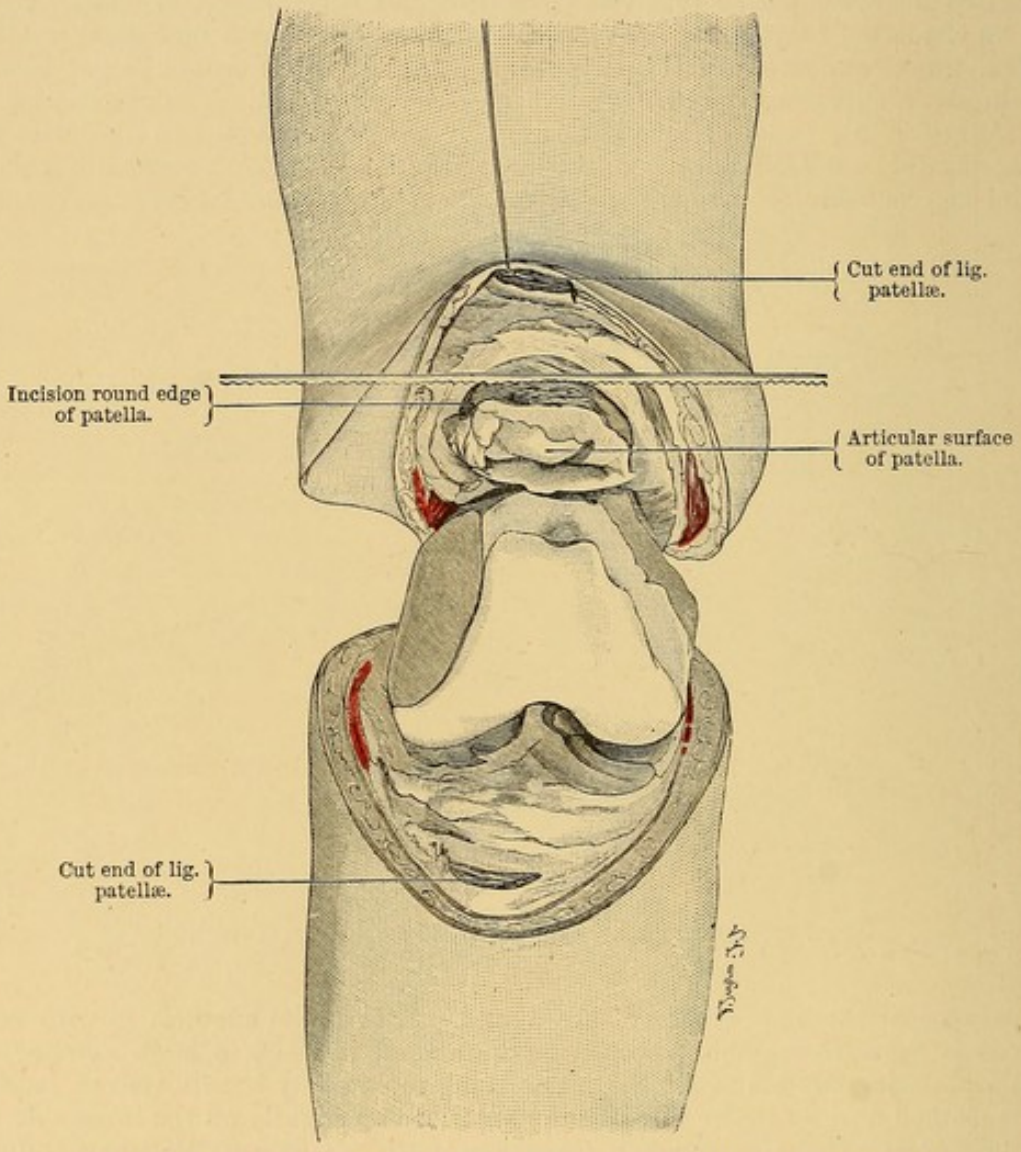


FIG. 238.—Supracondyloid osteoplastic amputation (Gritti) by an oval incision.

portion of the incision is made upon the outer aspect of the thigh, and extends down to the bone, which can thus be cleared subperiosteally up to where it is sawn across.

In amputating in the lower third of the thigh, the femoral vessels, and anteriorly and internally the anastomotica magna, and possibly also the superior articular branches of the popliteal, require to be ligatured. In the upper two-thirds, besides the femoral vessels, the profunda, and, in the upper third, the large branches of the external circumflex, must be ligatured.

315. Disarticulation at the Hip (Figs. 242, 243). 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 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 soft parts must also be removed. For all cases, on the other hand, where the 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. 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

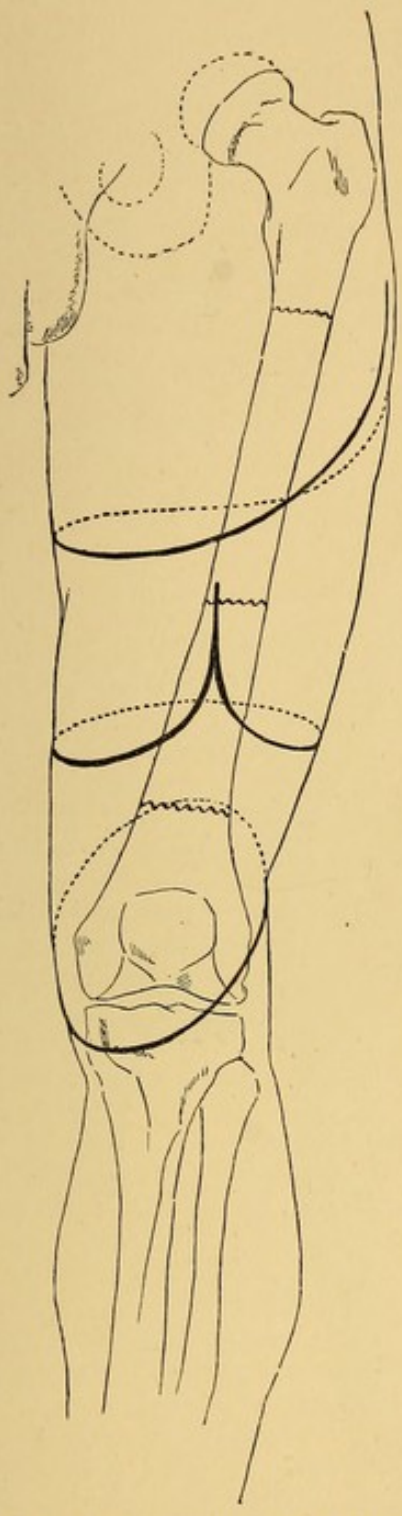


FIG. 239.—Amputation of the thigh below the trochanters; through the middle of the femur; above the condyles (supracondyloid).

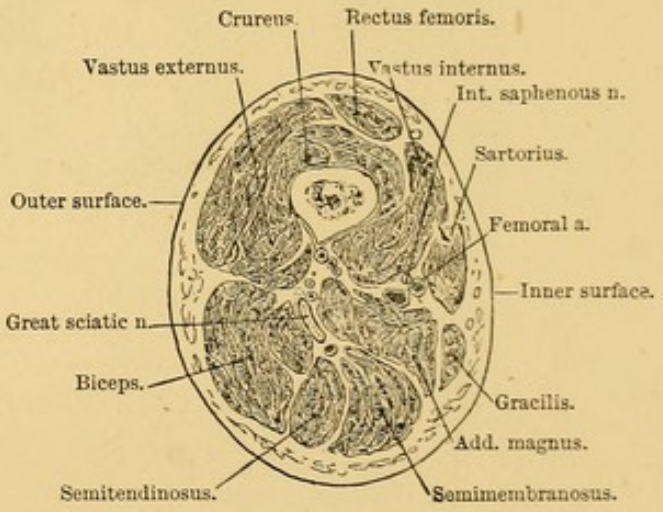


FIG. 240.—Transverse section through the thigh (from a photograph).

