OPERATIVE SURGERY

FOR STUDENTS AND PRACTITIONERS

BY

JOHN J. McGRATH, M.D.

CLINICAL PROFESSOR OF SURGERY, FORDHAM UNIVERSITY; PROFESSOR OF OPERATIVE SURGERY, NEW YORK POST-GRADUATE MEDICAL SCHOOL; CONSULTING SURGEON TO THE PEOPLE'S HOSPITAL; VISITING SURGEON TO THE HARLEM AND NEW YORK FOUNDLING HOSPITALS; FELLOW OF THE NEW YORK ACADEMY OF MEDICINE; MEMBER OF THE AMERICAN MEDICAL ASSOCIATION.

FOURTH REVISED AND ENLARGED EDITION

With 364 Illustrations, Including Full-page Color and Half-tone

PHILADELPHIA
F. A. DAVIS COMPANY, PUBLISHERS
1913

Philadelphia, Pa., U. S. A.
Press of F. A. Davis Company
1914-16 Cherry Street

PREFACE TO FOURTH EDITION.

SINCE the publication of the last (third) edition many important advances have been made in surgical technique. These have been incorporated and fully described in the present edition. Much new matter and many new illustrations have been added. The minor operations have also been carefully considered and accurately described in this edition.

In the selection of individual operations the author has been guided by his own extensive experience in choosing those which have appeared to him to best accomplish the objects in view.

JOHN J. MCGRATH.

PREFACE TO THIRD EDITION.

In the preparation of the third edition particular care has been given to the section on abdominal surgery. This section has been entirely rewritten and much valuable new matter added. Many of the abdominal operations range in the class of emergency operations, for example, for acute appendicitis, for strangulated hernia, anastomosis of bowel, etc. These operations to be successful must be undertaken without delay and special attention has been devoted to the accurate description of the technique of these procedures.

John J. McGrath.

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PART I.

GENERAL CONSIDERATIONS.

ANÆSTHESIA.

General Anæsthesia.—Of the general anæsthetics ether and chloroform are the most commonly employed. Nitrous oxide and ethyl chloride are only used for short operations or preliminary to the administration of ether in order to avoid the excitement and struggling of the first stage. Of the two anæsthetics, ether and chloroform, the former is employed more commonly than the latter in the United States.

Ether is unquestionably a safer anæsthetic than chloroform, and is to be employed in all cases except where, for some special reason, its use is counterindicated. Ether stimulates the heart and increases the arterial tension. It counteracts the tendency to shock. It has a marked congestive influence upon the kidneys and acts as an irritant to the respiratory tract. Ether is therefore counterindicated in cases of marked atheroma, and in aneurism of the thoracic and abdominal aorta. In renal disease it is to be used sparingly and cautiously if at all. Bronchitis and broncho-pneumonia occur more frequently after ether than after chloroform, but some of these cases are due to exposure, dirty inhalers, and are avoidable.

Chloroform is a very dangerous drug and requires much experience and care in its administration. Statistics show ten fatalities with chloroform to one with ether. Chloroform is less dangerous when used in hot climates and high altitudes than in cool climates and lower altitudes. The first stage of chloroform narcosis is shorter than is that of ether and is not accompanied by as much excitement and struggling. Chloroform does not irritate the kidneys to the same degree that ether does. Chloroform has a peculiar depressing influence upon the heart action and lowers the blood-pressure. If the heart muscle is diseased, as in cases of myocarditis, fatty heart, and in conditions accompanied by chronic anæmia, chloroform may cause sudden death. Ether is unquestionably the preferable anæsthetic, and is to be used as the routine anæsthetic in practically all cases, reserving chloroform for the exceptional cases and for use in small quantities during the course of ether anæsthesia to overcome occasional resistance, muscular spasm, etc. Chloroform anæsthesia may be employed if the urine shows defective kidneys, although in advanced kidney disease chloroform is counterindicated on account of its destructive effect upon the secreting cells of the kidneys. Chloroform may be used where there is a tendency to cerebral apoplexy or pulmonary disease and in cases of empyema. Alcoholics and athletic persons take chloroform much more easily than ether. In these people, when ether anæsthesia is employed, it is of great advantage to occasionally add small quantities of chloroform during the course of the anæsthetization. Chloroform is well borne during labor, but should not be used in cases of threatened eclampsia on account of its destructive effect upon the cells of the liver and kidneys. Chloroform is not to be used in diabetics. In operations upon the brain and spinal cord chloroform is preferred by some operators, as the hemorrhage is said to be less than when ether is employed. In operations about the mouth and upon the respiratory passages where the mask can only be applied at intervals and for administration through a tracheotomy tube chloroform is the preferable anæsthetic. Chloroform is not a safe anæsthetic in tonsil and adenoid operations.

Mixtures of chloroform and ether or of alcohol, chloroform, and ether have been employed extensively by some surgeons, especially in England, but they have never come into very general use in America. In the chloroform and ether mixture the proportions are 2 of chloroform and 3 of ether. The proportions of the "A. C. E." mixture are 1 of alcohol, 2 of chloroform, and 3 of ether. The mixture should be made immediately before using and should be considered as chloroform. A very satisfactory method of combining ether and chloroform is to administer ether by the drop method with the occasional addition of a few drops of chloroform. This plan gives a very satisfactory anæsthesia in young children and in the aged. The admixture of ether and chloroform vapors may be obtained in any desired proportion with the Gwathmey apparatus.

ACETONÆMIA.—Ether and chloroform may both produce acetonæmia. Following the administration of ether, this condition is less serious than after chloroform because ether causes less damage to the cells of the liver and kidneys and does not interfere with the prompt elimination of the poison. After the administration of chloroform, especially if prolonged, and also in rare cases, after the administration of ether, there may occur a form of poisoning characterized by acetonæmia and fatty degeneration of the liver, kidneys, heart, and muscular structures. The changes in the liver resemble acute yellow atrophy. Symptoms usually appear within forty-eight hours after the anæsthetic has been administered. They may appear within fifteen hours or they may be delayed for five or six days. The symptoms are a greater or less degree of jaundice, persistent vomiting—the vomited matter finally resembles the dregs of beef-tea—restlessness, delirium, stupor, the patient gradually passing into a condition of coma; respiration embarrassed, maybe Cheyne-Stokes in character; skin cyanotic. The breath has a pronounced odor of acetone and the urine contains albumin, casts, and acetone, and diacetic and betaoxybutyric acids. The termination is usually fatal. This condition is more likely to occur in the young; the debilitated, starved, anæmic; those suffering from suppurative conditions; those with diseased liver, kidneys, diabetics. It may occur in those who were apparently healthy before the administration of the chloroform. That this condition may occur as the result of the administration of chloroform is another reason why this drug should be avoided, especially for prolonged operations.

Nitrous Oxide, Laughing Gas.—When pure, this agent is entirely free from irritant properties. It is supplied for anæsthetic administration in liquid form in iron cylinders.

Nitrous oxide may be employed as the anæsthetic with much satisfaction for short surgical operations, and also to induce the first stage of anæsthesia preliminary to the use of ether. In this way the struggling and muscular spasm, etc., of the primary stage of ether anæsthesia are avoided. If nitrous oxide is employed as the anæsthetic for brief surgical operations or preliminary to ether administration it may be used pure. Under these circumstances a very brief period, from one-half to two minutes, is required to induce anæsthesia.

For surgical procedures of longer duration the administration of the nitrous oxide must be interrupted with occasional inspirations of air or else the gas must be diluted. It may be administered pure, allowing occasional inspirations of air,—every second or third inspiration,—or else the slide in the tube attached to the mouth-piece may be kept partially open all the time, thus permitting continuous entrance of the atmospheric air and admixture with the nitrous oxide. In this manner anæsthesia with nitrous oxide may be continued for from five to ten minutes. During the nitrous-oxide anæsthesia the respiration should be regular and snoring and accompanied with only a moderate degree of duskiness. Nitrous oxide is to be avoided in pregnancy. If used it should not be pushed, as it is desirable to avoid marked clonic spasms which occur during the course of nitrous oxide administration. Nitrous oxide is counterindicated in myocarditis, degeneration of the heart muscle, fatty heart, and in thick-necked, asthmatic persons, and in empyema.

The mixture of nitrous oxide and oxygen is the safest of all anæsthetics, and may be used for prolonged surgical operations in many cases where both ether and chloroform would be dangerous. The condition of anæsthesia will be made much more even and satisfactory for operative purposes and without adding materially to the danger by the addition of small quantities of ether or chloroform to the mixture of gases. This is accomplished by forcing the gases through a bottle containing the ether or chloroform. The administration of this mixture requires special apparatus and special skill and experience upon the part of the anæsthetist.

Ethyl Chloride, a colorless, very volatile liquid, peculiar penetrating odor, very combustible. It is supplied in tubes or in capsules containing 3 to 5 c.c. The smaller dose is sufficient for inducing anæsthesia in children, the larger for adults. Anæsthesia is obtained in about ninety seconds and lasts about one minute and a half. Ethyl chloride is usually administered in a closed inhaler, but anæsthesia may also be obtained by throwing a continuous spray of ethyl chloride upon a Schimmelbusch mask. Rather wasteful of the drug, but quite satisfactory method of inducing anæsthesia. Ethyl chloride is a very satisfactory and safe anæsthetic for children and for short operations. It is used instead of nitrous oxide preliminary to ether in children for inducing the first stage of anæsthesia. The breathing is regular, deep, becoming stertorous; there is loss of conjunctiva reflex; the pupils become dilated; the face is not livid, and there is no muscular spasm.

Incomplete General Anæsthesia.—This plan consists in administering a liberal dose of morphin hypodermically, one-half hour before commencing the operation, and then giving the chloroform up to the point of deadening the sensation without nullifying the reflexes. In this way the pain is made endurable and at the same time, the reflexes being still active, the patient is able to cough, clear the throat, and expectorate. This plan of anæsthesia may be practiced with satisfaction in operations about the upper and lower jaw, nasal passages, larynx, etc., where there is danger of blood entering the respiratory canal and asphyxiating the patient if not coughed out.

The Administration of Anæsthetics has become much more complicated in recent years, owing to improved, but complicated, apparatus, and to the practice of combining different anæsthetics with each other and with air and oxygen. It is very desirable that the routine administration of anæsthetics be entrusted to an experienced anæsthetist wherever this is possible, and this becomes particularly necessary in unusual and dangerous cases.

The choice of the anæsthetic will vary according to the nature of the operation, condition, and age of the patient.

ETHER.—This anæsthetic may be given by the open or closed method, or by the vapor method.

Open Method.—A very common plan is to administer the ether drop by drop upon a Schimmelbusch mask, which is covered with several layers of gauze. This is commonly called the "drop method," is a very safe and simple way of administering ether, and is a favorite method with those who are not familiar with the more complicated inhalers. This method is very satisfactory for children. A few drops of chloroform may be poured upon the mask occasionally during the course of the anæsthesia or in the beginning of the anæsthesia if conditions warrant the addition of this drug. The Allis inhaler, or the old-fashioned folded-towel cone, may be used to administer ether by the open method. The end of the Allis inhaler, or folded-towel cone, may be stuffed so tight with cotton or gauze as to give the patient a very large percentage of ether.

Closed Method.—Also called the rebreathing method. This consists of breathing and rebreathing the same air charged with ether vapor in and out of a bag. A Bennett inhaler, or some one of its modifications, is employed. A great advantage of this method is that much less ether is used and the patient is therefore much less saturated with the drug. It requires less ether to induce anæsthesia and much less to keep the patient under during the course of the operation. This plan requires familiarity with the apparatus upon the part of the administrator.

Vapor Method.—After anæsthesia has been induced one may continue to administer the ether through a Junker bottle or, better, through the apparatus of Gwathmey, which permits of the admixture of chloroform to the ether in any proportion as may be indicated during the course of the operation.

The Gwathmey apparatus consists of three bottles. One bottle contains ether, another chloroform, and the third water. Air is forced through the fluids in the bottles by means of a rubber bulb that may be worked either by hand or by foot pressure. The apparatus is provided with a cock which may be arranged so as to direct all the air through the bottle containing ether, or through the bottle containing chloroform, or through both bottles at the same time in any desired proportion. Thus, if the stop-cock indicates air the patient is getting no anæsthetic whatever, nothing but unaltered atmospheric air; if the cock indicates ether he is getting all the ether vapor that the current of air passing through the ether bottle can take up; if the indicator points to chloroform he is getting chloroform; if the indicator is placed half-way between ether and chloroform he is getting equal parts of both drugs. The proportions may be changed as desired by moving the indicator. With this apparatus a safe and very satisfactory state of anæsthesia may be maintained. The mask which is used is shaped like the Schimmelbusch, but the rim is hollow and is perforated by a number of little holes. The vaporized ether or chloroform, or mixture of both, is forced through the little perforations in the rim of the mask. In operations upon the mouth, etc., the vapor may be discharged in the back of the mouth by using the bent tube shown in Fig. 1.

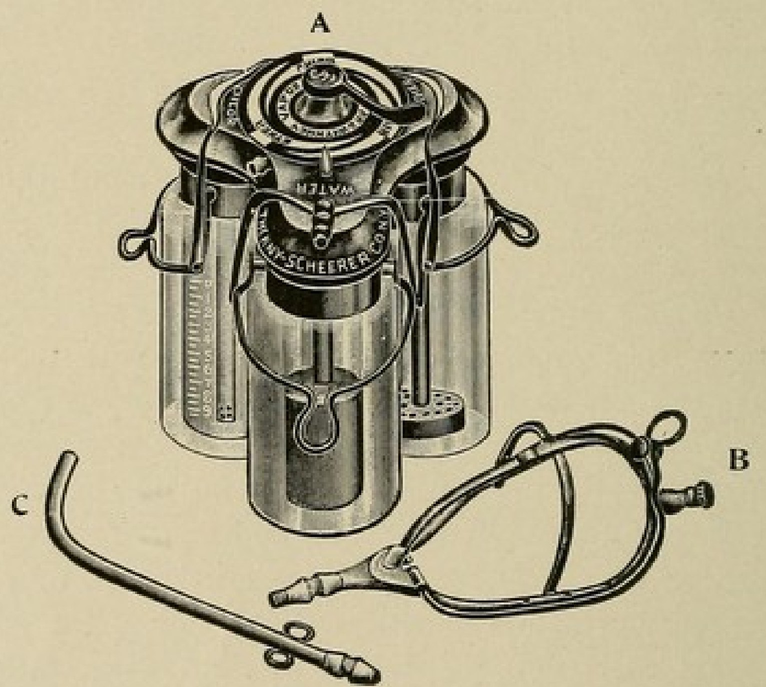

Fig. 1.—*A*, Gwathmey's three-bottle apparatus; *B*, mask with perforated rim; *C*, tube for administering anesthetic in mouth operations, etc.