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

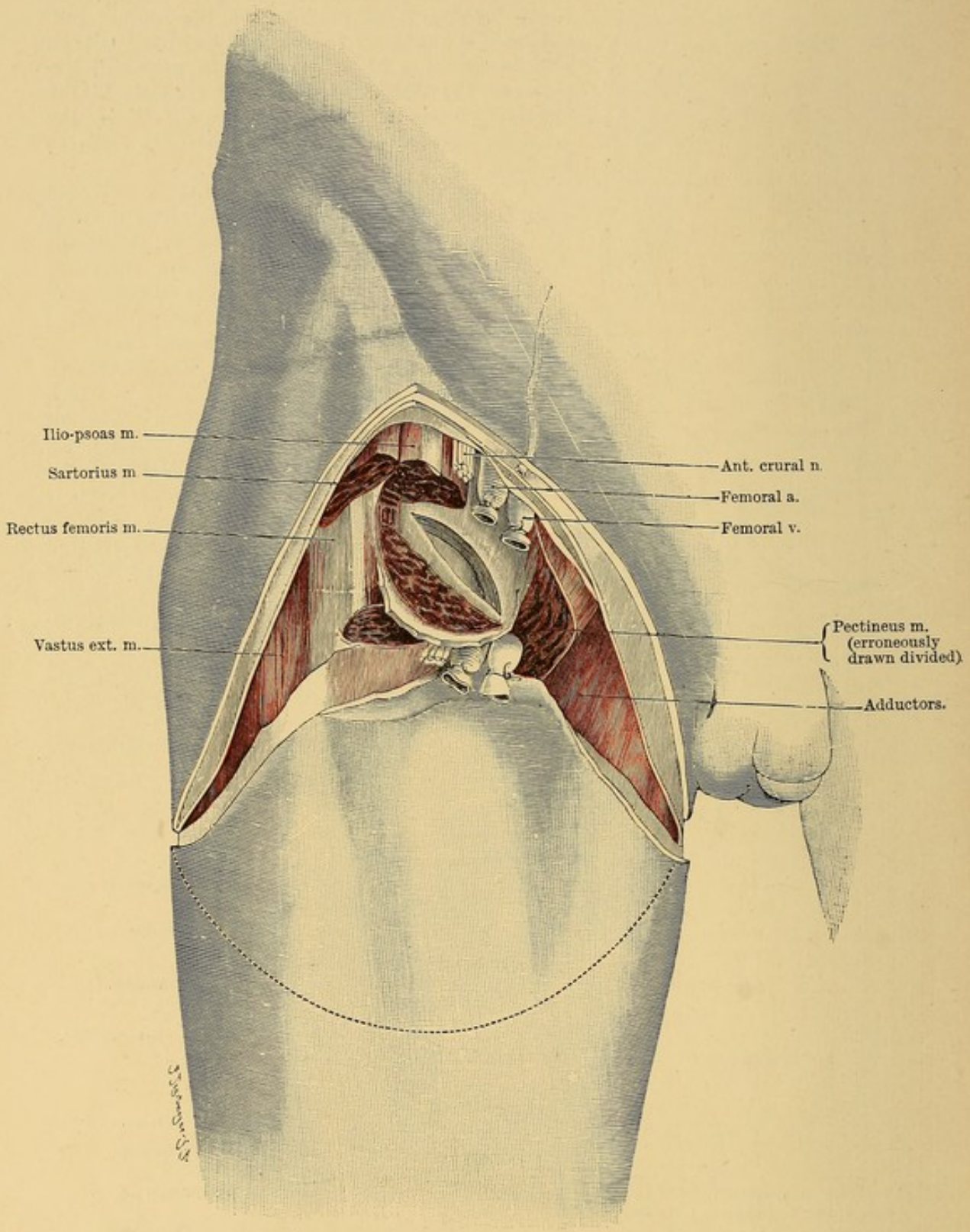


FIG. 241.—Disarticulation at the hip for disease affecting the soft parts in front. Extirpation method by the oval (or lanceolate) incision. The main vessels are first tied; the sartorius and ilio-psoas muscles are divided and the joint is opened anteriorly. The pectineus is erroneously represented as divided, whereas the anterior surface of the muscle should have been represented.

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 does 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. 241) (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. 241). 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. 242). In all cases where the soft parts in the region of the hip can be retained, this should be the regular procedure, 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 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. 239): if necessary we may adopt Liston's plan of making short anterior and posterior skin flaps and dividing the muscles circularly.

Beck and Esmarch, after amputating, 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

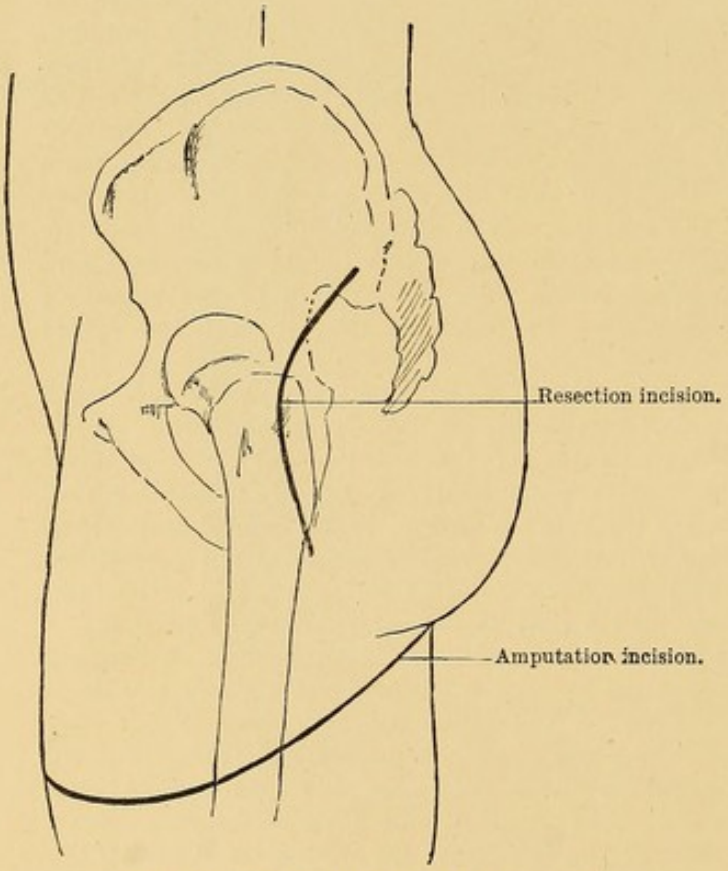


FIG. 242.—Disarticulation at the hip-joint.

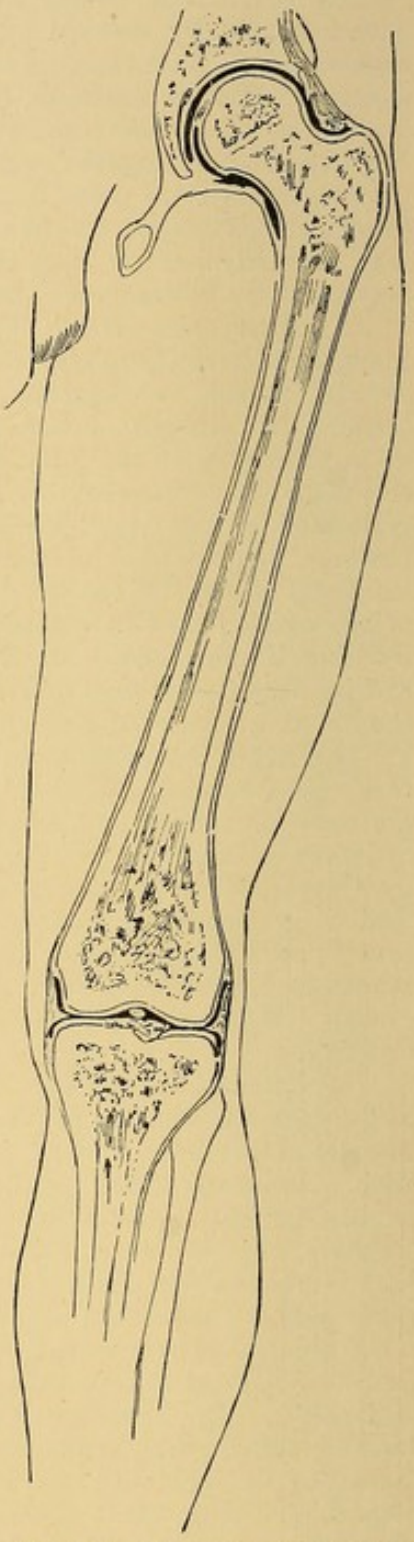


FIG. 243.—Coronal section of the hip- and knee-joints (after Henle).

cases, with no deaths (reported by Roux). Our method of operating 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 either circular or lanceolate, or two short skin flaps are formed according to the amount of skin available. 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. After being divided, the periosteum must be separated up with a blunt instrument, but the knife must be used to detach it from the linea aspera. 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, 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.

Roux, in the paper already referred to, has drawn some comparisons between our operation and the methods employed by Volkmann, Guyon, and Reverdin.

316. Interilio-Abdominal Disarticulation (Jaboulay's Operation). 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 performed 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 Girard 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. Girard has collected all the recorded cases, which he will shortly publish. We must refer the reader to his paper for a comparison of the details of his method with that of Jaboulay.

With reference to the form of skin incision to be employed, we are inclined, from our own experience of pelvic resection, to give the preference to Girard's rather than Jaboulay's method. It does not seem a matter of much importance whether or not we follow Girard in making a short anterior flap, but it is essential that the chief incision

should be made in the fold of the groin along the entire length of Poupart's ligament, so that the insertion of the external oblique aponeurosis may be divided as well as the internal oblique and transversalis muscles: these can then be raised up by the finger and the deep epigastric artery and vein ligatured, and in this way access can be got to the tumour lying deeply in the iliac fossa. By dividing the fascia transversalis and raising up the peritoneum, the main vessels can be conveniently ligatured and the anterior crural nerve divided. In severe cases the best plan is to ligature the common iliac vessels, as it is only by this means that we can be certain of preventing a fatal rush of blood. The psoas is then divided transversely, and by detaching the aponeurosis of the external oblique from the pubis the seat of division of the pelvis towards the middle line can be determined. In suitable cases the rami of the pubis and ischium may be exposed subperiosteally and divided with bone forceps without further injury. By this means the subsequent separation at the sacro-iliac joint is much simplified, and by avoiding the plexus of veins behind the symphysis and the origin of the corpora cavernosa, hæmorrhage is restricted. In our case we found, in a vascular tumour, that the only way of controlling the hæmorrhage was to ligature the common iliac artery and vein, as the veins in the muscles were greatly enlarged and caused severe hæmorrhage. Kadjan had the same experience.

If the whole of the pubis and ischium have to be removed, the division must be made at the symphysis. This having been effected, the incision is prolonged backwards and the muscles separated from the crest of the ilium, so that a finger may be passed under them into the iliac fossa as far back as the sacro-iliac joint. A gluteal flap, consisting of skin and muscle, is now made by carrying the knife rapidly along the gluteal fold so as to join the upper incision at the anterior superior spine of the ilium. By forcibly rotating the leg outwards the triangular ligament is detached from the pubis, and the transverse perineal muscle and the sacro-sciatic ligaments from the ischium. By passing above the posterior muscles the sacro-iliac joint can then be divided, without great difficulty, with a strong resection knife, the assistant meanwhile drawing the bulging viscera of the iliac fossa, along with the peritoneum and transversalis fascia, well over to the opposite side.

Next, the large and small gluteal muscles are detached from the sacrum, the branches of the internal iliac artery being ligatured. Last of all the great sciatic nerve is cut through.

It is always necessary to have everything ready for immediate intravenous transfusion of normal saline, *i.e.* the median basilic vein should be ready exposed for this purpose, as the bleeding is invariably considerable.

Y. UPPER EXTREMITY

317. Amputation and Disarticulation of the Fingers (Figs. 244 and 245). 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. Any method may therefore be used, but a flap from the palmar aspect is preferable, as it avoids a palmar cicatrix. The oblique circular incision is most to be recommended, and is better than Farabœuf's lateral-palmar incision for the index and little finger. 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. 244). In disarticulations at the interphalangeal joints the knife is applied over the joint line, and directed obliquely downwards towards the palmar aspect. By forcibly flexing the finger 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.

In amputations the palmar flap must be turned back before the rest of the incision is carried round the bone.

In disarticulating a finger at the metacarpo-phalangeal or at the carpo-metacarpal joint the *lanceolate incision* is used, the longitudinal portion extending backwards over the head of the metacarpal bone, or, in the latter case, over its base. The tendons are divided at the edge of the retracted skin. The periosteum is divided and separated along with the capsule.

In the case 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 removing the metacarpal bone of the thumb or little finger it is especially important to preserve intact the short muscles of the thenar and hypothenar eminences, because by so doing a very useful and movable stump is obtained, especially if the bone is removed subperiosteally.

In disarticulating a finger, with or without its metacarpal bone, the transverse incision follows exactly the line of the web of the fingers: incisions must not be made higher up in the palm.

318. Disarticulation at the Wrist-Joint (Fig. 246). 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.

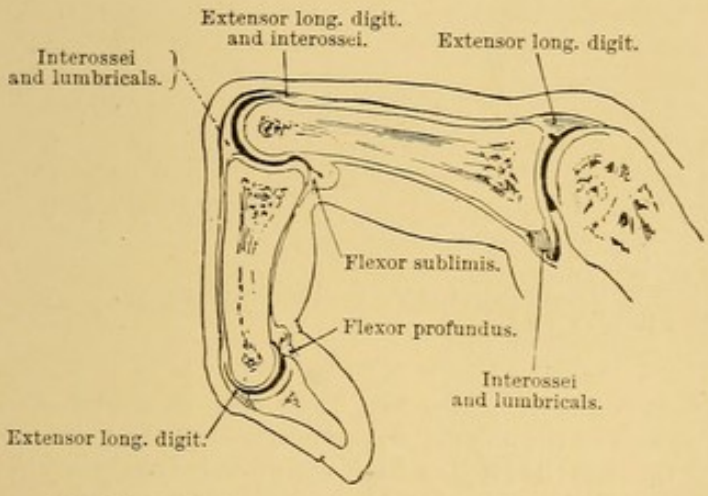


FIG. 244.—To show the line of the joints in the flexed position of the finger.

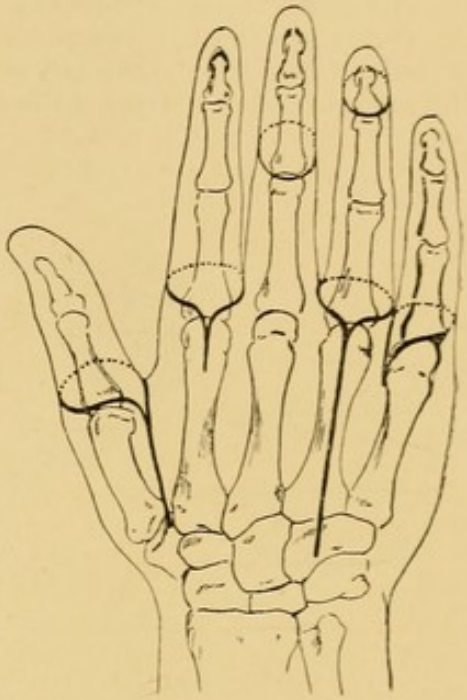


FIG. 245.
Disarticulation of little finger.
„ index finger.
„ ring finger along with its metacarpal bone.
„ thumb along with its metacarpal bone.
(Dorsal aspect of hand.)

An oblique circular incision is made with its upper end at the level of the wrist-joint and its lower end about the middle of the palm. 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, and 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 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.

The vessels which require a ligature are—on the palmar aspect, the ulnar or the superficial palmar arch, the branch to the deep arch, and the superficial volar branch of the radial; on the dorsal aspect, the radial artery.

319. Amputations through the Forearm (Fig. 246) present no peculiarities which necessitate departure from the general rules. For the same reasons as in the hand, an oblique incision with an anterior flap is to be recommended. This prevents the formation of a cicatrix in front.

The radial, ulnar, and interosseous arteries must be ligatured.

Treves recommends a circular method for the lower third, and anterior and posterior flaps for the upper and middle thirds, because in the two latter situations the subperiosteal separation of the muscles is much more difficult.

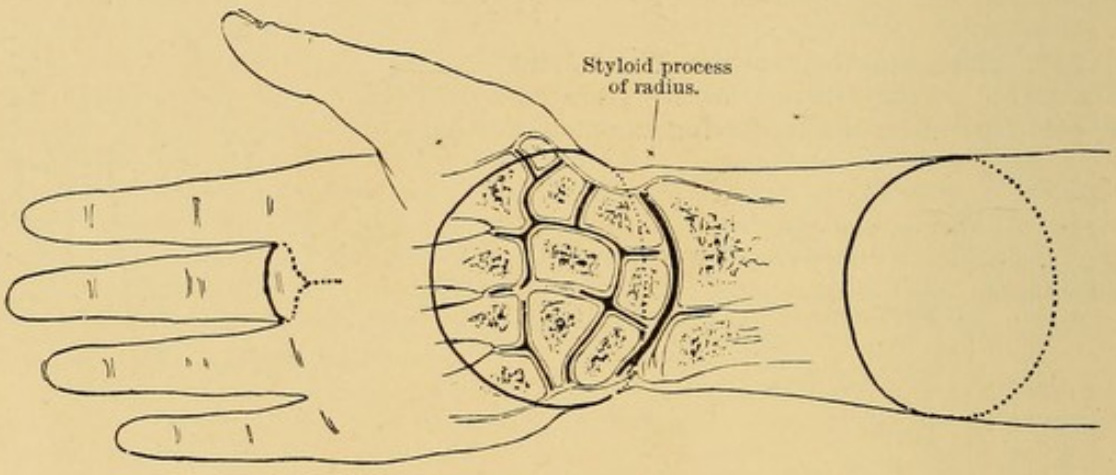


FIG. 246.—Disarticulation of middle finger. Disarticulation of the hand at the wrist-joint. Amputation through the forearm.