It is desirable that the vapor be warmed, and this is accomplished by interposing a heater between the bottles containing the ether, chloroform, and the mask. This heater contains thermolite salts. It is placed in very hot water and thus heated. It will remain hot for one or two hours. The ether and chloroform vapor passes through the heater before reaching the mask and is thus warm when the patient

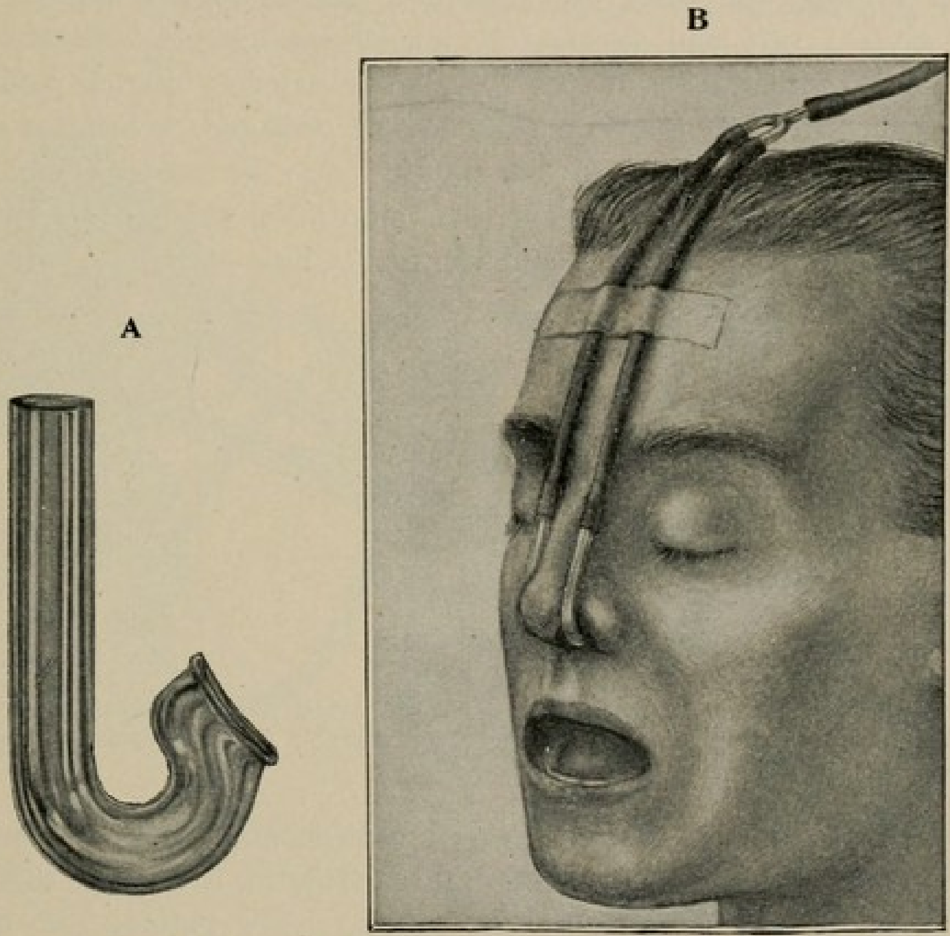

Fig. 2.—Lumbard's Nasal Tubes. *A*, Full-size tube for adult; *B*, tubes in use.

breathes it. With this apparatus anæsthesia is maintained with from two to four ounces of ether per hour.

The vapor method is valuable in operations about the head, neck, and mouth, since the vaporized ether can be administered through nasal tubes such as those of Lumbard (see Fig. 2) with the anæsthetist removed some distance from the site of the operation, or the Lumbard tubes may be used in connection with the Gwathmey apparatus. The anæsthetic may be administered through a bent metal tube placed in the mouth or a mouth-gag which is provided with perforated tubes along the blades may be used in these cases, and has the additional advantage of being a mouth-gag at the same time (Fig 3).

Oxygen may be used as the medium instead of air in ether or chloroform anæsthesia. For this purpose the Gwathmey apparatus may be used, the rubber tube from the hand bulb or foot pump being disconnected and applied to the oxygen tank. The oxygen thus passes through the ether or chloroform bottles to the mask. This plan gives a safe and satisfactory anæsthesia.

The administration of ether may be preceded by nitrous oxide up to the point of unconsciousness and loss of resistance, when the ether is gradually substituted. Ethyl chloride may be used for children instead of nitrous oxide. This plan eliminates the struggling and excitement of the first stage and represents less ether used.

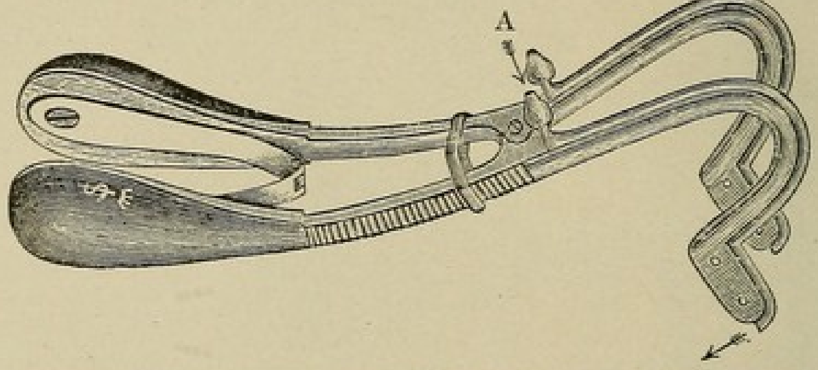

Fig. 3.—Mouth-gag with Perforated Tubes along Blades. Arrow *A* indicates ends of tubes to which the rubber tubes carrying the anæsthetic vapor are attached.

It is desirable in most cases as a routine practice to administer, half an hour before commencing the anæsthetic, a dose of morphin gr. $^1/_6$ to $^1/_4$ and atropin gr. $^1/_{150}$ to $^1/_{100}$. The patient goes under the anæsthetic more readily and less ether is required to keep him under. This is especially true of alcoholics and athletes. This preliminary dose may be omitted in the very young and in the old and feeble.

Rectal Administration of Ether has been resorted to with varying degrees of satisfaction for operations upon the head, neck, and mouth. The Gwathmey apparatus may be used for this method of anæsthesia.

Chloroform.—Chloroform may be administered by the open or drop method, using a Schimmelbusch mask and a drop bottle, or it may be administered in vapor form by forcing a current of air through a bottle of chloroform. The Junker apparatus or one of its modifications is used for this purpose. The vaporized chloroform is taken up by the air that is forced through the liquid chloroform in the bottle by compressing the bulb.

Gwathmey's apparatus, already described, is very satisfactory for the administration of chloroform, and is provided with means for warming the anæsthetic. Oxygen may be forced through the bottles instead of air, and thus we may obtain oxygen-chloroform anæsthesia.

Various sequences and combinations of chloroform and ether and nitrous oxide and oxygen may be used in special cases, and these

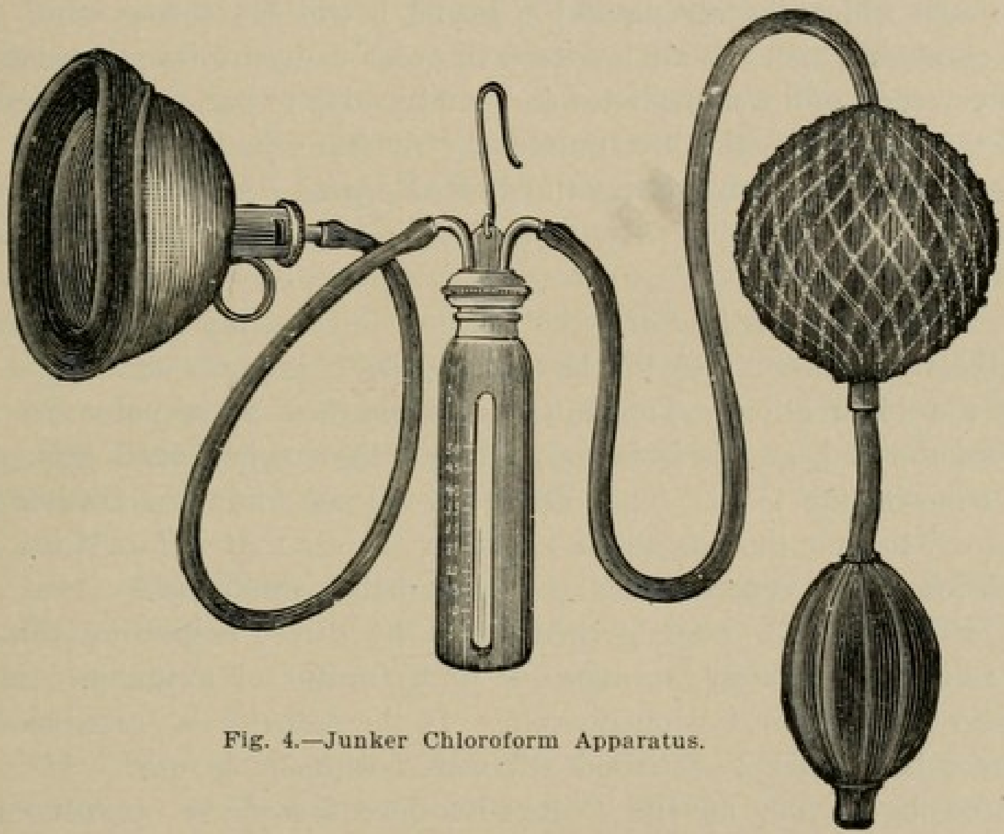

Fig. 4.—Junker Chloroform Apparatus.

mixtures give very satisfactory and safe anæsthesia. Special apparatus and special familiarity with the effects of the various mixtures are required in order to obtain successful results with these combinations.

During the course of ether or chloroform anæsthesia oxygen may be administered in varying quantity. This will often contribute much to the safety of anæsthesia in cases that would be hazardous otherwise.

Intratracheal Anæsthesia. THE INSUFFLATION METHOD OF MELZER AND AUER.—This is unquestionably a most valuable method for maintaining anæsthesia during the course of operations that necessitate opening the thoracic cavity. Ether, chloroform, or nitrous oxide and oxygen may be administered in this way. With ether and chloroform the percentage of ether and chloroform must be lower than when administered in the ordinary way through the mouth and nose—with ether the degree of saturation is not more than 10 per cent. Several different forms of apparatus have been constructed,—those of Elsberg, Janeway, Cotton-Boothby. The essentials of the intratracheal apparatus are: a source of air supply, which may be obtained either by use of a foot-pump or electric motor; a bottle containing water through which the air passes; a second bottle containing ether over or through which the air is forced in order to secure its percentage of ether vapor, and a manometer and safety valve to register the pressure of the vapor and the intrapulmonary pressure, and to allow for the escape of any pressure above the desired degree. Air filters, warmers, etc., are very desirable parts to the apparatus, but are not necessarily essential.

The patient is first anæsthetized in the usual manner, and then a catheter is passed into the larynx and down into the trachea as far as the bifurcation. The catheter is marked at a point 26 cm. from the end, and it is introduced into the trachea until this point is opposite the teeth. The catheter is a loose fit in the trachea and larynx, so that there is ample space for the air that is forced into the trachea to escape from the larynx around the catheter.

The catheter may be introduced by direct inspection through a Chevalier Jackson laryngoscope or by means of a tunneled introducer such as the Cotton-Boothby. If the catheter is introduced by direct inspection a sterilized silk-woven catheter is used. If introduced by means of the Cotton-Boothby introducer a soft-rubber catheter is employed. No. 22 is appropriate for most adults. No. 24 may be used in those cases where it is desirable to inhibit to some extent the escape of air around the tube, where it is important to maintain a higher degree of intrapulmonary pressure; for example, in operations upon the lungs, œsophagus, etc., that necessitate opening the thoracic cavity. In any given case, if the catheter is not sufficiently large, the lungs may be kept inflated by occasionally making a moderate degree of pressure with the fingers upon the sides of the larynx at the level of the thyroid cartilage. This may be done as often as necessary to keep the lungs sufficiently inflated.

With practice the introduction of the catheter into the trachea becomes a matter of comparative ease.

It is important that the pressure of the air, as it enters the trachea, should not exceed 20 millimetres of mercury.

A steady, continuous stream of air charged with ether, or whatever anæsthetic is being used, is forced through the catheter into the trachea. The ether-charged air mixes with the air in the bronchi and lungs and is free to escape alongside the catheter from the trachea and larynx. No effort is made to imitate the usual rhythm of inspiration and expiration. In cases where the thorax is open the lungs are seen to be in a condition of partial inflation, which may be increased or diminished if desired by increasing or diminishing the pressure of the gas as it enters the trachea. By compressing the larynx with the fingers upon the thyroid cartilage, and thus preventing the free escape of the gas from the larynx around the catheter, the lungs may be inflated up to their full capacity.

This method of anæsthesia demands familiarity with the special apparatus required and special skill in introducing the catheter into the larynx and trachea. With practice the introduction of the catheter becomes a matter of comparative ease. It is necessary that skill and judgment, based upon experience, be used in regulating the quantity of the anæsthetic and the pressure under which it is introduced into the trachea.

Local Anæsthesia.—The skin may be anæsthetized sufficiently for simple incision or puncture by freezing, either by the application of ice, chopped and mixed with salt, in a bag, or by the ethyl-chloride spray.

Ethyl chloride is a very volatile substance, boiling at the body temperature. It is supplied in glass cylinders with a removable brass cap. If the cylinder is held in the hand for a few moments sufficient heat is imparted to volatilize the fluid in the cylinder, which then escapes in the form of fine spray. The spray is directed against the part to be anæsthetized for a few minutes.

Local anæsthesia may be obtained by the use of solutions of cocain or some of its substitutes.

Cocain is not as satisfactory as some of its allied preparations. It spoils upon boiling, and therefore it is difficult to insure its sterility. Alone and in too large dosage, it may cause dangerous, and even fatal, vasomotor, cardiac, and respiratory disturbance, with cyanosis, mental excitement, delirium; weak, rapid, irregular pulse; slow, shallow respiration. Combined with adrenalin, it can be used with safety in relatively large doses. One grain of cocain in ½ per cent. solution up to 2 grains in $^1/_{10}$ per cent. solution may be used. The weaker the solution, the greater the quantity of the drug that may be given with safety.

Eucain is less toxic than cocain, and its solutions can be boiled without spoiling. It is not as powerful an analgesic as cocain. It is used in combination with adrenalin and may be used in double the quantity as cocain.

Novocain is not so powerful an analgesic as cocain, but has a low degree of toxicity and can be boiled. It is employed in combination with adrenalin, and can be used in much stronger solutions and larger quantities than cocain. It is very satisfactory for inducing local anæsthesia.

Stovàin is less toxic than cocain. It does not stand boiling as well as eucain or novocain. It is a favorite drug for inducing spinal analgesia.

Tropacocain is the safest and best drug for inducing spinal analgesia. It is not desirable to add adrenalin to solutions for spinal injection. Solutions of tropacocain can be boiled.

Various other substances, such as solutions of urea, quinine, etc., have been recommended from time to time as very efficient local anæsthetics.

The mucous membranes may be anæsthetized by direct application of the analgesic solution; the conjunctiva by the instillation of a few drops of 4 per cent. solution of cocain or novocain; the nose and throat by swabbing or spraying; the larynx by swabbing with a 10 or 15 per cent. solution.

The skin is rendered analgesic by injecting the solution into this layer and the deeper parts by injecting each succeeding layer of tissue as it is exposed during the course of the dissection. This is known as the infiltration method.

Anæsthesia of a given area may be obtained by injecting the solution into the nerves that supply the part that is to be operated upon. The solution is injected into the nerves proper, or into the sheaths of the nerves or the tissues immediately surrounding the nerves. The nerves may be treated in this manner as they are exposed during the course of the operation, or the solution may be injected before beginning the operation, before incising the skin, down into the region of the nerve that supplies the part to be operated upon, with the object of introducing the solution directly into the nerve-trunk or into the tissues immediately surrounding the nerve.

The effect of the analgesic solution is still more pronounced if it can be confined to the part by interrupting the circulation by means of a rubber-elastic ligature; for example, in operations upon the extremities by tying a rubber band about the limb above the site of operation.

Infiltration Method.—For operations that require a limited amount of dissection cocain in a $^1/_{10}$ per cent. solution, introduced into the skin hypodermically, is very satisfactory. The solution should be thrown into the deeper layer of the skin proper, so as to raise welts, and not into the loose tissue underneath the skin, and should be introduced, a few drops at a time, through a succession of punctures along the line of the proposed incision. After the first puncture and injection have been made the needle is introduced each succeeding time through the skin that has already been anæsthetized. After the skin has been incised the deeper layers are injected as they are met with during the progress of the operation.