320. Disarticulation at the Elbow (Figs. 247, 248, 249, 250). 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 circular method described under the general principles of amputations, in which the soft parts of the forearm are divided down to the bones, and the latter shelled out subperiosteally as far as the joint, is the most simple procedure and gives the best functional results (Fig. 247). 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, beginning above and anteriorly at the line of the joint, and ending posteriorly a hand's breadth below the tip of the olecranon. With

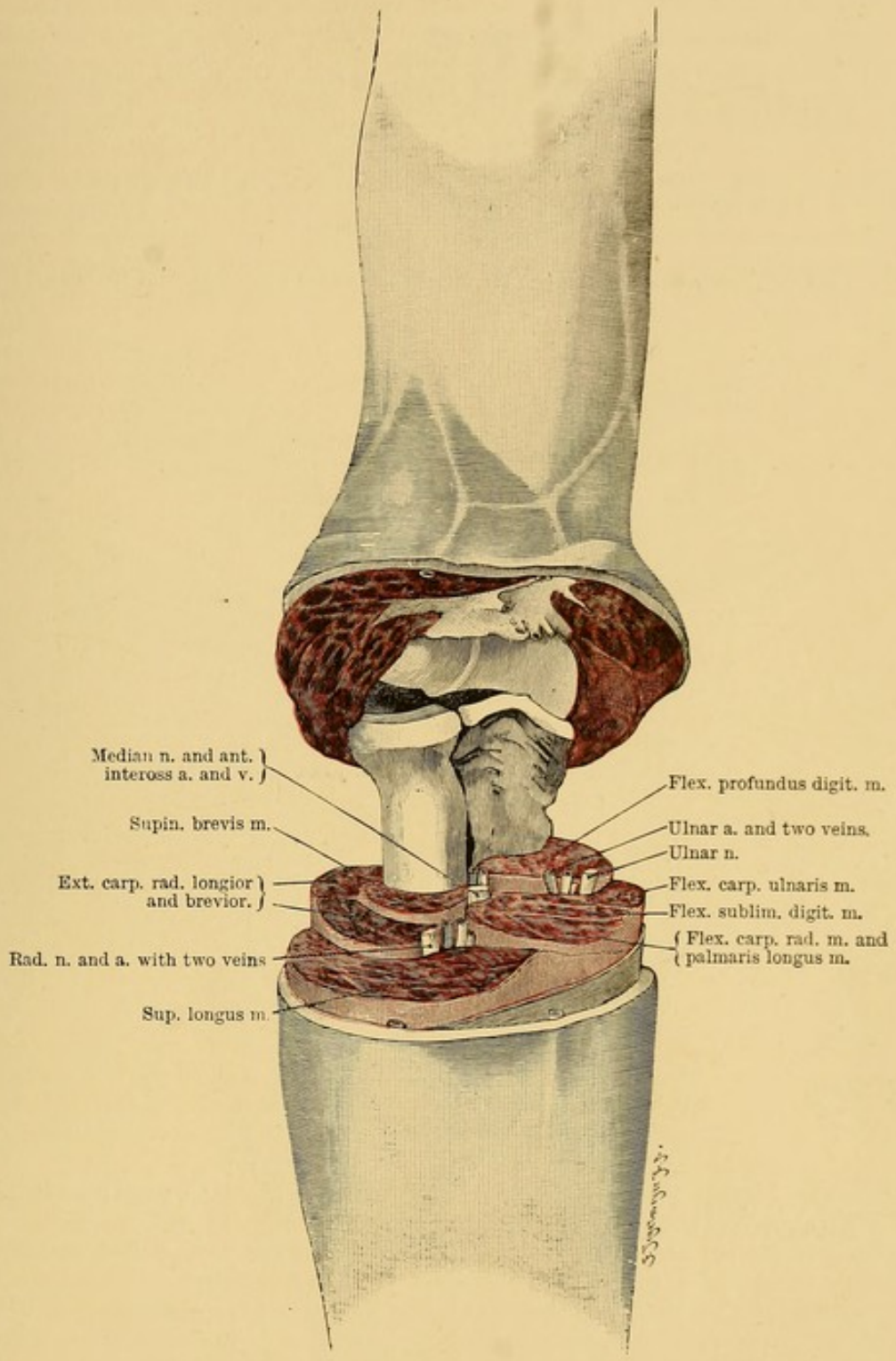


FIG. 247.—Disarticulation at the elbow-joint by a circular incision. The incision has been made down to the bone, and a "muscle-stump" provided by subperiosteal removal of the bones of the forearm. The soft parts are retracted upwards, and the joint is opened from in front.

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

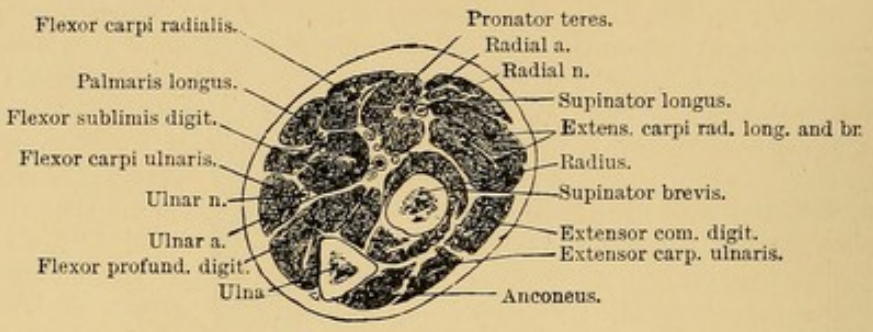


FIG. 248.—Transverse section through the upper third of the forearm (from a photograph).

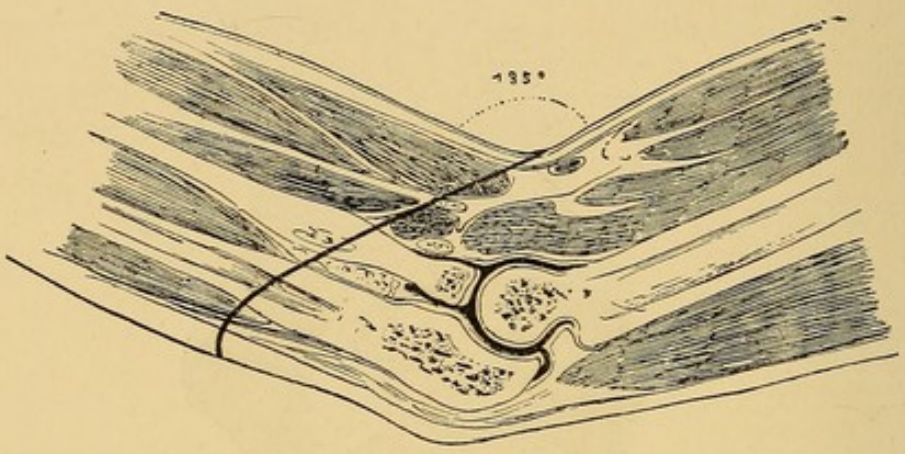


FIG. 249.—Disarticulation at the elbow-joint.
(Longitudinal section through the elbow-joint, after Braune.)

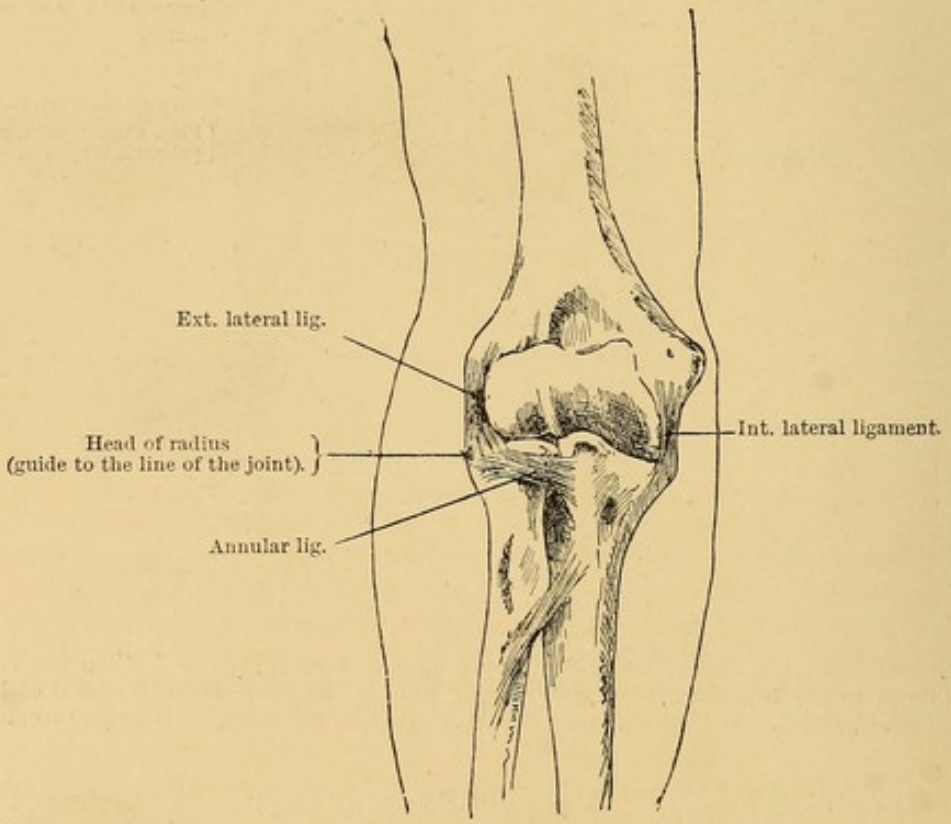


FIG. 250.—Ligaments of the elbow-joint.

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.

321. Amputation through the Upper Arm (Fig. 251). 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

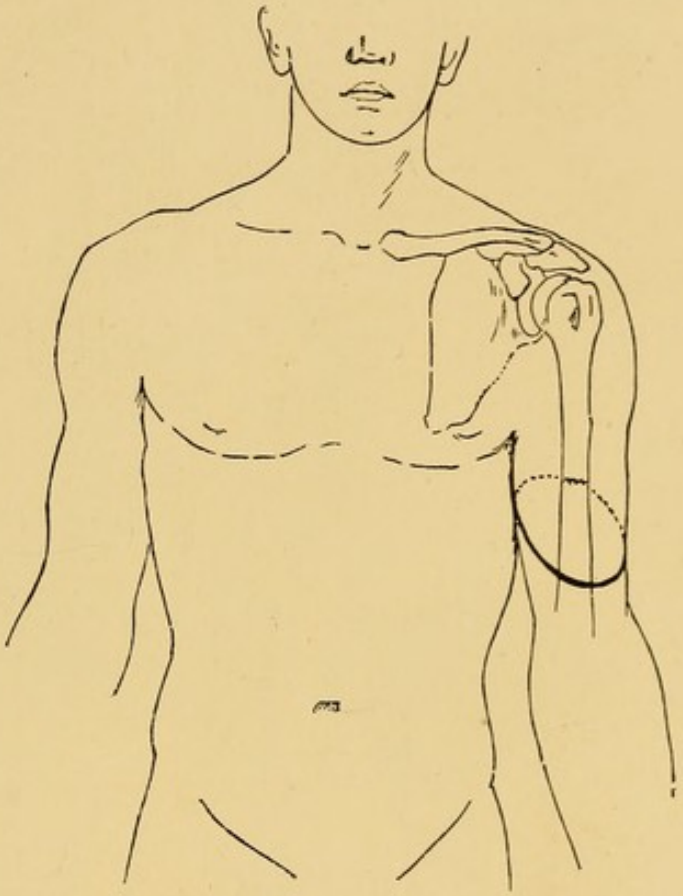


FIG. 251.—Amputation through the upper arm.

internal bicipital sulcus. The biceps retracts very much. A simple circular incision answers very well 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.

Moreover, the plan of amputating above the insertion of the deltoid and the adductors is a good one, because the rotation of the head inwards and outwards is retained and the application of an artificial limb is facilitated. The method resembles that to be described for disarticulation, except that the incision begins at the tip of the acromion (Guthrie's lanceolate incision). The rules for high amputation are practically the same as those for disarticulation at the shoulder-joint. The brachial and superior profunda arteries, together with the smaller arteries, namely, the

inferior profunda and possibly the anastomotica magna, must be ligatured. When the bone is sawn where the musculo-spiral nerve winds round it, it is very important to resect the end of the nerve.

322. Disarticulation at the Shoulder (Figs. 252, 253). 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 anterior racket and the anterior lanceolate incisions.

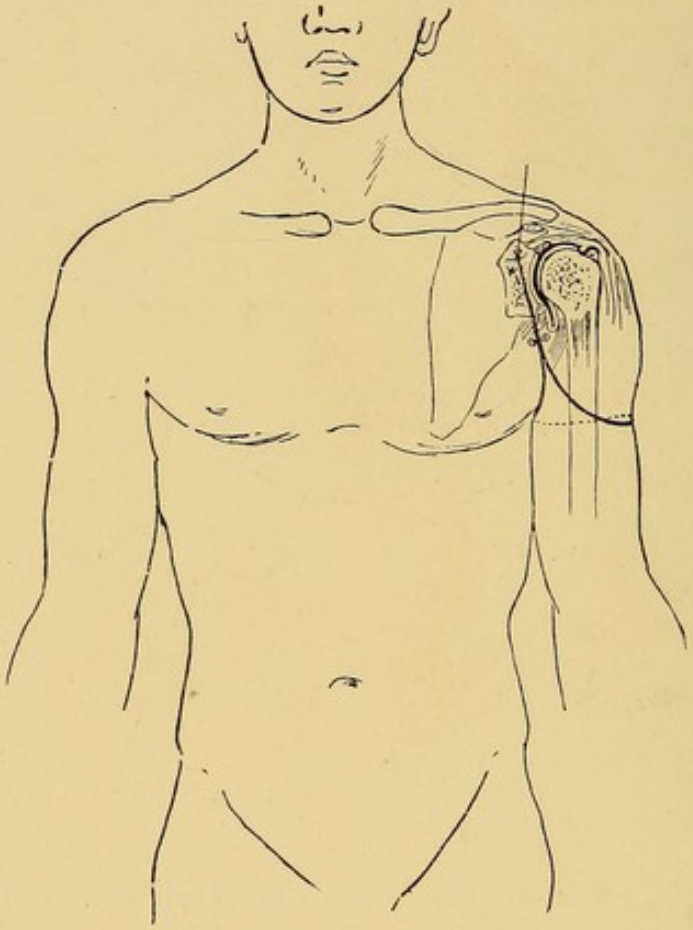


FIG. 252.—Disarticulation at the shoulder-joint.

In all cases, on the other hand, where the soft parts of the shoulder must be completely removed, one has to employ modified incisions analogous to those described for disarticulation of the arm and shoulder girdle. 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 performed by doing 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. This method, however, is not necessary, as the hæmorrhage can be as easily controlled by employing a simple lanceolate incision, which can be made with a single sweep of the knife.

Especially in the ordinary cases requiring disarticulation, viz. crushes of the arm, 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