A satisfactory solution is made as follows:—

Cocain hydrochlorid	gr. j.
Adrenalin (1 to 1000)	♏ xv.
Salt solution (gr. j to ℥j)	℥ij.

This makes approximately a $^1/_{10}$ per cent. solution, and 2 to 4 ounces (equal to 1 to 2 grains of cocain) may be used during the course of an operation, the amount depending upon the age, etc., of the patient. Novocain is a very satisfactory substitute for cocain, and has several advantages over the latter. It can be used in stronger solution—¼ per cent.—and in greater quantity. Adrenalin is added to the solution in the proportion of 7 minims to the ounce. An all-glass syringe, capable of being boiled and with a capacity of 10 c.c., is used. The syringe should be boiled in water free from soda, etc.

Schleich Method.—The solution used contains cocain and morphin. It is thrown into the skin with a hypodermic, as described above for cocain, along the course of the intended incision. The solutions vary in strength according to the amount of cocain that they contain, and are known as Nos. 1, 2, and 3.

Solution No. 1.

Cocain muriate	gm.	0.2	gr. iij.
Morphin muriate	gm.	0.025	gr. ⅖.
Sodium chloride	gm.	0.2	gr. iij.
Sterile water	c.c.	100.0	℥iii⅖.

This is the strongest solution. A quantity up to 6 drams may be used.

Solution No. 2.

Cocain muriate	gm.	0.1	gr. iss.
Morphin muriate	gm.	0.025	gr. 2/5.
Sodium chloride	gm.	0.2	gr. iij.
Sterile water	c.c.	100.0	℥iii2/5.

This is the solution that is commonly used, and of this a quantity up to 3 ounces may be injected.

Solution No. 3.

Cocain muriate	gm.	0.01	gr. 1/6.
Morphin muriate	gm.	0.025	gr. 2/5.
Sodium chloride	gm.	0.2	gr. iij.
Sterile water	c.c.	100.0	℥iii2/5.

No. 3 is the weakest solution, containing only one-tenth as much cocain as No. 2. A pint of this solution can be used.

Regional Anæsthesia.—Certain regions may be rendered analgesic by injecting a solution of cocain or some of its substitutes directly into the sensory nerves that supply the part. The skin is first anæsthetized, as described above, the skin incised, and each sensory nerve sought for and injected as it is exposed during the course of the operation. A solution of cocain, ½ to 1 per cent., or a 2 per cent. solution of novocain, with adrenalin 15 minims to the ounce added, is employed. This plan is used with success in abdominal section, appendicitis, hernia, operations for goitre, etc. In operating for inguinal hernia, for instance, the skin is first anæsthetized by the infiltration method, and then after this layer has been incised the nerves that supply the parts—the hypogastric branch of the ilio-hypogastric, the inguinal branch of the ilio-inguinal, and the genital branch of the genito-crural—are injected according as they are exposed.

Regional analgesia may also be obtained by injecting the analgesic solution through the unbroken skin down into the region of the sensory nerve-trunks that supply the part, depositing the solution directly in the nerve-trunk or in the tissues immediately surrounding the nerve. In this way the median, ulnar, external popliteal, and the anterior and posterior tibial nerves may be temporarily paralyzed and the parts supplied by them rendered free from pain. Amputation may be thus done without pain and with little or no shock. A rubber ligature is placed about the upper part of the limb. The same plan of anæsthesia is illustrated when the digital nerves are injected prior to amputation of fingers, toes, operations on ingrowing nails, etc.

Spinal Anæsthesia (Analgesia).—Anæsthesia of the lower part of the body may be obtained by throwing the analgesic solution into the spinal subarachnoid space by means of a hypodermic syringe. This method of inducing analgesia was introduced by Bier. A 5 per cent. solution of stovain or tropacocain in salt solution is employed. Stovain is not so stable as tropacocain upon boiling; 15 to 20 minims (1 c.c.) of this solution, equivalent to 3/4 to 1 grain of the drug, being introduced according to the age, physical condition, etc., of the patient. This is the usual dose for an adult. An all-glass syringe, which is capable of being boiled, with a bevel, slip nozzle, and with a capacity of 2 c.c. (30 minims) is used. The needle is made of platinum-iridium, 9 to 10 cm. long, and with a diameter of 1 mm. The bevel of the needle at the point is short. The needle is fitted with a stylet. The syringe and needle are both boiled in pure water, free from soda, etc., before using.

The puncture is made in the lumbar region, usually between the third and fourth spines, or the injection may be made between the first and second lumbar, or between the twelfth dorsal and first lumbar. Anæsthesia of the lower limbs, abdomen, and the lower part of the chest is obtained. It is desirable to administer, by hypodermic injection, one-half hour before the spinal injection is made, 1/4 grain of morphin and 1/100 grain of hyoscin to quiet the patient. (See "Lumbar Puncture," page 541.)

DIVISION OF THE TISSUES.

Division of the Soft Parts.—Bloody Division of the Soft Parts.—The division of the integument may be accomplished with the knife or scissors, either by direct incision or by transfixion (Fig. 5). The deeper soft parts may be divided with cutting instruments or by tearing with the fingers or blunt instruments, the handle of the scalpel, thumb forceps, etc. This plan of blunt dissection is especially serviceable in enucleating encapsulated tumors or lymphatic nodes and in separating between different layers of tissue along the normal connective-tissue planes.

The contents of hollow viscera, serous spaces, and cystic tumors may be evacuated or withdrawn in part for the purpose of diagnosis by means of the trocar and cannula or some form of aspirating apparatus. Substances may also be introduced into the body through cannulæ or with some form of syringe.

Bloodless Division of the Soft Parts.—This result may be accomplished with the thermocautery, galvanocautery, elastic ligature, écraseur, or wire snare, and by the action of corroding chemicals.

Division of Bone.—Bones may be divided through an incision in the soft parts with the chisel and mallet, bone forceps, or with some form of saw,—circular, chain, or wire, or with the flat saw; with the drill, dental burr, or bone scoop. The De Vilbiss, Hudson, Dahlgren forceps are very satisfactory instruments for the purpose of dividing the bone in making large bone-flaps in the skull. The bones are covered with an adherent vascular membrane, the periosteum, which should be incised with the knife and separated from the bone with the elevator before applying the cutting instruments to the bone.

The bone may be divided without an incision in the soft parts —for the purpose of correcting deformities, etc.—either by manual

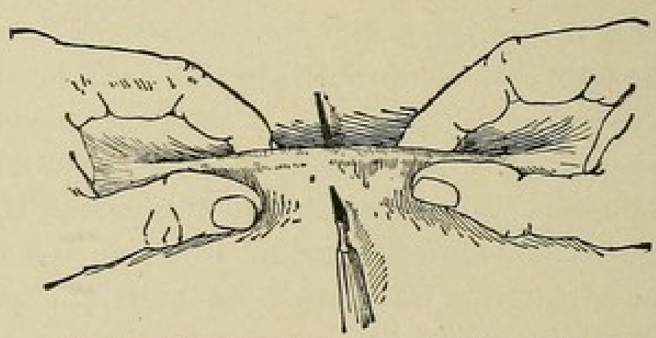

Fig. 5.—Division of the Skin by Transfixion.

force or by the use of an instrument known as the osteoclast. The osteoclast consists of a solid metal bar with two sliding bracelets, one on either end, and between these a brace which may be raised or lowered by means of a screw.

HEMORRHAGE.

During the course of an operation the hemorrhage must be controlled in order to minimize the loss to the patient and to keep the field clear for proper work.

Hemorrhage may be described as capillary, venous, and arterial.

Capillary hemorrhage is characterized by a general oozing.

Venous hemorrhage is characterized by a steady welling of blood into the wound, often filling it so as to obscure the bleeding point. Venous blood is rather darker in color than arterial blood. If a large vein is divided close to the trunk,—*i.e.,* in the neck or axilla,—or if one of the intracranial dura mater sinuses is opened, the blood may escape in a remittent stream, synchronous with the respiratory movements, diminishing or ceasing during inspiration and increasing during expiration. During inspiration, under these circumstances, air may be sucked into the veins, but, if limited in quantity, this will not result in any harm; nevertheless it should be guarded against.

Arterial hemorrhage is characterized by the brighter color of the blood and by the fact that it escapes in a distinct remittent jet of considerable, though varying, force. The jet is synchronous with the heart's action, increasing during ventricular systole and diminishing during ventricular diastole.

Means to Arrest Hemorrhage.—The Natural Arrest of Hemorrhage is effected by the clotting of the blood. If the divided vessels are not too large and the blood-pressure not too great, nature will thus be able to bring about a cessation of the hemorrhage. Nature is assisted in her efforts to control hemorrhage from a severed artery by the fact that when an artery is divided its orifice contracts, thus diminishing the size of the opening through which the blood escapes, and further by the fact that the inner elastic coat of the vessel, the intima, retracts, coiling up within the artery, thus blocking the lumen of the vessel and offering a considerable impediment to the flow. As the hemorrhage continues the blood-pressure becomes progressively less and less, and this is an important factor in the natural arrest of hemorrhage. Where hemorrhage has ceased spontaneously caution should be exercised in administering cardiac stimulants, intravenous saline infusion, etc., because as a result of raising the blood-pressure the hemorrhage may be renewed. This fact is to be borne in mind, especially in hemorrhage from internal parts, ruptured ectopic pregnancy, hemorrhage from lungs, stomach, intestine, etc., while the source of the hemorrhage is not directly accessible.

The natural arrest of hemorrhage from a severed vein is facilitated by the low blood-pressure within the vessel and by the collapsibility of its thin, flaccid wall.

Artificial Arrest of Hemorrhage.—Artificial measures are usually resorted to, in order to control hemorrhage. These may be classified as indirect means, acting outside at a distance from the wound, and direct means, acting locally within the wound.

Indirect Means. *The Elastic Bandage and Constrictor (Esmarch).*—Operations upon the extremities may be rendered practically bloodless by the use of the Esmarch bandage and constrictor.

The extremity being elevated, a rubber bandage about three inches broad is applied about the limb, each turn being drawn pretty tight. The bandage is applied spirally about the limb, commencing below and working upward toward the trunk, each turn somewhat overlapping its predecessor; in this way the blood is forced out of the limb. Having reached a point above the site of the proposed operation, a rubber band or thick elastic tube, the constrictor, is passed around the limb several times and then made fast. The rubber spiral bandage may then be removed. In most cases the application of the rubber spiral bandage may be dispensed with, it being sufficient to elevate the limb to a perpendicular position for a few minutes, at the same time massaging or stripping it from the periphery toward the trunk, in order to force the bulk of the blood out of it. While

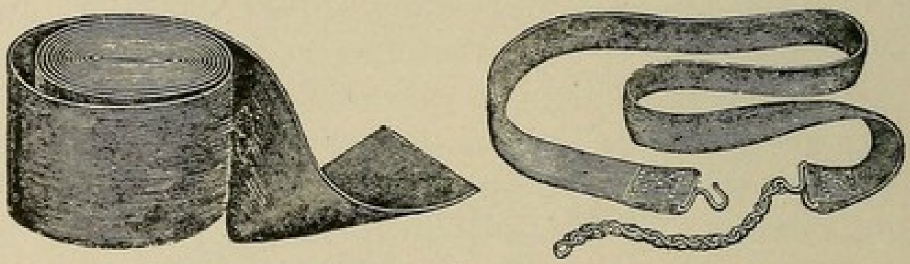

Fig. 6.—Esmarch Bandage and Constrictor. The constrictor is provided with a chain and hook.

the limb is thus elevated, the rubber constrictor bandage is applied about the upper part of the limb.

In cases of tuberculous disease, malignant disease, and sepsis one should certainly omit stripping the limb or applying the rubber spiral bandage on account of the likelihood of forcing infectious elements onward into the healthy tissues. Under these circumstances one should be content with elevation of the limb for a few minutes before applying the constrictor.

The rubber constrictor that is placed about the limb may be secured with a strip of gauze which is placed underneath the constrictor so that, after the first loop of an ordinary knot has been taken in the constrictor, the gauze strip may be tied over this to secure it and prevent it from slipping; the second and final loop is then taken in the rubber constrictor. The constrictor shown in the illustration is provided with a chain and hook.

The constrictor should be applied sufficiently tight to shut off the arterial current, but not tight enough to bruise the nerve-trunks against the underlying bone.

For operations upon the lower extremity, except at the hip-joint, the constrictor is placed about the thigh, just above the knee-joint or higher up, nearer the hip-joint. For disarticulation at the hip-joint the constrictor is placed about the limb as high up, near the trunk, as possible, and it is then prevented from slipping down by steel pins, or skewers, which are passed through the soft parts (Wyeth).

For operations upon the upper extremity, except at the shoulder-joint, the ligature is placed about the arm, just above the elbow-joint or higher up nearer the shoulder-joint. For disarticulation at the shoulder-joint the constrictor is applied as high up as possible; it may be passed through the axilla and over the shoulder and prevented from slipping by a steel pin, or skewer, that is thrust through the soft parts, transfixing the upper part of the deltoid muscle mass.

The main arterial and venous trunks, if they have been divided during the course of the operation, may be secured and ligated before the constrictor is removed. Any additional bleeding branches may be secured and ligated after the constrictor has been removed.

By Digital Compression of the Main Arterial Trunk at a Distance from the Site of the Operation.—During amputation of the thigh the common femoral artery, as it emerges from under Poupart's ligament, may be compressed against the underlying pubic bone.

During amputation of the forearm or disarticulation at the elbow-joint the brachial may be compressed against the humerus, and during amputation through the upper arm or at the shoulder-joint the hemorrhage may be controlled by digital compression of the subclavian artery against the first rib. This plan is rather untrustworthy.

Preliminary Ligation in Continuity.—This is a very satisfactory method of controlling hemorrhage in certain bloody operations. For example, in disarticulation at the hip-joint preliminary ligation of the common femoral may be practiced, the vein being tied at the same time through the same incision. In amputation of the tongue one or both linguals may be ligated as a preliminary step to the main procedure. In extirpation of the lower jaw, etc., preliminary ligation of the external carotid may be practiced with great advantage.