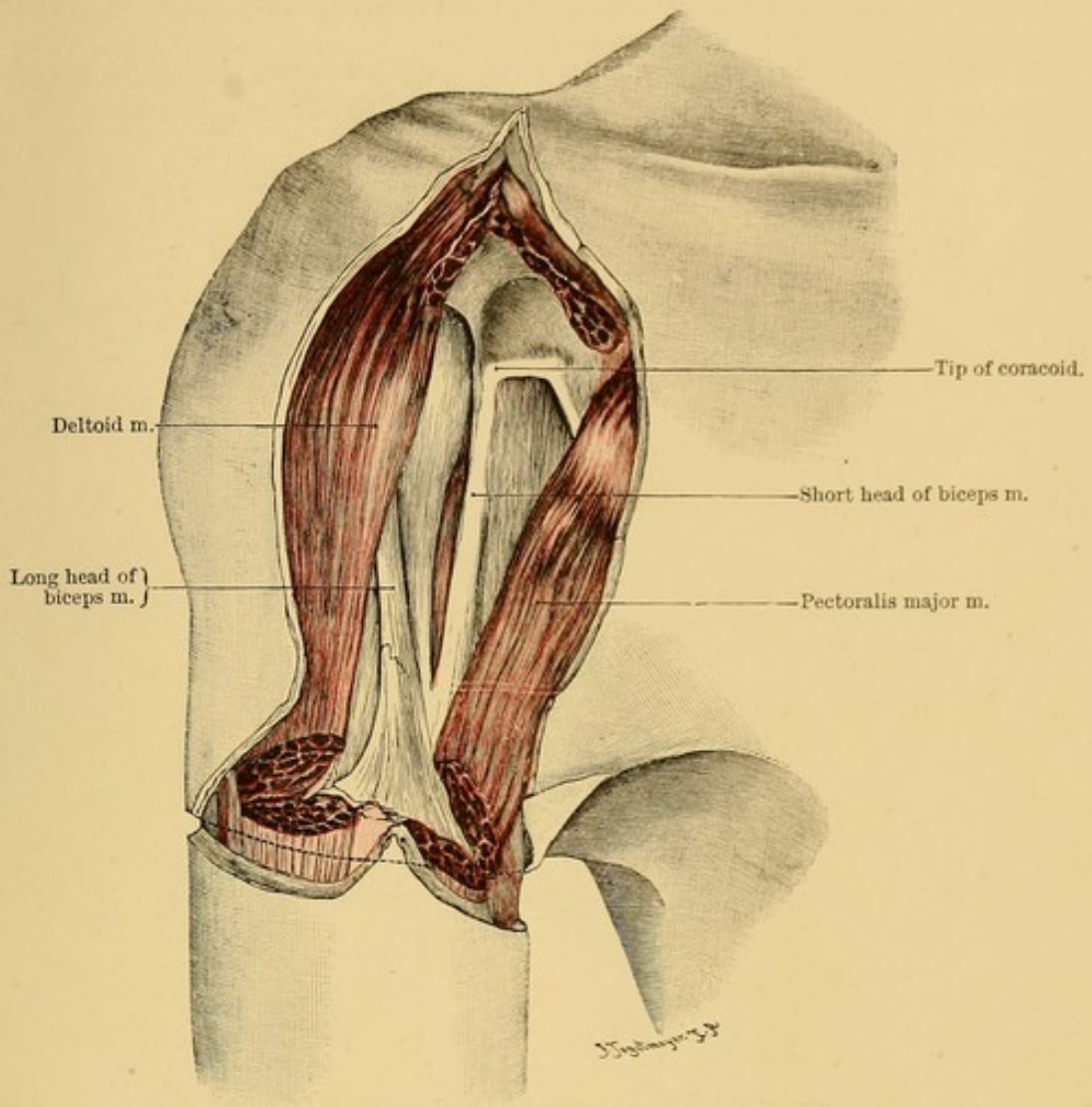


FIG. 253.—Disarticulation at the shoulder by the racket incision. The incision is made along the anterior edge of the deltoid, commencing above the coracoid process, which is exposed along with the origins of the short head of the biceps and the coraco-brachialis. The anterior border of the deltoid has 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.

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 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]

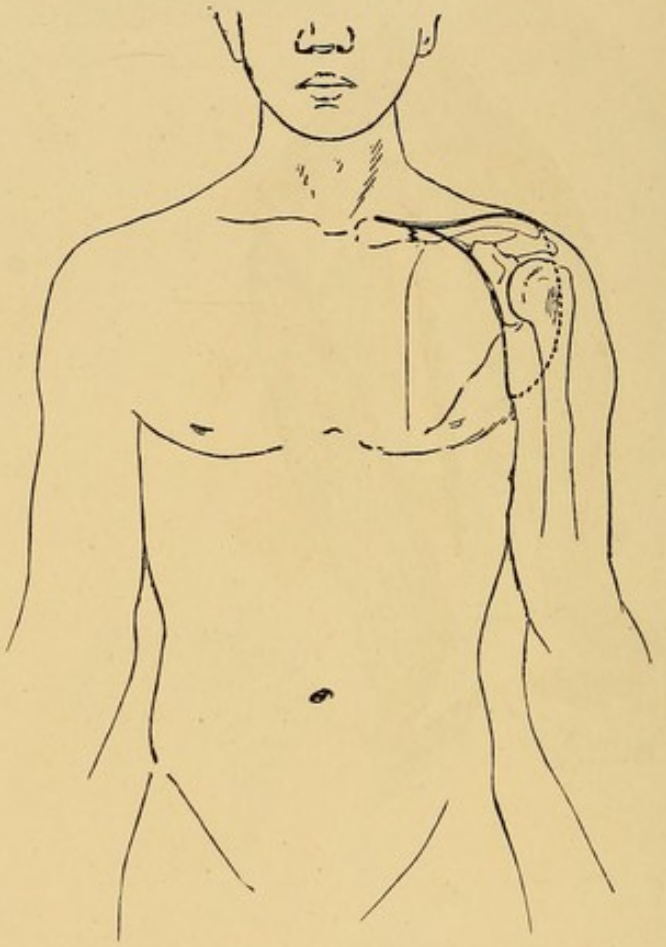


FIG. 254.—Removal of the upper extremity together with the shoulder girdle.

Larrey's racket method, recommended by Farabœuf, in which the longitudinal incision is placed externally, is not so good, as it does not avoid the circumflex nerve, and therefore causes paralysis of the deltoid.

323. Disarticulation of the Arm, together with the Shoulder Girdle (inter-scapulo-thoracic amputation, Figs. 254, 255). Berger's operation is most commonly performed for injuries and tumours of the head of the humerus and the scapula, but 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). Thanks to the exact manner of carrying it out, the operation is no more dangerous than disarticulation at the shoulder,

[1] Spence's *Lectures on Surgery*, vol. ii.

and gives far better permanent results. In 1898 Berger found that out of forty-six

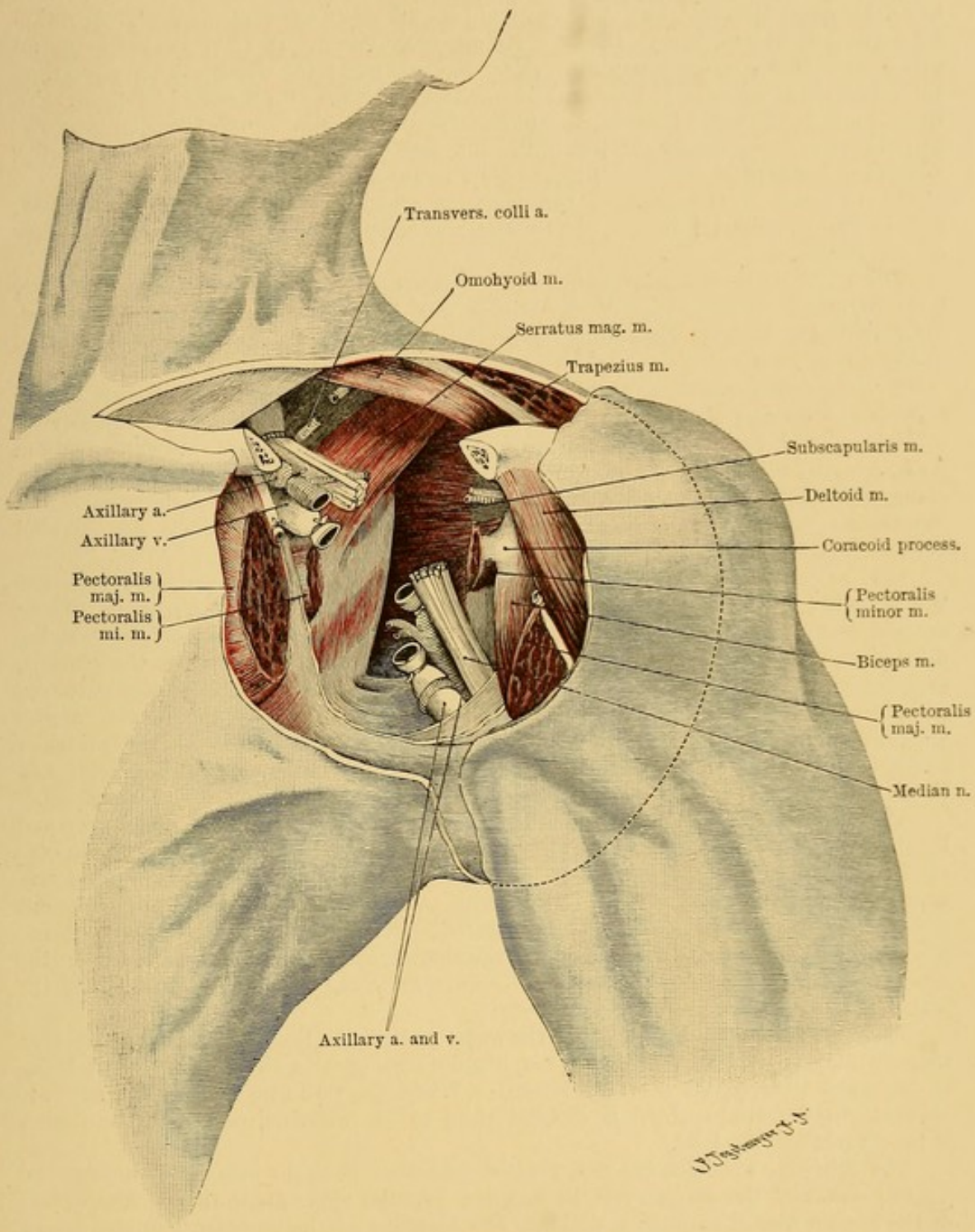


FIG. 255.—Disarticulation of arm and shoulder girdle, anterior incision, followed by division of clavicle pectorals, main vessels, and brachial plexus. The chest wall is seen on the left; the anterior aspect of the scapula covered by the subscapularis occupies the floor of the wound.

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.

In tumours of the head of the humerus which are completely circumscribed, and in circumscribed tumours of the scapula, excision of the bone takes the place of amputation.