Position.—Position of the part has much to do with the severity of the hemorrhage during an operation. Elevation of the part is often sufficient, of itself, to check capillary and venous hemorrhage. The volume of arterial blood sent to the part is diminished and the return-flow through the veins is facilitated. These factors, together, serve to markedly diminish the pressure in all the vessels of the elevated part. This is especially true of the limbs, but also of the pelvis and the head. With the pelvis raised as in the Trendelenburg position, the hemorrhage during the course of operations upon the pelvic organs is much diminished. During operations upon the head, face, and neck it will be found that the hemorrhage, especially the venous, is very much less with the patient in the semi-erect position

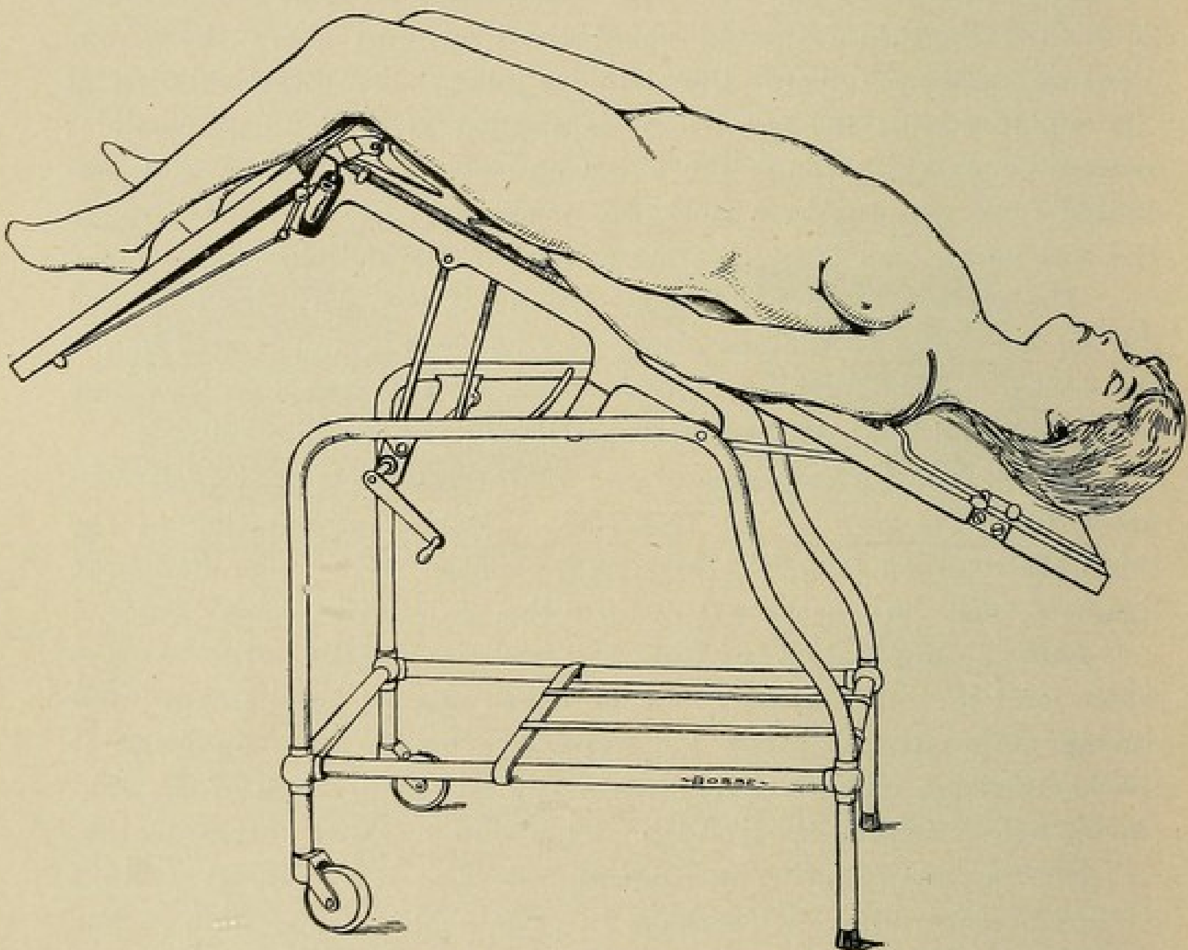

Fig. 7.—Trendelenburg Position.

than it would be with the patient in the Rose position, with the head hanging low over the end of the table.

Direct Means of Controlling Hemorrhage are applied within the wound itself, and these may be divided into three groups: Agents that act locally through the nervous system; chemical agents that act directly upon the escaping blood, causing it to coagulate; and mechanical agents.

Agents that Act Locally Through the Nervous System.—Application of heat or cold, usually in the form of water, hot or cold, or ice, tends to diminish and check hemorrhage. If hot water is used it should be as hot as the hand can bear, about 130° F.; if cold, it should be quite cold.

Heat and cold both act by causing the small arterioles to contract and diminish in size. Heat causes albumin to coagulate so that, when heat is applied to a wound, the wound surface becomes glazed with a thin, albuminous film, and in this way heat possesses an additional potency in checking oozing. Heat is a more effective agent in controlling hemorrhage than cold, since the latter acts only by causing a diminution in caliber of the small arteries.

Heat in the form of a hot saline irrigation is a very satisfactory agent to check oozing from capillaries and small arteries and veins. A very effective means is pressure with a gauze compress wrung out in very hot water.

Chemical Agents. Styptics.—These agents tend to check hemorrhage by acting directly upon the escaping blood, causing it to coagulate, and thus seal the mouths of the severed vessels. They are but little used except in operations upon the nose, etc., and are of service only to control capillary hemorrhage and oozing from small veins and arteries. The common styptics are the persulphate of iron, tincture of the chloride of iron, powdered alum, tannic acid, etc. The styptic cotton is ordinary absorbent cotton impregnated with one of these agents.

Adrenalin, applied locally in 1 to 1000 solution, is a very prompt and effective means of controlling hemorrhage by causing contraction of the arterioles.

MECHANICAL MEANS. *Digital Compression.*—With the finger in the wound hemorrhage may be controlled by pressure exerted directly upon a severed vessel, thus closing it until it can be secured with an artery forceps. In operations upon the neck, for example, a large vessel may be divided and then so obscured by the great volume of escaping blood that it cannot be located and secured with the artery forceps. With the finger thrust into the wound the hemorrhage may be checked temporarily by compressing the injured vessel until the wound can be cleared of blood and the vessel located and grasped with an artery clamp. This is especially true of large veins; when cut, the blood may well into the wound in such volume that one is unable to locate the divided vessel.

Digital compression may be applied to the main vessels in the wound before they are divided in order to minimize the loss of blood.

For example, in exarticulating at the shoulder-joint, after the incisions have been made, but before the brachial artery and adjoining vessels have been cut, the assistant grasps the mass of soft parts which includes the main vascular trunks and compresses these between the thumb and fingers until after the limb has been amputated and the vessels secured by the operator.

Tamponade.—This is really one way of applying the principle of compression. This method is especially serviceable in controlling oozing and bleeding from veins. For example, hemorrhage from an injured intracranial sinus may be readily controlled by packing a strand of gauze into the wound between the sinus and the skull, hemorrhage from the uterus by packing the uterus.

If an abscess cavity or a cavity in a bone is tamponed and a good snug dressing applied so as to exert a considerable degree of firm compression, this will usually suffice to check all oozing from capillaries and small veins.

Bleeding from the nutrient artery of a bone may be checked by plugging the orifice of the nutrient canal with a piece of catgut or a wooden peg. Oozing from the end of a long bone, from the edges of the bones of the skull in craniotomy, etc., is readily controlled by a few minutes' firm compression with a hot gauze pad. Occasionally the hemorrhage from the edges of the bone in craniotomy is excessive and persists. Under these circumstances it can be controlled by applying Horsley's wax, a putty-like substance composed of vaselin, paraffin, and carbolic acid. The wax is smeared against the edges of the bone.

Suture of the Wound controls hemorrhage from capillaries and small veins by bringing the contiguous surfaces into apposition, and is simply one method of applying the principle of compression.

Forcipressure consists in crushing the coats of the severed vessels with hæmostatic forceps. It is a well-known fact that even large arteries when crushed or torn do not bleed, and it is upon this same principle that forcipressure is applied to control hemorrhage. The bleeding artery or vein is seized with the forceps, which is then closed down upon the vessel with much force, in this way crushing the coats of the vessel, especially the inner coat, and so effectually controlling the hemorrhage. If the vessels are small the forceps may be removed after a few minutes, when it will be found that the hemorrhage has ceased. Forcipressure is a very satisfactory method of dealing with larger vessels when situated deep in a small wound where they are not readily accessible for ligation. Under these circumstances, however, it is wise to allow the forceps to remain in place for twenty-four to forty-eight hours, including them in the dressing, since the hemorrhage might recur if they were removed earlier. By allowing the forceps to remain one gives the blood a chance to form a good firm clot to occlude the vessels.

Torsion.—This method of occluding a bleeding vessel consists in seizing the end and twisting it until the inner coat of the vessel is ruptured and the end of the vessel, in the grasp of the forceps, is twisted free. This measure may be applied to small arteries and

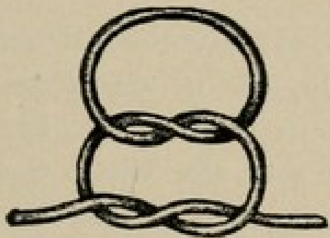

Fig. 8.—Square Knot.

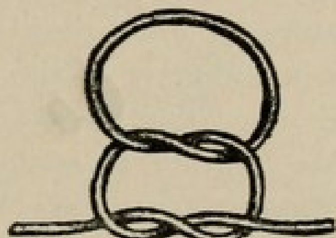

Fig. 9.—Slip-knot.

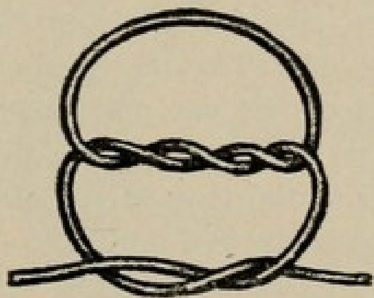

Fig. 10.—Surgeon's Knot. The first loop is made double to prevent slipping while taking the second loop.

veins as an adjunct to forcipressure. Torsion may be more effectually applied by grasping the free end of the vessel with one forceps and the vessel itself a short distance beyond, transversely, with a second forceps. While the vessel is steadied with the forceps that grasps it transversely, it is twisted repeatedly upon itself with the forceps that grasps its extremity.

Ligature.—The most commonly employed and safest means of securing several arteries and veins, especially if of large calibre. In the day of the non-absorbable, non-aseptic ligature many plans were devised to obviate the use of the ligature, since it had to be cast off before the wound could heal, and thus precluded the possibility of union by first intention, and because, as the ligature separated and came away, it was often accompanied by a dangerous secondary hemorrhage.

With the aseptic, absorbable ligature, an ideal method of controlling hemorrhage in the wound was instituted. The aseptic, absorbable ligature permits the immediate closure of the wound and does not in any way interfere with the healing process. Some surgeons still use silk for ligature. Although silk may be rendered absolutely aseptic, it has the disadvantage of not being absorbable, and may therefore occasionally act as a foreign body, keeping the wound open until it separates or until it is removed. The ligatures may be applied to the exposed vessels before they have been divided or afterward, and may be applied to the isolated vessels or may include the immediately adjoining soft parts as well.

Ligature of blood-vessels before they have been severed is exemplified in the tying of the external jugular in operations upon the neck after the vessel has been exposed in the incision, but before it is cut; the ligature is applied double and the vessel then divided between these. Again, in disarticulation through the hip-joint the main vessels may be exposed during the course of the operation, ligated, and then divided. In resecting portions of the alimentary canal the mesentery or omentum that carries the blood-supply to the parts must be tied off. This is usually done in sections, each ligature including from one to one and a half inches of the mesentery or omentum; in this case not only are the blood-vessels included in the ligatures, but all of the tissue from one ligature to the next.

Ordinarily the ligatures are applied to the vessels after they have been severed. The bleeding point is seized with a hæmostatic forceps and the ligature is then slipped over the end of this and tied.

Occasionally, vessels in dense fibrous tissue, in the dura mater and wall of the chest, when cut, retract into the surrounding tissue so that their ends cannot be seized with the forceps. Under these circumstances it may be necessary to carry the ligature around the vessel with a curved needle.

Treatment of Severe Hemorrhage.—After the hemorrhage has been controlled by ligation, tampon, etc., it may be necessary to replace the blood which has been lost by infusion of normal salt solution or by direct transfusion of blood from another person.

Intravenous Saline Infusion.—Any prominent superficial vein may be used for this purpose; the median cephalic at the bend of the elbow is the one usually selected. A tourniquet or bandage is first applied about the arm, high up near the axilla and just sufficiently tight to constrict the superficial veins, but not tight enough to shut off the arterial current; this causes the superficial veins to become swollen and more conspicuous. The skin is then pinched up over the vein and may be incised by transfixion with the knife or with the scissors, care being taken not to injure the vein itself. The vein is then plainly exposed and thoroughly isolated for less than

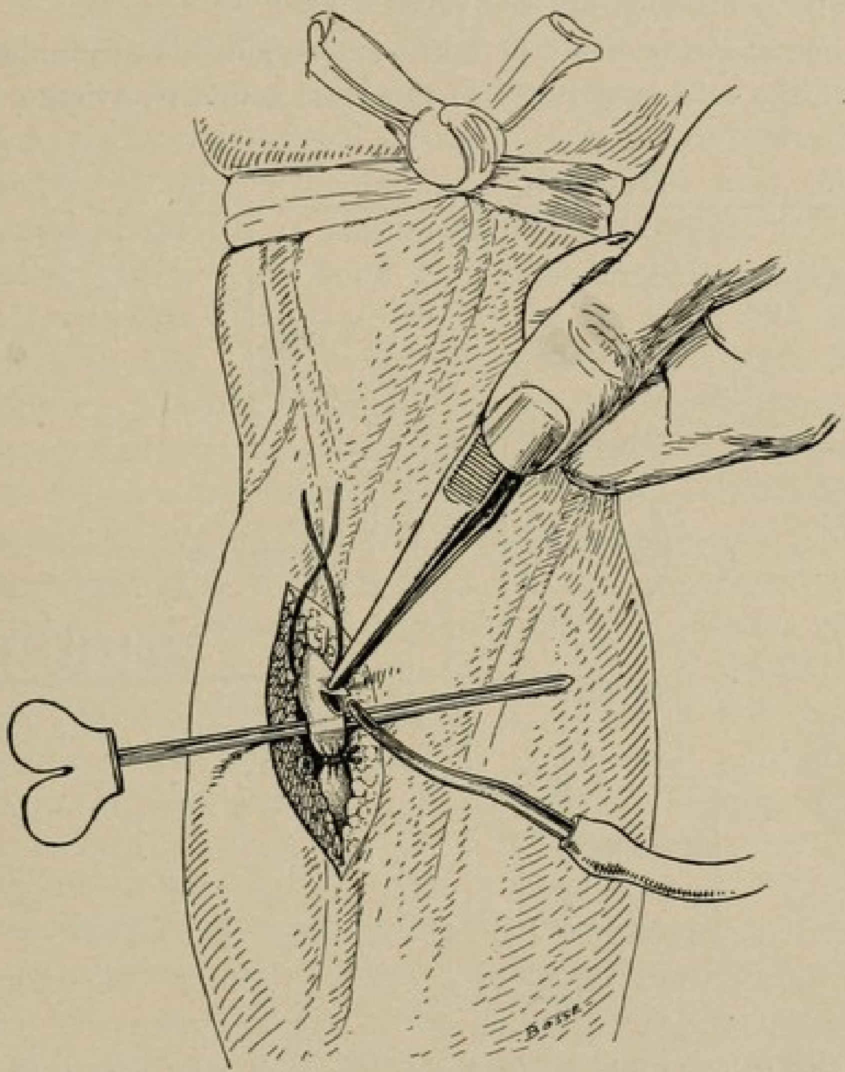

Fig. 11.—Superficial Vein Exposed for Saline Infusion. The vein, which is raised upon the director, has been surrounded by two ligatures and opened ready to introduce the cannula. The lower ligature has been tied. The upper ligature has not been tied; one loop of the knot has been taken, but not drawn tight.

one inch and raised well out of its bed upon a director, after which a double catgut ligature is passed around the vein. This ligature is then cut, so as to leave the vein surrounded by two ligatures, one above and the other below. The lower ligature is tied. A single loop of a knot is taken loosely in the upper ligature, the ends of which are left long. The vein is then freely opened with a narrow-bladed knife, or the vein may be picked up with the thumb forceps and snipped half across with the scissors. The vein bleeds. Through the opening made in the vein the end of the cannula, with the saline solution flowing from it, is slipped up into the vein beyond the upper ligature, which is then tied fast about the cannula, in order to retain it securely in place within the vein.