The application of a tourniquet is out of the question. The first step, therefore, is to begin the incision in such a position that the main vessels may be ligatured, the rest of the incision depending upon the extent to which the skin is implicated in the disease.

A *lanceolate incision* is usually employed, beginning at the sternal end of the clavicle and passing along it to the acromion process. The periosteum of the clavicle is divided, and the bone sawn through at its inner third, drawn outwards with a hook, and the subclavius muscle carefully separated. The subclavian artery and vein, along with the cords of the brachial plexus, are exposed by dividing the muscle and the fascia. The nerves are cut across individually and the vessels are divided between two ligatures.

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 now 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. The skin incision is prolonged downwards towards the anterior fold of the axilla, the pectoralis major and minor are cut across, and the vessels secured and ligatured. When the axilla contains infected glands the muscles are divided close to the thorax and the vessels secured. In the absence of infected glands the muscles are divided close to their insertions into the humerus and coracoid process respectively.

The dissection is continued along the outer wall of the thorax towards the serratus magnus and 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 arm and shoulder are now 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. The posterior skin incision is now completed from behind, as shown in Fig. 255, and the arm and shoulder girdle are removed without appreciable loss of blood.

Our description thus corresponds essentially to the interscapulo-thoracic dis-

articulation of Berger, who, along with 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.

APPENDIX

THE FREEING OF THE DUODENUM AND GASTRODUODENOSTOMY[1]

ACCORDING to Villard, in 1892 (a few years after the publication of our paper on pylorectomy with subsequent gastroduodenostomy, which Jaboulay and Villard seemed to have been quite unconscious of, even in 1900) Jaboulay originated the idea of performing a gastroduodenal anastomosis for pyloric strictures. He operated on one case unsuccessfully in 1894, using a Murphy's button.

In 1897 Villard again took up the operation in an improved form. In 1900 he published three cases in which he performed what he termed "Subpyloric Gastroduodenostomy," two of which were successful. In a footnote he refers to a further successful case.

He gives full directions for performing the operation, but states that it is "not destined to supplant its predecessors pyloroplasty and gastroenterostomy, but will remain an alternative in the presence of contraindications for the one or the other."

Henle published (*Zentralblatt für Chirurgie*, 1898, Nov. 29), from the clinic of Mikulicz, a successful case of gastroduodenostomy for stenosis of the pylorus, in which pyloroplasty was impossible, but in which the position of the parts, owing to adhesions, rendered an anastomosis of the upper part of the duodenum to the greater curvature of the stomach quite simple.

Henle comes to the conclusion that the occasions on which the operation can be carried out are not frequent, and that the majority of cases that are not suited for pyloroplasty will not permit of gastroduodenostomy. Henle states that "to be able to lift up the pylorus sufficiently and to alter the horizontal part of the duodenum into a vertical position the duodenum must possess a considerable degree of mobility."

That this is not essential has been proved by Villard's operations. But there exists an inexplicable contradiction between Villard's illustrations and his descriptions. From his illustrations it appears that he does not do a subpyloric anastomosis, but unites the descending part of the duodenum to the stomach. He states that this portion of the duodenum lies deeply and is but little movable, and therefore good assistance is needed, but that when once a suture has been introduced above and below, the parts to be anastomosed can be drawn up into the wound to a sufficient extent. Whoever will try this will find that it is by no means easy. The problem, therefore, is whether or not gastroduodenostomy is destined to take a more important place in the treatment of simple strictures of the pylorus. We shall now endeavour to decide this question.

In intrauterine life the duodenum hangs free in the abdominal cavity (Merkel), and in childhood it still possesses considerable mobility. In later life its right side is directed towards, and becomes adherent to, the posterior abdominal wall, so that its anterior surface only is covered by the parietal peritoneum of the posterior wall of the abdomen. Even in the adult it may readily be demonstrated that the duodenum can be comparatively easily freed again, so that, as in the fœtus, its descending portion and inferior flexure may be rendered movable and brought forwards.

To free the duodenum in this way it is necessary to divide the parietal peritoneum to the right of the descending part of the duodenum. The membrane is divided vertically over the front of the right kidney, a little to the left of the descending limb of the hepatic flexure of the colon. The parietal peritoneum stretches, in this situation, from the front

[1] Translated from *Zentralblatt für Chirurgie*, Jan. 10, 1903.

of the right kidney to the colon, forming the upper layer of the transverse mesocolon. If the finger be passed upwards along the second part of the duodenum, in front of the peritoneum covering the kidney, it will enter the foramen of Winslow, above the superior flexure of the duodenum and behind the free border of the gastrohepatic omentum, which contains the portal vein, the hepatic artery, and the bile duct.

We recommend that this delicate layer of parietal peritoneum be divided with the knife two fingers' breadth to the right of, and parallel to, the second part of the duodenum, so that the peritoneum covering the anterior surface of the duodenum may not be injured, as would be the case were the peritoneum simply torn through.

If the divided peritoneum adjacent to the second part of the duodenum be grasped and pulled forward, the fingers can then be introduced behind the duodenum so as to raise it from the vertebral column, the vena cava, and the aorta. If the peritoneum which descends towards the colon be also divided, the inferior duodenal flexure can also be raised up, not a single vessel of any size being injured. The head of the pancreas is raised up along with the duodenum so that the concave border of the latter, which must not be separated, becomes so movable that it offers no hindrance to the raising up of the duodenum.

By this procedure the muscular coat of the posterior surface of the duodenum is not laid bare, being covered by a layer of connective tissue.

By the above manipulations the second part of the duodenum is rendered so movable that it can easily be brought up to the anterior surface of the pyloric portion of the stomach above the greater curvature.

The extent to which the duodenum can be freed depends on the arrangement of the vessels. The right gastroepiploic artery (the main branch of the gastroduodenal artery) gives off important branches which pass from the left concave border of the duodenum, across its transverse (third) part to the transverse colon. These vessels, which lie behind the upper layer of the gastrocolic ligament, do not interfere to any extent with the raising of the duodenum from the vertebral column. If the colon be thrown upwards, the large right colic artery will be seen crossing in front of the duodenum and then running along its lower margin to reach the ascending colon and the hepatic flexure. While these vessels are not so easily displaced to the left as the branches which go to the colon from the right gastroepiploic vessels, they nevertheless do not prevent the inferior flexure of the duodenum from being sufficiently freed to allow the whole of its descending portion to be raised up from the vertebral column into a convenient position for suturing. The duodenum and stomach, before being opened, must be grasped between the fingers above and below the intended line of suture so that escape of contents may be prevented.

The part of the duodenum that can be least freed is the superior flexure, because to it is attached the gastrohepatic omentum containing the important vessels already mentioned. This ligament, and its prolongation downwards along the concave border of the duodenum on to the head of the pancreas, forms an axis round which the descending limb and inferior flexure of the duodenum can be rotated forwards. The lower end of the axis of rotation is determined by the vessels which descend vertically across the terminal portion of the duodenum, and which do not interfere with the raising up of the inferior flexure and the adjacent portion of the third part of the duodenum.

During the whole procedure all that is injured are the peritoneum in front of the kidney and between it and the commencement of the transverse colon, and the loose cellular tissue in front of the vena cava and aorta. It is advisable to preserve the edge of the divided peritoneum adjacent to the duodenum, and to use it as a covering for the posterior wall of the duodenum (now directed to the right). The anterior surface of the duodenum (now directed to the left) which is sutured to the stomach has its peritoneal covering left intact. This is a matter of considerable importance in gastroduodenostomy, because the presence of a peritoneal covering prevents the stitches from cutting through and ensures a secure union of the surfaces. The mobility of the duodenum is of double importance when the movement of the pyloric portion of the stomach is interfered with by the cicatrisation and contraction which is so often present in the conditions for which this operation is performed. It is the extent of adhesion which determines the situation of the opening in the stomach, *i.e.* whether it be made in its anterior wall above the greater curvature, or behind the greater curvature, the gastrocolic ligament being in this case divided. The first method is simpler.

Our experience has shown that in most cases the different methods of gastrojejunostomy give excellent results. Now and then, however, a failure occurs, either from the establishment of a vicious circle, or from the formation of a peptic ulcer. It is not to be wondered at, therefore, that more than one author has come to perform gastroduodenostomy.

By conducting the stomach contents into the intestine at the level of, or above, the

opening of the bile and pancreatic ducts we do away with the danger of the accumulation of the biliary and pancreatic secretions in the intestine and of their regurgitation into the stomach. Nor can a peptic ulcer occur, because the neutralisation of the stomach contents and the cessation of the peptonising process occur normally as soon as ever the stomach contents enter the duodenum.