Deliberate care should be taken to introduce the cannula into the lumen of the vein, and not into the loose connective tissue that sur-

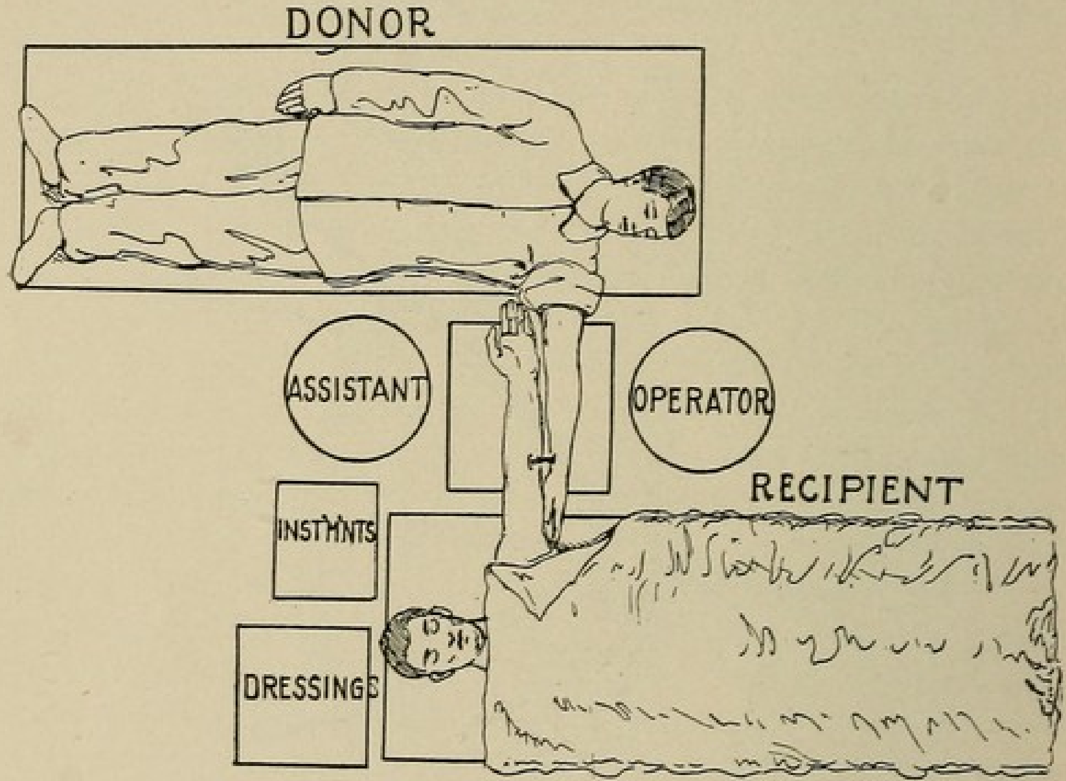

Fig. 12.—Plan of Arrangement of Tables, Patients, Operator, etc., in Arterio-venous Transfusion.

rounds the vein. This is an accident which may readily occur and is to be avoided by thoroughly isolating the vein and lifting it well out of its bed before incising it. Before the cannula is introduced into the vein the solution should be allowed to flow, and thus avoid carrying air into the vein; although it is of no consequence if a small quantity of air does enter the vein, nevertheless this should be avoided if possible.

After the cannula has been introduced into the vein and secured by tying the ligature, the bandage is removed from the upper part of the arm and the fluid allowed to flow. From 1000 to 1500 c.c. at a temperature of 115° F. may be introduced. The fluid should not be permitted to flow too rapidly. Ten minutes should be allowed for 1000 to 1500 c.c. The reservoir is held at an elevation of about two feet.

The saline infusion acts by restoring the arterial pressure and the character of the pulse is a good guide as to the quantity of fluid to be introduced. The solution may be made in emergency by dissolving a heaping teaspoonful of salt in one quart of water.

Arterio-venous Anastomosis of Blood-vessels for Transfusion, Carrel's Operation.—The transfusion of blood from one person to another can only be accomplished with safety when the intima of the vessel of the one is continuous with the intima of the vessel of the other. The blood must not come in contact with foreign material or tissues. The anastomosis may be made with suture or with Crile's cannula. The donor and the recipient rest upon tables placed side by side with their feet in opposite directions. The tables are provided with movable head-pieces that may be lowered or raised in the event of cerebral anæmia or acute cardiac dilatation. The left arm of each patient rests upon a small square table which is of the same height as the large tables and placed between them. The operation is done under local anæsthesia, a solution of $^1/_{10}$ of 1 per cent. of cocain, to which a small quantity of adrenalin is added, being used. The solution is injected into the skin and then deeper into the tissues about the vessels. It is advisable to administer to each patient, half an hour before the operation, $\frac{1}{4}$ grain of morphin hypodermically. The face of each patient is covered with a damp towel for psychic effect and to shut off vision and allay nervousness. Special instruments are required for the operation: 3 or 4 pair of narrow, fine-pointed artery forceps, mosquito forceps, for catching the ends of the vessels; 2 pair of fine-pointed dissecting forceps; fine-pointed straight scissors; 2 Crile clamps for temporarily compressing the vessels; several very fine, straight needles (No. 16, Kirby's English needles) threaded with very fine strands of silk for suture; No. 1 Chinese twisted silk is unravelled into its component strands in order to get threads sufficiently fine to enter the minute eye of the needle. The entire operation must be done with extreme gentleness and deliberation.

Suture Method.—The donor's radial artery is exposed at the wrist and freed from its bed for a distance of 3 cm. Every bleeding vessel is clamped so that the field is absolutely free from blood. In isolating the radial artery every branch that is given off, no matter how small, is ligated and divided so that the vessel is entirely free for a distance of 3 cm. The portion of the artery which is thus exposed is ligated at the distal end, and a Crile clamp placed upon the proximal part and screwed down gently so as to exert just enough pressure to control the flow of blood. The artery is divided close to the ligature and cut square across with sharp, straight scissors. The outer coat of the artery, the adventitia, is seized with the dissecting forceps, pulled down over the end of the artery, and cut off, square, with the sharp, straight scissors. The adventitia then retracts still

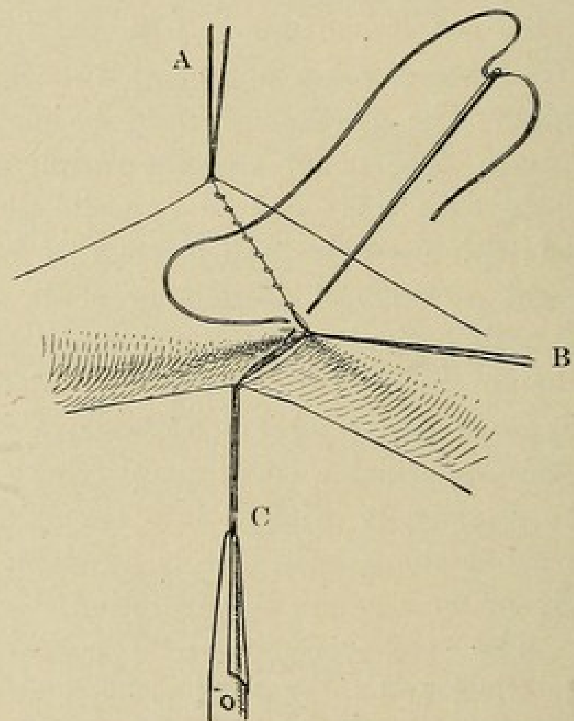

Fig. 13.—Arterio-venous Anastomosis, Suture Method.

farther and thus leaves a free margin for the introduction of the sutures. The free end of the radial artery, about 2.5 cm., is thus ready for the anastomosis.

The vein of the recipient, usually the median basilic, is exposed and treated in a similar manner, ligated, a Crile clamp applied, the vein divided close to the ligature, and it is then ready for the anastomosis.

The ends of the vessels are brought sufficiently close to each other and are joined by three sutures of the finest silk, placed equidistant apart. These sutures penetrate all the coats of the vessels and, when tied, bring the ends of the vessels close together at three points equidistant apart. These sutures are left long to serve as tractors. When tension is made on the tractor sutures the ends of the artery and vein which have been joined together form an equilateral triangle. (*A, B, C,* Fig. 13.)

The ends of the artery and vein are joined together by a continuous suture of the finest silk carried in the finest straight needle (Kirby's English needle, No. 16). The suture is soaked in sterile vaselin or oil. By making traction upon two tractor sutures and

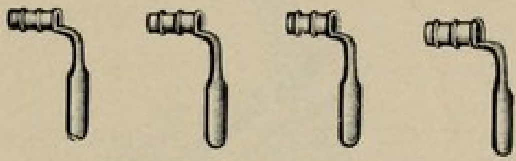

Fig. 14.—Crile's Cannulæ.

hanging a weight (mosquito forceps) on the third, the introduction of the suture is facilitated and the danger of picking up the opposite wall of the vessels in passing the needle is obviated. In this way the vessels for one-third of their circumference are sutured together. The succeeding thirds of their circumference are sutured in the same manner, this being facilitated by changing the suspended hemostat to the next tractor suture and making traction with the other two.

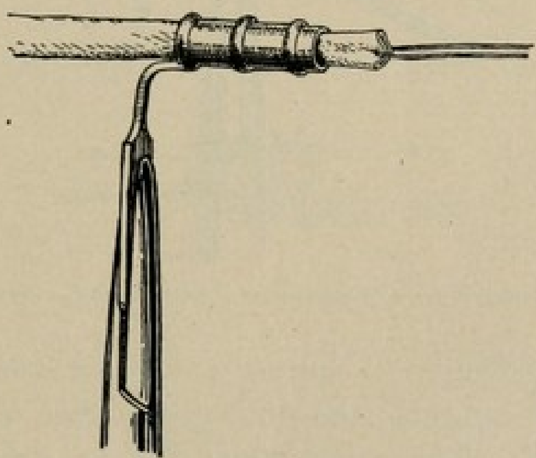

Fig. 15.—Arterio-venous Anastomosis with Crile's Cannula, etc.

The sutures are applied very close together, and very close to the edges of the artery and vein, except in the neighborhood of the tractor sutures, where they take a broader bite in order to secure the vessels beyond the holes made by the tractor sutures. When the anastomosis has been completed the clamps are removed, first from the vein and then from the artery, and the blood allowed to flow.

During the operation and while the blood is flowing, the vessels are kept constantly moist with warm saline solution.

With the Crile Cannula.—The cannulæ consist of short metal cylinders, the external surface divided into two portions by a ridge that passes around the middle. A similar ridge marks each end of the cannula. There are four sizes; the smallest has a diameter of 1.5 mm., the next 2 mm., the next 2.5 mm., and the largest 3 mm. (about 1/8 inch). The cannula is provided with a handle near one end by which it may be conveniently held in the grasp of an artery forceps.

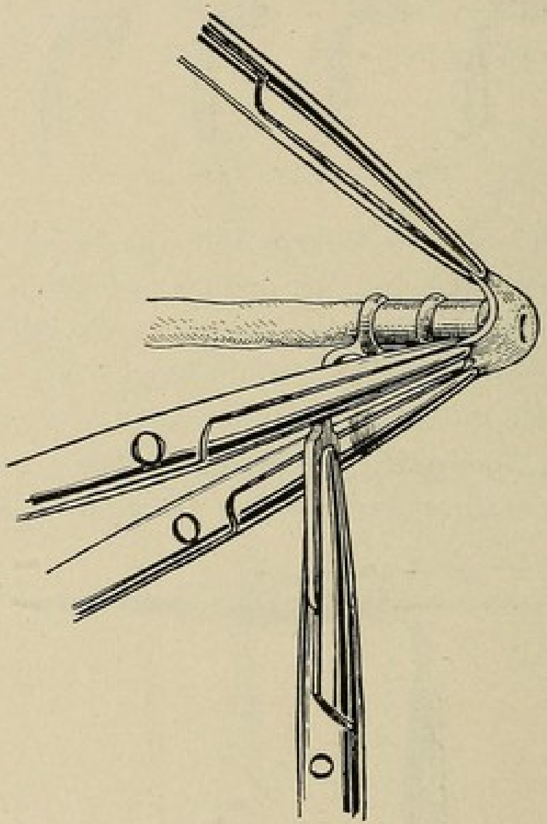

Fig. 16.—Arterio-venous Anastomosis with Crile's Cannula, etc.

There is no difficulty in finding a vein sufficiently large to accommodate a large cannula; the difficulty is that the artery may be found rather small. The artery must not be stretched unduly in drawing it over the end of the vein upon the cannula; the intima must not be injured. The size cannula to be used, therefore, will depend upon the size of the artery. If too large a vein is used for the size cannula selected it will become folded upon itself within the lumen of the cannula, will occupy too much room, and thus obstruct the flow of blood.

The vessels are exposed and treated as has already been described in the "Suture Method." The end of the vein is secured with a silk suture and pulled through the cannula (Fig. 15). The end of the vein which has been thus pulled through the cannula is seized with three mosquito forceps, taking a firm hold, but not extending up into the lumen of the vessel any farther than necessary, and is turned back,

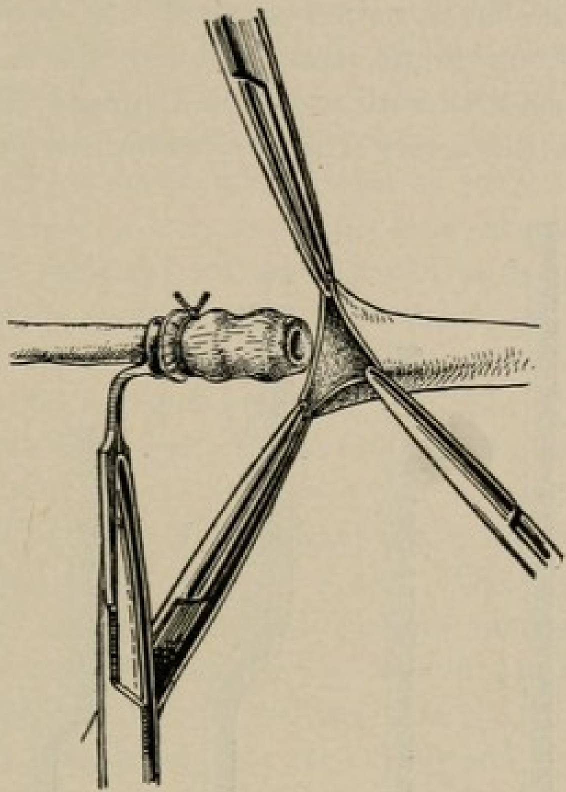

Fig. 17.—Arterio-venous Anastomosis with Crile's Cannula, etc.

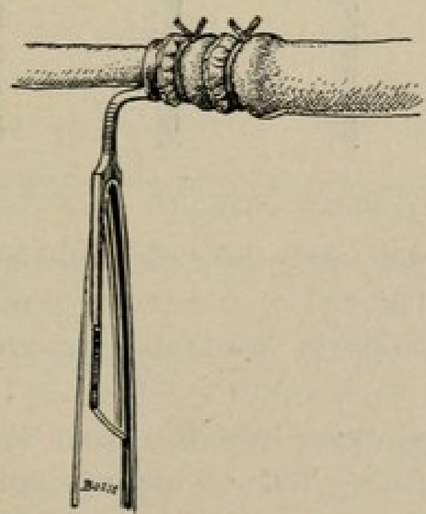

Fig. 18.—Arterio-venous Anastomosis with Crile's Cannula, etc.

cuff-fashion, over the cannula, all the way back to the handle, and is secured thus by a ligature of fine silk, which is tied around the vein upon the cannula in the groove nearer the handle (Figs. 16 and 17). The cannula is thus entirely covered over by the cuffed-back vein.

The surface of the vein which has been cuffed back over the cannula is carefully smeared with sterile vaselin to allow the end of the artery to be more readily drawn over it.

The end of the artery is next secured. It may have contracted, and will require very gentle dilatation with the end of a mosquito forceps, which is smeared with vaselin and slipped into the end of the artery. The end of the artery is secured with three mosquito hemostats

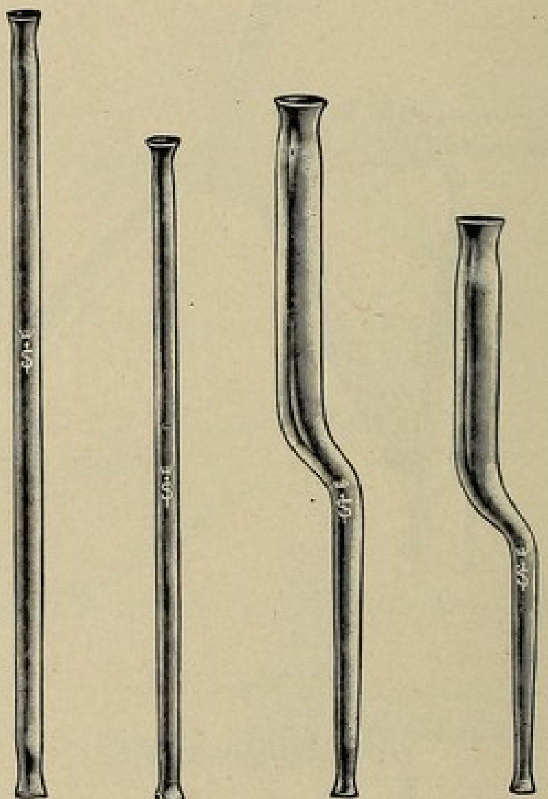

Fig. 19.—Brewer's Transfusion Tubes.

and is gently pulled well over the cuffed end of the vein upon the cannula (Fig. 17). The end of the artery is secured in position by tying a ligature around it in the remaining groove on the cannula (Fig. 18).

The artery forceps which held the cannula is now removed and the operation is complete. The clamps are removed first from the vein and then from the artery and the blood allowed to flow.

There are two important points in using the cannula: (1) the vein must be drawn straight through the cannula so that the long axis of the cannula and long axis of the vein correspond to each other, otherwise the lumen of the vein just beyond the cannula will be obstructed and interfere with the free flow of blood; (2) when the blood is flowing a moderate degree of tension should be made in the direction of the long axis of the vein, otherwise the wall of the vein tends to be drawn into the cannula and to obstruct the flow.

The donor must be free from disease and sufficiently robust to spare the blood required. The blood of the donor must not be hæmolytic for that of the recipient. It is desirable that the blood be tested beforehand to determine this fact. The quantity of blood allowed to pass will depend upon a number of conditions, the strength of the donor and needs of the recipient. In a general way the pulse, etc., of donor and recipient are good guides as to quantity. If the flow is too fast acute cerebral anæmia of the donor or acute cardiac dilatation of the recipient may result. If this occurs it will be necessary to moderate the flow and lower the head end of the table of the donor and raise the head end of the table of the recipient.

WITH BREWER'S TUBES.—A simple and very satisfactory method of transfusion. The tubes are made of glass, are of different sizes, and are either straight or with an elbow. The ends of the blood-vessels are exposed and prepared in a manner similar to that already described. The tube is dipped in hot melted paraffin before using and allowed to cool, and then introduced into the blood-vessels. One end of the tube is introduced into the artery and secured there with a ligature tied over the end of the artery upon the tube. The clamp is removed from the artery and a few jets of blood allowed to escape, and the free end of the tube then introduced into the end of the vein and secured with a ligature,—quite similar to the plan of introducing the cannula in intravenous saline infusion.

SUTURE OF THE TISSUES.

The various suture materials may be grouped into two classes: temporary and permanent.

Temporary sutures are made of simple catgut, which softens and becomes absorbed in from five to ten days according to its thickness, and chromicized catgut, which remains longer, from two to four weeks or even six weeks, according to its thickness and the manner of its preparation.

Permanent sutures consist of silk, silkworm gut, kangaroo tendon, horse-hair and metal, silver wire, etc. (Kangaroo tendon becomes absorbed after sixty days; so that it is not, in the strict sense, permanent.)

Suture of the Skin.—For this purpose a stitch may be used, continuous or interrupted, which penetrates the skin, or else a non-penetrating intracuticular stitch may be employed.

The stitch should not be drawn too tight, as it constricts the parts and may thus interfere with the blood-supply and the healing process. If the stitch is drawn too tight it may cut its way through the tissues, and besides may add much to the pain and discomfort of the patient. The stitch should be drawn just tight enough to bring the parts into immediate contact. The knots should be so arranged that they lie to one side or the other of the line of the incision.

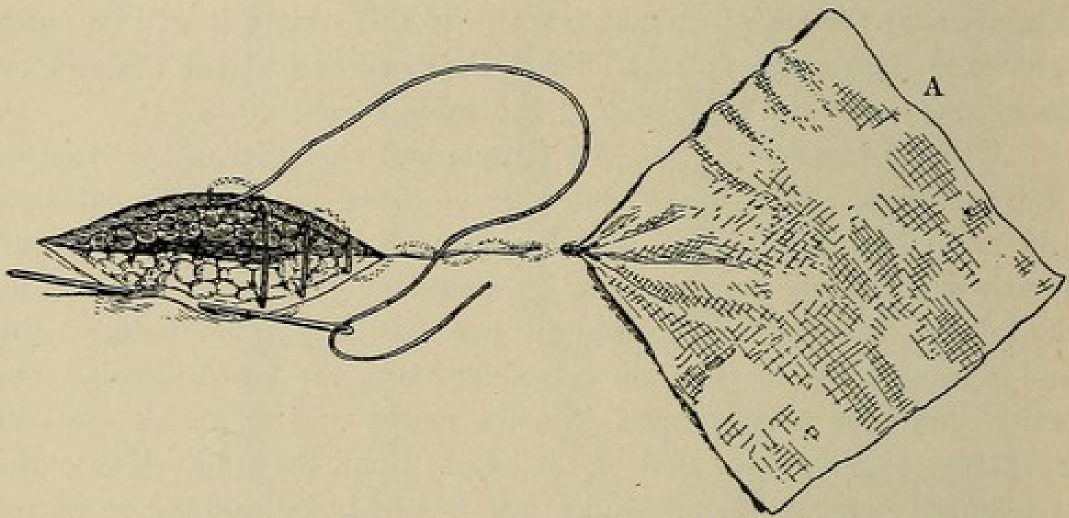

Fig. 20.—Intracuticular Suture. *A*, pledget of gauze, fixed to end of the suture.

The Intracuticular Suture.—For this suture simple or chromicized catgut or some permanent material—silk-worm gut, silk, etc.—may be used. This is the most satisfactory method of approximating the edges of the skin. The resulting scar is very much less unsightly, and the danger of stitch abscess is reduced to a minimum. The stitch is introduced with a straight needle or with a curved needle in a holder; a straight Hagedorn needle is preferable. In introducing this stitch it is necessary to catch the firm under-layer of the skin proper—not the loose subcutaneous fat and connective tissue—and to take a good long bite with each thrust of the needle. In crossing from one edge of the incision to the other, care should be taken to enter the needle directly opposite the point at which it emerged. The suture may be secured at each end with a small gauze pad.

One pad is fixed to the end of the thread before commencing the suture, and then, after the needle emerges through the last puncture, it is carried through the second pad and the suture secured with one or two stitches in this.

Suture of Muscle.—Divided muscle is usually approximated with absorbable material,—simple or chromicized catgut. If the muscle has been cut across, at right angles to the course of its fibers, the part should be placed in a position to relax the muscle and special care should be exercised to bring the cut edges securely together. This is accomplished by introducing a sufficient number of interrupted sutures or a continuous suture of moderately thick catgut,

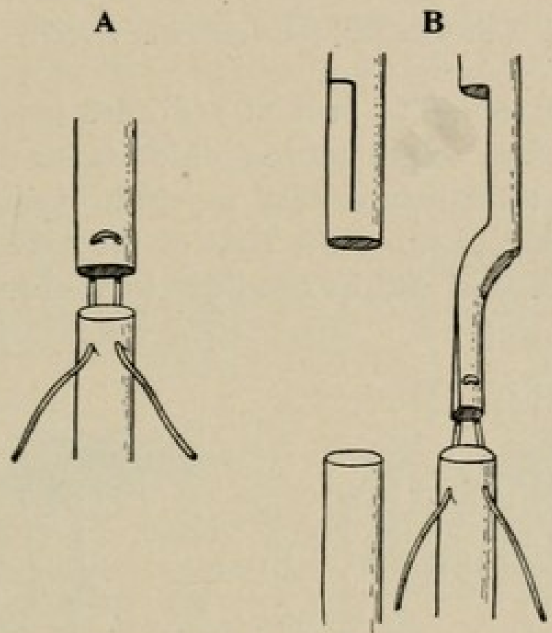

Fig. 21.—Suture of Tendon. *A*, ends of divided tendon united with mattress suture; *B*, upper end of tendon split and turned down to meet lower end.

each taking a good secure bite in the muscle, or several mattress sutures may be used for this purpose. If the muscle has been divided along the course of its fibers,—*i.e.*, between its fibers,—several interrupted catgut sutures will usually suffice to retain its edges in apposition.

If the sheath of a broad muscle has been divided,—for example, the sheath of the rectus,—care should be taken to reunite the edges of the sheath accurately with chromicized catgut.

In operations for the cure of hernias the edges of the muscles or of the aponeurosis are united with a non-absorbable suture material,—silk, silk-worm gut, kangaroo tendon, or silver wire,—with the idea of leaving these as permanent sutures to retain the parts in close apposition for a considerable length of time.

Suture of Tendons.—Severed tendons are sewed end to end with fine, ten-day chromicized catgut. A single mattress suture or one or more ordinary interrupted sutures that pass through the tendon proper are usually employed for this purpose. If a part of the tendon has been destroyed so that the ends cannot be approximated, a flap may be turned back from one or both ends in order to meet this deficiency.

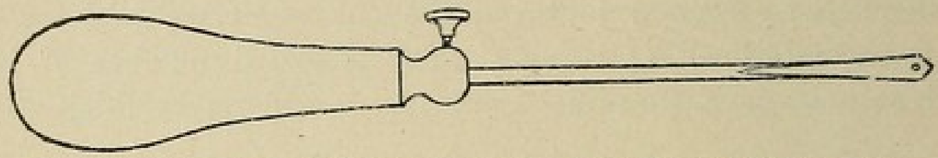

Fig. 22.—Bone Drill with Eye Near the Point to Carry Suture, etc.

Suture of Nerves.—The ends of a divided nerve may be joined with one or two plain catgut sutures which secure the sheath of the nerve, or, better, these sutures may penetrate the nerve proper, the essential point being to bring the ends of the nerve into immediate contact. In old cases it will be necessary to freshen the ends of the nerves before suturing.

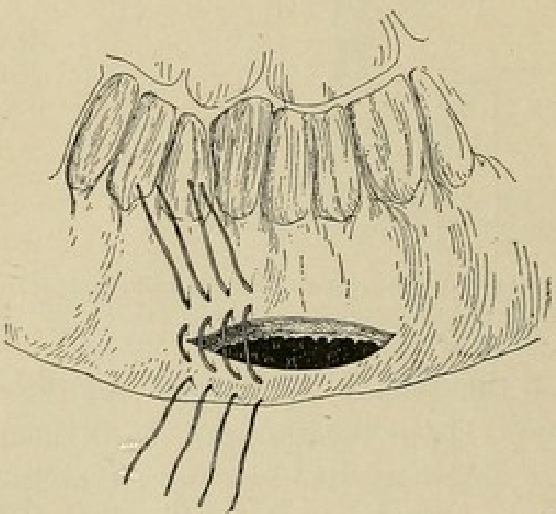

Fig. 23.—Segment of Bowel. Interrupted Lembert sutures in place.

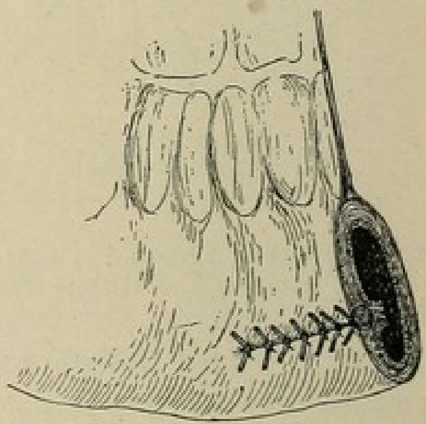

Fig. 24.—Segment of Bowel. Lembert sutures tied. It will be noted that they do not penetrate through the entire thickness of the wall of the gut.

Bone and Cartilage.—For the purpose of suturing bone and cartilage silver wire is usually employed. Sometimes heavy, chromicized catgut or kangaroo tendon is used. In order to pass the sutures, holes must first be made through the bone. This is done with the drill. Before withdrawing the drill the suture is introduced through the small eye in the point of the drill, and then as the instrument is withdrawn it brings the suture after it. If the suture is too thick to enter the eye in the point of the drill, a loop of silk may be passed through the eye of the drill and the suture drawn through with this.

Bones are sometimes joined with one or more sutures of chromicized catgut or kangaroo tendon which do not go through the bone, but include the periosteum and the fibrous tissue that cover the bone; this method may be used, for example, to unite a fractured patella so as to avoid entering the knee-joint and the handling that would be necessary in the making of drill-holes.

Fragments of bone may also be joined by steel nails, ivory pegs, etc., that are driven from one fragment of bone into the other, or the fragments may be held together by metal plates,—Lane's plates,—

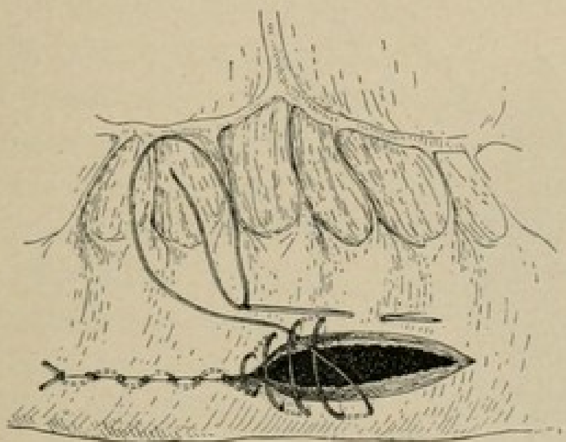

Fig. 25.—Cushing Suture Applied to Close Opening in the Bowel. It is a continuous stitch and passes through the wall of the gut parallel with the line of the incision instead of at right angles to it.

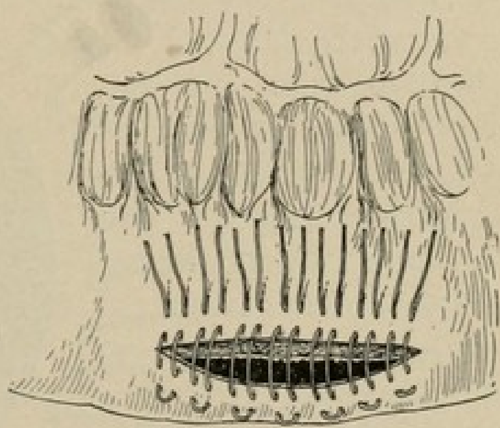

Fig. 26.—Halsted's Intestinal Suture.

which bridge across the fracture and are secured by being screwed to the fragments.

Suture of Serous Surfaces, Bowel, etc.—The essential object is to secure rapid adhesion by approximating serous surface to serous surface, and this is accomplished by means of the Lembert suture.

The Lembert suture catches the serous and muscular coats of the bowel, but does not penetrate into the mucous membrane layer. It should not enter into the lumen of the gut, etc. For this suture silk should be employed. It may be introduced interrupted or continuous, and is applied in such a manner as to invert the edges and join opposite serous surfaces.

A straight, round, cambric needle is usually employed to carry the Lembert suture, but occasionally, especially in sewing deep within the abdominal cavity, a thin, curved, surgeon's needle in a holder may be more convenient.

In applying the Lembert suture the needle is introduced a short distance from the edge of the opening in the bowel, and after passing in the wall of the gut for a short distance and catching up the serous and muscular coats, but not entering the mucous membrane coat, it emerges near the edge of the wound in the gut; the needle is then carried across the opening in the bowel and introduced upon the other side at a point directly opposite and in a similar manner.