Professor Tavel informs us that in 1902 he performed gastroduodenostomy with a very good result in a man who, in spite of careful feeding, had become very anæmic from bleeding from a gastric ulcer. Tavel found that an incision through the front of the pylorus, allowing two fingers of the left hand to be introduced into the stomach and duodenum, greatly facilitates the introduction of the sutures, as the parts can then be drawn forward and kept in good apposition.

In the Transactions of the German Society of Surgeons for 1899 there appears an incomplete notice of a case operated on in a similar manner by Krönlein.

Professor Graser communicated, at Karlsbad, in 1902, the report of a case of gastroduodenostomy operated on by de Quervain.

Koslowsky (*Russisch med. Rundschaw*, 1902, Nov. 1, Berlin, Hirschwald), who has twice performed subpyloric gastroduodenostomy, regards the operation as an ideal one, and predicts for it a wide application.

After what has been said above regarding the freeing of the duodenum, the following will suffice to describe our method of performing gastroduodenostomy. The most suitable incision is one similar to that which we recommend for exposing the gall-bladder, viz. an oblique incision two fingers' breadth below and parallel to the right costal margin, beginning at the middle line. After dividing the skin and fascia the rectus muscle is cut through as far as the broad abdominal muscles. The posterior layer of the rectal sheath, the fascia transversalis, and the peritoneum are divided. In muscular subjects the transversalis muscle is split parallel to its fibres, which are then firmly drawn apart. Should any adhesions exist between the gall-bladder and the colon they must be divided. The liver is drawn upwards, the stomach to the left, and the transverse colon and the descending limb of the hepatic flexure downwards. The duodenum is then brought into view and its outer border is clearly defined. A pad of gauze is placed against the under surface of the liver, and the latter is then drawn well upwards with a suitable retractor. Gauze compresses are also employed to push aside the stomach and colon.

The delicate layer of parietal peritoneum covering the kidney is divided vertically 1½ inches external to the second part of the duodenum, and the incision is then continued vertically downwards through the upper layer of the transverse mesocolon (which is held on the stretch) as far as the larger branches of the vessels. The fingers are then introduced behind the left edge of the incision through the peritoneum, and the duodenum is separated from the vertebral column, the vena cava, and the aorta, until it can be brought forward and pressed against the pyloric portion of the stomach, which, in its turn, is compressed against the left edge of the wound in the abdominal wall so as to shut off the general cavity of the stomach and prevent escape of its contents. Both stomach and duodenum are now compressed above and below between the fingers of an assistant, and the lateral anastomosis is effected in the usual manner by two rows of sutures.

To one who has once convinced himself how easily and securely this lateral gastroduodenostomy can be performed—provided the duodenum can be rendered sufficiently movable—it will be evident how admirably the operation fulfils the indications for treatment in stenosis of the pylorus. Unlike the other surgeons who have performed gastroduodenostomy, we do not limit the operation to special cases; on the contrary we regard it as the normal procedure, and we are of the opinion that it will take precedence over all the previous methods of gastroenterostomy and pyloroplasty.

The method is subject to only one contraindication, viz. the presence of such extensive adhesions to the under surface of the liver that the duodenum cannot be sufficiently freed. This difficulty of adhesions can, however, often be overcome, as we have proved in three of our cases; but the fact of having to perform the suturing inside the abdomen is apt to interfere with the security of the stitching, especially in difficult cases. It is on this account that subpyloric gastroduodenostomy did not meet with universal acceptance. The subpyloric portion of the duodenum cannot be drawn out of the wound on account of its connection with the gastrohepatic omentum and the important structures contained within it. This fixation to the under surface of the liver may be so firm that only the lower two-thirds, or only the lower part, of the vertical portion of the duodenum, together with the inferior flexure, can be brought in contact with the stomach.

We therefore propose that, instead of Villard's subpyloric gastroduodenostomy, the name *lateral gastroduodenostomy* be given to this operation, to distinguish it from our method of inserting the divided duodenum into the posterior wall of the stomach after

resection of the pylorus. The great difference between Villard's subpyloric gastroduodenostomy and our procedure is, that we render the descending portion of the duodenum, the inferior flexure, and a considerable portion of the third (transverse) part so movable that the parts to be sutured can readily be raised up and surrounded with gauze so that the sutures can be introduced extraperitoneally with comfort and security.

We intend in future to perform lateral gastroduodenostomy in all cases of stricture of the pylorus, and only to have recourse to gastrojejunostomy in cases rendered unusually difficult by firm adhesions. We have performed the operation on five occasions, four times for cicatrical stenosis and once for malignant stricture. The results have been convincing. Regurgitation of bile either does not occur at all, or only at first, when a large gaping opening has been made. It is advisable to make the anastomotic opening as high as possible, and not too large. The patient with carcinoma was at once relieved of all her discomfort. Only one patient complained subsequently of very severe pain, and he had a simultaneous cholecystotomy performed for gall-stones. That a dilated and sacculated stomach is not so well emptied as by our inferior gastrojejunostomy is obvious. If gastroduodenostomy be performed in such a case it is advisable to occasionally wash out the stomach.

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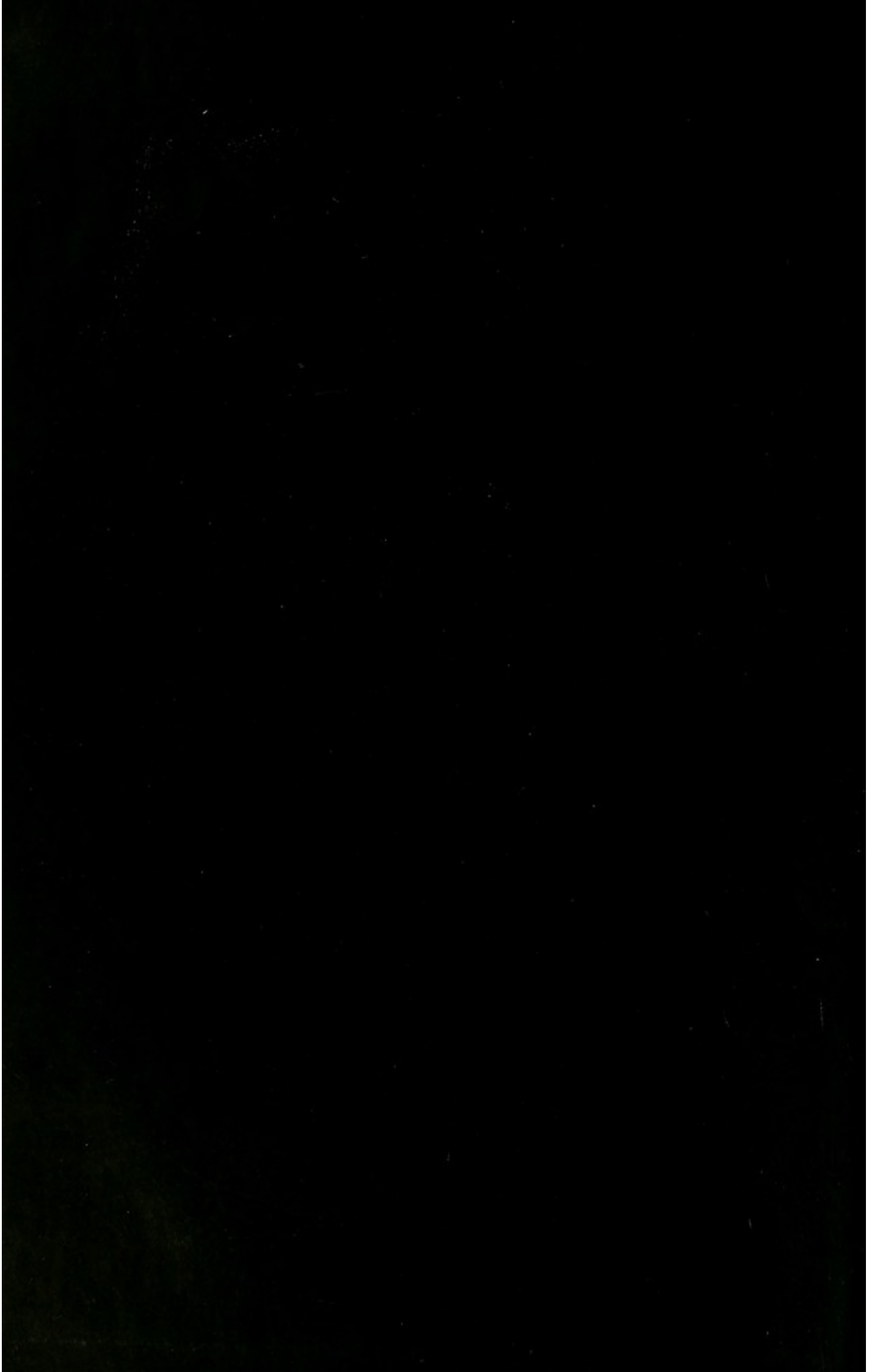

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