The suture may also be introduced and carried in the wall of

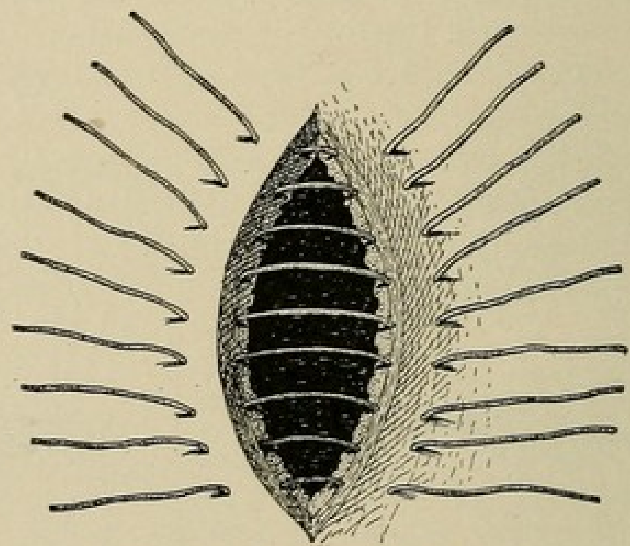

Fig. 27.—Non-penetrating Suture.

the gut along a line parallel with the incision instead of at right angles to the line of the incision,—the Cushing suture.

Small wounds of the bowel may be closed with a single row of Lembert sutures or with a Lembert suture in the shape of a purse-string. Larger wounds of the hollow abdominal viscera should be closed, first with a continuous or interrupted row of No. 1, ten-day, chromic catgut sutures that penetrate through all the layers of the organ, joining the parts accurately edge to edge, and then, after the opening has been thus closed, the Lembert stitch, which unites the opposite serous surfaces to each other, is applied. The Lembert stitch buries the penetrating suture and inverts the edges of the wound, so that the serous surfaces become apposed to each other. The outside Lembert suture that buries the deeper penetrating mucous suture is sometimes called the "outside serous" suture.

Suture of Wounds of the Bladder.—Closure of wounds of the urinary bladder requires special mention. They may involve the serous or the non-serous portion of the organ.

Wounds of the serous portion should be closed first with a continuous catgut stitch, No. 1, ten-day chromicized, which should include all the coats except the mucous membrane. Each loop of this suture should be drawn tight. This serves to close the opening. These sutures do not penetrate, hence do not appear upon the inner surface of the bladder. A continuous Lembert stitch of silk is then introduced which unites the opposite serous surfaces, immediately adjacent to the edges of the incision, to each other and buries the first row of sutures.

Wounds of the non-serous portion of the bladder: *i.e.,* its anterior wall. Wounds of this part of the bladder should be closed with a continuous or interrupted row of No. 1, ten-day chromicized catgut sutures that include the whole thickness of the bladder wall except its mucous membrane layer. These sutures should close the opening in the wall of the bladder very accurately; owing to the absence of the serous coat from this part of the bladder, the Lembert suture—"outside serous suture"—cannot be applied. Since we cannot look for rapid adhesion in wounds of this part of the bladder, it is well to allow the abdominal incision to remain partly open, packing with gauze down to the suture line in the wall of the bladder, so that, if there is any leakage, the fluid may find its way out of the wound.

PART II.

HEAD AND FACE.

HEAD.

Surgical Anatomy of the Head. THE SCALP —The head is covered by the scalp, which is a dense layer, composed of the skin, subcutaneous connective tissue, and the aponeurosis of the occipito-frontalis muscle. These three layers together constitute the scalp.

The subcutaneous connective tissue is dense and serves to unite the skin intimately with the underlying aponeurosis of the occipito-frontalis muscle. It is continuous behind, in front, and upon the sides with the superficial fascia (subcutaneous fatty and connective-tissue layer) of these parts. In it ramify the blood-vessels and nerves.

The arteries of the scalp are large and numerous. Bleeding from these vessels can often be controlled by pressure applied against the underlying bony surface. Anteriorly are the frontal and supra-orbital arteries; on the sides, branches of the temporal; and, behind, the occipital and posterior auricular. These vessels all course from below upward toward the crown of the head, their branches anastomosing freely with each other all around. These arteries are found at times to be very tortuous.

The occipito-frontalis muscle is broad and flat, consisting of an anterior and a posterior muscular portion and an intermediate aponeurotic portion which covers the top of the skull. This aponeurosis is firmly united with the overlying skin, whereas it is but loosely attached to the pericranium beneath. Upon either side the aponeurosis is continued into the temporal fascia. In cases where the scalp is torn off, the aponeurosis of the occipito-frontalis comes away with the skin and subcutaneous connective tissue, thus leaving the pericranium exposed.

In the temporal region the subcutaneous connective-tissue layer is looser than upon the top of the head, and in it run the branches of the temporal artery and vein and the auriculo-temporal nerve. Beneath the subcutaneous layer in the temporal region is the temporal fascia. This is a strong, fibrous layer covering in the temporal muscle and is attached above, all around, to the temporal ridge and below, to the upper border of the zygomatic arch, where it splits into two layers between which are included a small arterial and nervous branch. The aponeurosis of the occipito-frontalis muscle thins out upon each side and is continued into this temporal fascia. Beneath the temporal fascia is the temporal muscle. This is a broad, fan-shaped muscle which arises from the whole surface of the temporal fossa and from the under surface of the temporal fascia; it is attached by a strong tendon to the tip, anterior border, and inner surface of the coracoid process of the inferior maxilla.

The pericranium is a shining, fibrous layer of periosteum which is closely attached to the external surface of the bones of the skull: most intimately at the suture lines, through which it is continuous with the dura mater lining the inner surface of the bones.

Collections of pus or blood between the skin and the occipito-frontalis aponeurosis give rise to circumscribed tumors because they cannot become diffused in the dense subcutaneous connective-tissue layer. Between the aponeurosis and the pericranium, however, such collections may become widely diffused, owing to the looseness of the tissue which joins the aponeurosis and the pericranium together, and, raising the whole scalp so that it resembles a water-bag, may gravitate and point in the frontal or occipital regions. Beneath the pericranium, between this layer and the surface of the bone, such collections are again limited, owing to the close union between this structure and the underlying bone (see Fig. 39).

The Skull.—The skull is a rounded, elastic case made up of a number of bones joined, for the most part, edge to edge. The base of the skull is irregular and is strengthened along certain lines by ribs of bone, the intervening portions being often very thin. It presents many openings for the entrance and exit of important structures.

The Vault of the Skull is arched, rounded, and smooth. The bones entering into the formation of the vault are flat and vary in thickness in different places. These so-called flat bones that enter into the formation of the vault are made up of spongy tissue—diploë—inclosed between two plates of hard compact bone: the inner and outer tables. The outer table is twice as thick as the inner. The external surface of the skull is covered by the periosteum (pericranium) already mentioned. The internal surface is lined by the dura mater, which is very closely applied to the surface of the bones, serving the purpose of a periosteum; the large vascular branches that ramify upon the inner surface of the skull are lodged in the dura.

The spongy substance—diploë—inclosed between the two layers of compact bone presents an extensive system of venous canals. These communicate with the intracranial venous sinuses that are found between the layers of the dura mater, and with the veins of the scalp. The vault of the skull varies in thickness in different places and in different individuals. About the middle it is thin, its average thickness in this situation being from 4 to 5 mm.; it becomes thicker toward the front and still more so toward the occiput. Along the course of the intracranial venous sinuses, and also corresponding to the depressions for the Pacchionian bodies which are located upon either side along the middle line, the bone is thinner. Where the skull is thin it is at the expense of the diploë, which in certain parts may be entirely absent, the two tables being in direct contact with each other. This is the condition in the temporal region.

The lines of junction of the bones of which the vault is made up are irregular and might be mistaken for fractures when exposed in scalp wounds. The junction of the two parietal bones in the middle line forms the sagittal suture. The junction of the two parietal bones with the frontal anteriorly forms the coronal suture. The point where the coronal crosses the sagittal suture is called the bregma. This is the site of the anterior fontanelle, which does not close until some time between the eighteenth and twenty-fourth month. Occasionally it closes earlier. The time at which the fontanelle closes is of diagnostic importance in infants. Posteriorly the parietal bones articulate with the occipital bone and forms the lambdoidal suture. In the middle line, corresponding to the junction of the sagittal and lambdoidal suture lines, is the lambda. This location may be marked by the presence of one or more Wormian bones, and corresponds to the position of the posterior fontanelle. The posterior fontanelle is found closed at birth or closes shortly thereafter. Anteriorly, corresponding to the articulation of the nasal bones with the frontal is a line of suture, the fronto-nasal suture. Occasionally meningocele (anterior) protrudes at this site. Ascending in the middle line for a short distance from the line of articulation between the nasal and frontal bones, the remains of a suture line may be seen which represents the line of union between the two halves of which the frontal bone originally consisted. This is called the frontal suture.

The mid-point of the fronto-nasal suture is called the nasion. In the middle line, just above the nasion, is a prominence, the glabella. This is an important surgical landmark. Behind, the prominent external occipital protuberance may be readily felt. This is called the inion. A line corresponding to the sagittal suture drawn from the nasion to the inion might be called the sagittal line. Passing outward, on either side, from the external occipital protuberance, is

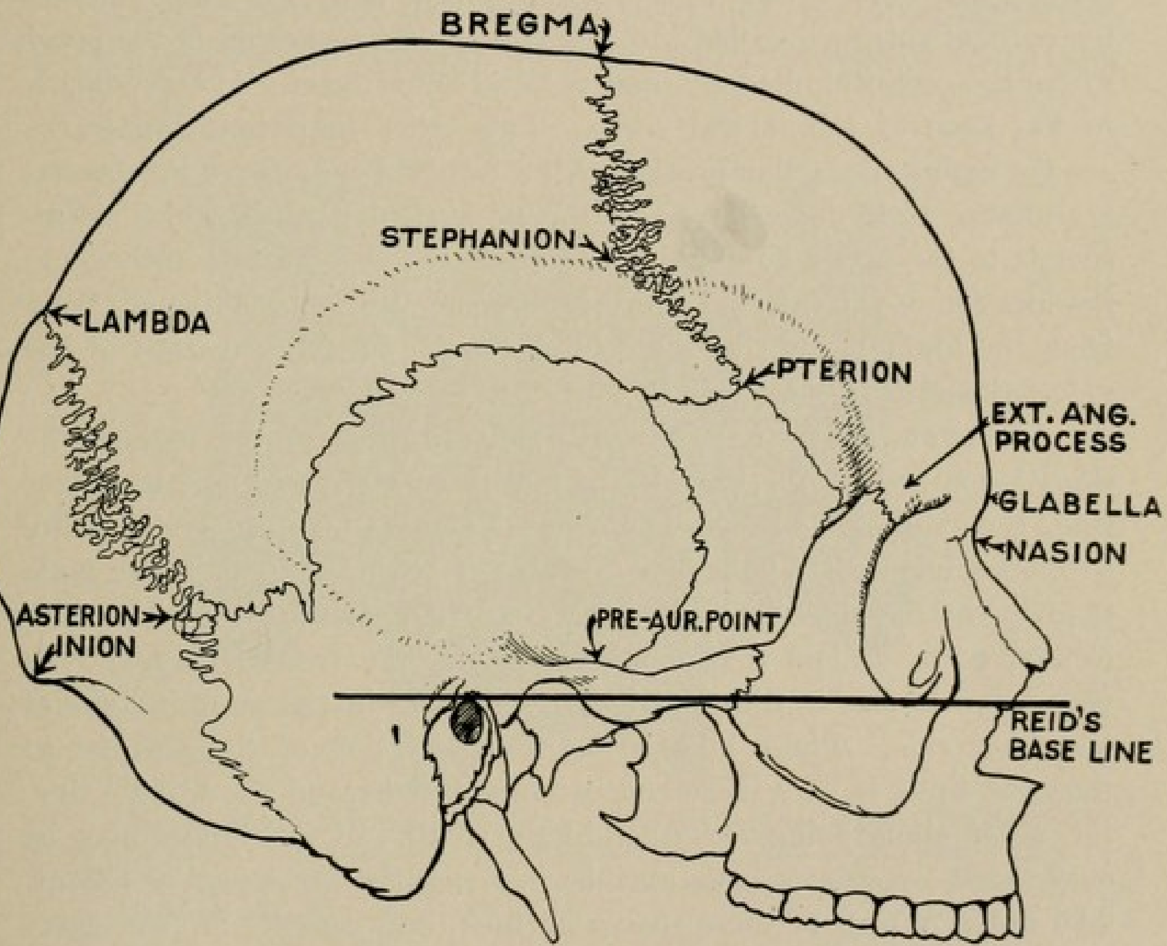

Fig. 28.—Side of the Skull. Shows various important landmarks.

the superior curved line of the occipital bone. The external occipital protuberance corresponds fairly accurately to the position of the internal occipital protuberance and the superior curved line of the occipital bone to the level of the attachment of the tentorium cerebelli, course of the lateral sinus, etc. The prominence corresponding to the lambda, some distance above the external occipital protuberance, should not be mistaken for the latter. A fœtal suture extending upward in the middle line from the foramen magnum may persist. This is the usual site of cranial meningocele.

The point on the side of the skull, where the anterior inferior angle of the parietal bone articulates with the frontal and the great wing of the sphenoid, is called the pterion, and is located one and one-half inches behind, and one-quarter inch above, the external angular process of the frontal bone. The pterion corresponds to the Sylvian point where the Sylvian fissure breaks up into its three branches, and to the course of the anterior branch of the middle meningeal. The point where the superior temporal ridge crosses the coronal suture is called the stephanion. The asterion is the point where the occipital, mastoid, and parietal bones meet. It corresponds to the knee of the lateral sinus. Two other important landmarks are the external angular process of the frontal bone, where the frontal articulates with the malar, and the preauricular point which corresponds to the upper border of the root of the zygoma just anterior to the location of the external auditory meatus. Reid's base line is drawn from the lower margin of the orbit through the upper margin of the external auditory meatus.

Frontal Sinuses.—Corresponding to the frontal region, the skull is marked by the presence of two large air-spaces, one on either side, the frontal sinuses. The frontal sinuses do not become fully developed until after puberty. They are more prominent in the male than in the female. They are separated from each other by a septum located more or less in the middle line. The frontal sinuses vary very much in size in different individuals, and in the same individual on either side. There may be marked deviation of the septum, so that one sinus is very large and extends over beyond the middle line, the other sinus being correspondingly small. Both sinuses may be very large, or one or both may be but slightly developed or absent. The anterior wall of these spaces is thick, and consists of two layers of hard, compact bone, with an intervening diploëic layer. The posterior wall is thin. The frontal sinuses are lined with mucous membrane and communicate with the nasal fossa through a large canal, the infundibulum, which opens under the middle turbinated bone, toward the front. The anterior ethmoidal cells are in close proximity to the floor of the frontal sinuses—only a thin plate of bone intervening—and these may become involved in suppuration of the frontal sinuses. Pus in the frontal sinus may perforate the floor of the sinus and point in the upper inner angle of the orbit, or the process may extend through the posterior wall of the sinus into the cranial cavity, and set up a meningitis, abscess in the frontal lobe, etc.

The Side of the Skull.—In the mastoid region the bone is prolonged downward in the form of a teat-like process; the mastoid process (mastoid region—see page 113).

Corresponding to the temporal region, the skull is made up of the squamous portion of the temporal bone, which is very thin, and of part of the parietal bone. Ascending upon the surface of the bone, beneath the temporal muscle, are several deep temporal arterial branches.

The parietal and the occipital bones and the mastoid portion of the temporal bone present openings for the passage of veins from

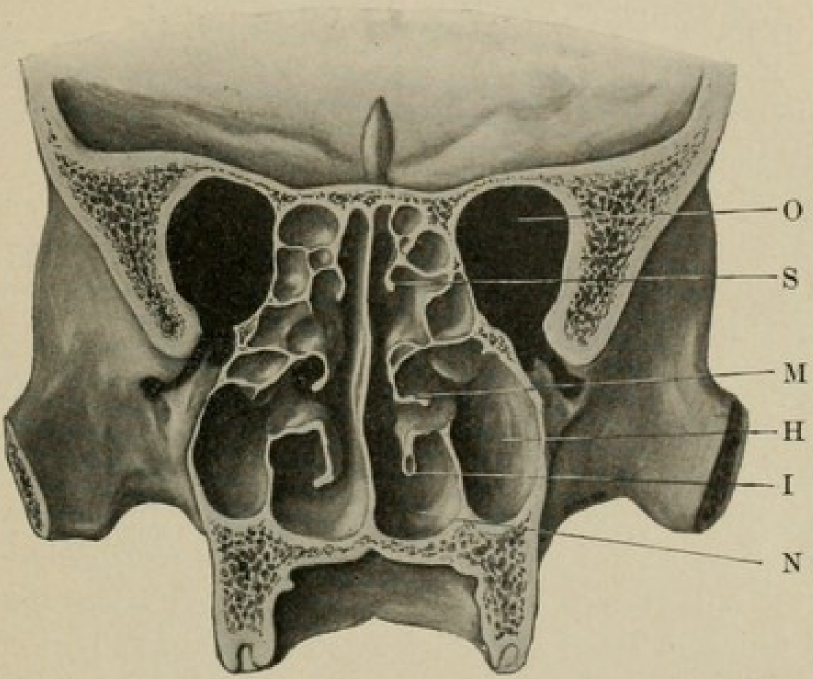

Fig. 29.—Transverse Section through the Anterior Fossa. Shows the relation of the floor of the anterior fossa to the roof of the orbital and nasal cavities; *S*, *M*, *I*, superior, middle, and inferior turbinate bones; *H*, antrum of Highmore; *O*, orbital cavity; *N*, nasal cavity.

the exterior of the skull which empty into the intracranial sinuses, and these may be the routes through which infection is carried into the cranial cavity.

The Base of the Skull, studied from within, is seen to consist of three fossæ located upon different levels:—

The Anterior Fossa is situated upon the highest level. The floor is made of the cribriform plate of the ethmoid in the middle, and of the frontal and the lesser wing of the sphenoid upon the sides. The ethmoid is perforated by numerous small openings for the passage of branches of the olfactory nerve and blood-vessels, to and from the nasal cavity. The floor of the anterior fossa is very thin and corresponds to the roof of the orbital and nasal cavities. The roofs of the various sinuses (air-spaces) adjacent to the upper part of the nasal cavity are very thin and correspond to the floor of the anterior fossa of the skull. Disease of these sinuses may readily extend to the meningeal membranes and to the anterior lobes of the brain. There is also danger of perforation in operating within these sinuses.

The frontal lobes rest upon the floor of the anterior fossa. Fracture of the anterior fossa is characterized by escape of blood through the nose or into the orbital cavities, with resulting subconjunctival ecchymosis, bulging of the eyeballs, etc.

THE MIDDLE FOSSA.—The middle fossa of the skull is of much surgical importance. It lodges the temporo-sphenoidal lobes. It is narrow in the middle and widens out upon either side. The floor of the middle fossa corresponds about with the level of the zygoma and is limited in front by the posterior border of the lesser wing of the sphenoid and by the optic groove; behind by the dorsum epiphii and the upper border of the petrous portion of the temporal bone. The upper border of the petrous portion is marked by a groove for the superior petrosal sinus and gives attachment to the tentorium cerebelli. The floor of the middle fossa consists in the middle line of the upper surface of the body of the sphenoid, presenting in front the optic groove, at either end of which is the optic foramen; behind the optic groove is the sella turcica, a deep depression which lodges the pituitary body and which is bounded behind by the dorsum epiphii. Laterally the floor of this fossa consists of the upper surface of the great wing of the sphenoid, the anterior surface of the petrous portion of the temporal and a part of the squamous portion of the temporal. The body of the sphenoid is marked upon either side by a groove which commences behind at the foramen lacerum medium (carotid foramen) and terminates in front at the optic foramen. This lodges the cavernous sinus, etc.

The foramen lacerum medium is formed at the expense of the anterior superior surface of the apex of the petrous portion of the temporal; it is bounded in front by the posterior border of the great wing of the sphenoid and behind by the apex of the petrous portion; through this opening the internal carotid artery enters the cranium. Behind and external to this foramen the antero-superior surface of the petrous portion presents a depression in which the

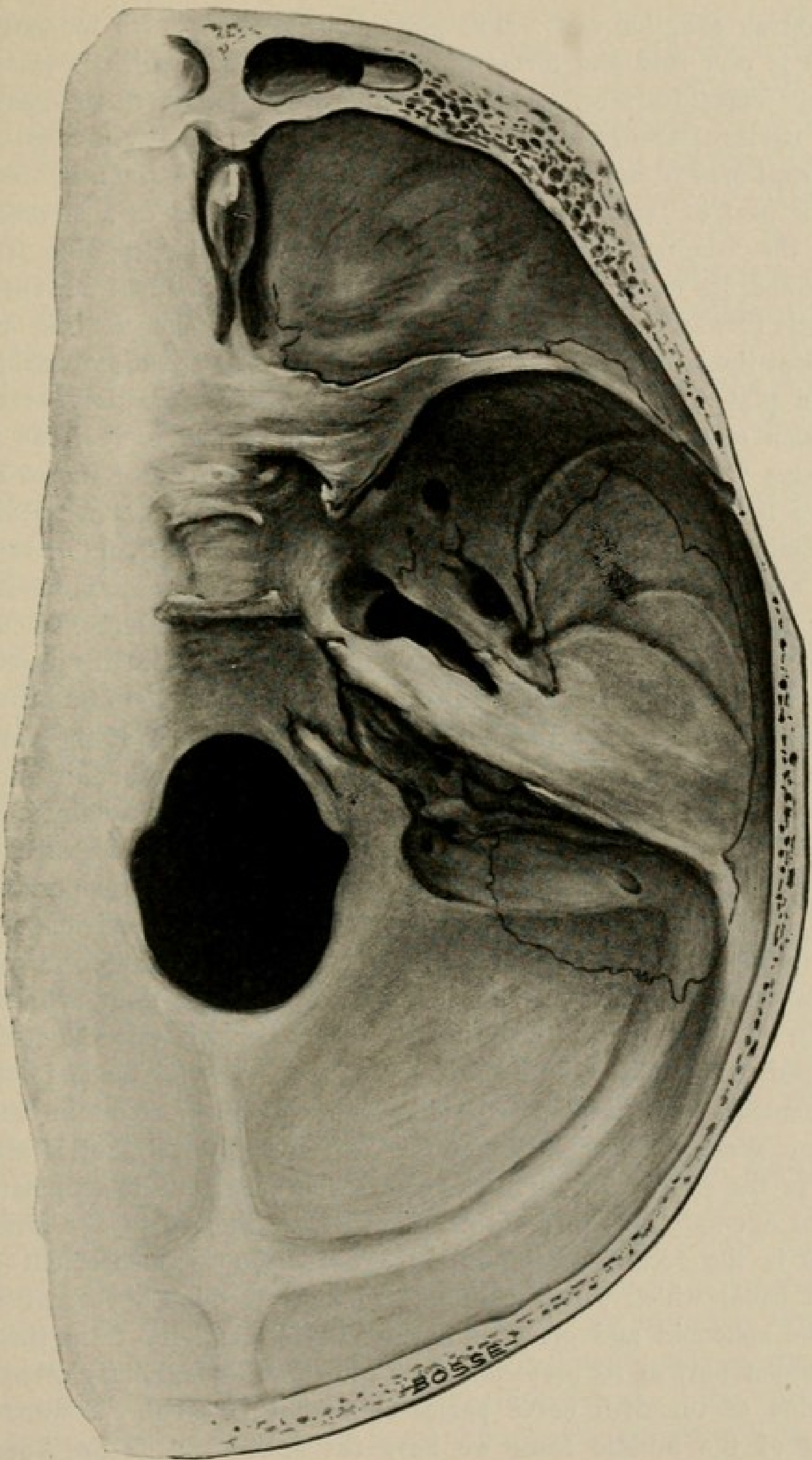

Fig. 30.—Base of the Skull from Within.

Gasserian ganglion rests. The plate of bone upon which the ganglion rests is very thin and forms the roof of the canal, which is traversed by the carotid artery. Anteriorly in close proximity to the ganglion and its three trunks is the cartilaginous end of the Eustachian tube. In front of, and external to, the foramen lacerum medium, in the posterior part of the great wing of the sphenoid, there is a large opening, the foramen ovale. As its name indicates, this opening is oval in shape, its long diameter being directed from without inward and a little forward. This opening is seen externally upon the base of the skull at the root of the pterygoid process, external to the external pterygoid plate. Through this opening the inferior maxillary or third division of the fifth nerve, together with the motor root of the fifth, emerges from the cranial cavity. Just external to the foramen ovale and a little behind it, in the apex or angle of the great wing of the sphenoid, is the foramen spinosum, through which the middle meningeal artery enters the skull. From this opening a groove is seen running outward, marking the squamous portion of the temporal near its junction with the petrous portion; this groove lodges the posterior branch of the middle meningeal artery and is continued upward upon the side of the skull across the posterior inferior part of the parietal bone. Commencing at or near the foramen spinosum there is another groove, which runs forward and outward across the squamous portion of the temporal and the great wing of the sphenoid, ascending upon the side of the skull, across the anterior inferior portion of the parietal bone; in this groove rests the anterior division of the middle meningeal artery. The groove that lodges the anterior branch of the middle meningeal artery is very often quite deep with sharp edges, or it may be converted into a canal. In this way the vessel is gripped very tightly, and any blow or violence that tends to shake or displace the contents of the cranium is likely to result in tearing of this vessel. As a matter of fact this is the vessel that is almost always the site of intracranial hemorrhage when due to traumatism. About one-half inch in front of, and a little internal to, the foramen ovale is the foramen rotundum. This is the commencement of a short canal which passes obliquely forward through the great wing of the sphenoid and opens into the spheno-maxillary fossa through the upper part of its posterior wall; the superior maxillary or second division of the fifth nerve passes through this canal. Toward the front of the middle fossa we have the sphenoidal fissure opening into the orbit; this is a large triangular opening between the free border of the great wing and the under surface of the lesser wing of the sphenoid, its base being inward toward the body of the sphenoid. Through this fissure pass the third, the fourth, the ophthalmic or first division of the fifth and the sixth nerves, the ophthalmic vein, etc.

In the outer part of the petrous portion of the temporal bone is lodged the hearing apparatus—the middle ear and mastoid antrum, and the internal ear and auditory nerve. The roof of the middle ear and antrum, tegmen tympani, is very thin, and infection may readily spread from these cavities into the cranial cavity—to the meninges and temporo-sphenoidal lobe.

Fracture of the middle fossa of the skull is marked by the escape of blood or cerebro-spinal fluid from the ear, or, maybe, into the pharynx through the Eustachian tube.

THE GASSERIAN GANGLION, ETC.—The Gasserian ganglion is frequently the object of surgical intervention, and its relationship to important adjacent structures, to the cavernous sinus, the internal carotid artery, etc., is of the greatest interest.

The cavernous sinus is a wide, loose, thin-walled canal which is situated between the layers of the dura mater. It reaches from the apex of the petrous portion of the temporal bone behind to the inner end of the sphenoidal fissure in front, being lodged in the cavernous groove upon the side of the body of the sphenoid. The lumen of the cavernous sinus presents a peculiar reticular structure, being broken up into numerous cellular spaces by trabeculæ and septa which pass in various directions. Anteriorly the cavernous sinus receives the ophthalmic vein, and posteriorly it joins with both petrosal sinuses and communicates with the pterygoid plexus through the veins which enter the skull through the foramina ovale, spinosum, and lacerum medium. The external border of the cavernous sinus corresponds to a line running from before backward, which would just skirt the inner margin of the foramen rotundum.

The internal carotid artery enters the cranium through the foramen lacerum medium and passes forward, along the side of the body of the sphenoid, enveloped by the cavernous sinus, the sinus being, as it were, wrapped entirely around the artery. (One could not wound the artery in this situation without first cutting into the sinus.) Anteriorly, at the inner side of the anterior clinoid process, the internal carotid, after giving off its ophthalmic branch, turns upward and, passing through an opening in the dura mater, divides into its two terminal branches, the anterior and middle cerebral arteries. Along the outer side of the artery, and therefore also inclosed within the cavernous sinus, runs the sixth nerve. In the outer wall of the cavernous sinus and intimately united to it, the third, the fourth, and the ophthalmic or first division of the fifth nerve are lodged; these structures cannot be separated from the wall of the sinus without

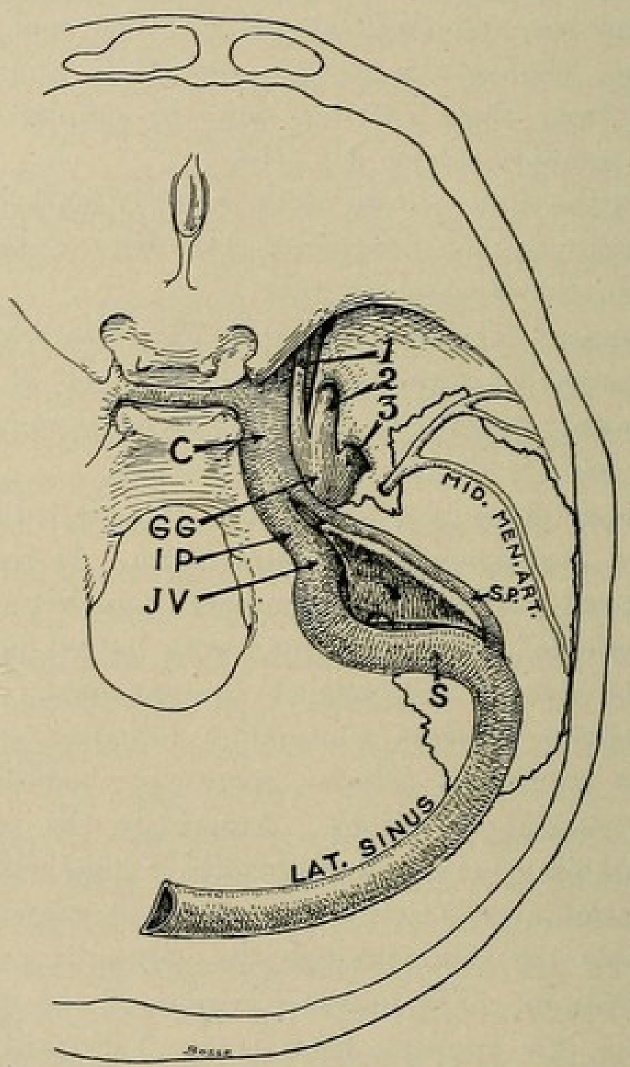

Fig. 31.—Middle Fossa showing the Position of the Gasserian Ganglion, Three Divisions of the Fifth Nerve, etc. *C*, cavernous sinus; *GG*, Gasserian ganglion; *IP*, inferior petrosal sinus; *JV*, commencement of the internal jugular vein; *S*, sigmoid sinus; *SP*, superior petrosal sinus; 1, 2, 3, first, second, and third divisions of the fifth nerve. The intimate relationship of the first division of the nerve with the cavernous sinus is indicated.

tearing it, and their relation to each other is in the order given both from within outward and from above downward.

The fifth nerve at its origin appears upon the side of the pons Varolii, and consists of a thick sensory and a small motor root; these pass forward through an oval slit in the dura mater and across the upper border of the petrous portion of the temporal bone, near its apex, into the middle fossa of the skull. As the roots pass over the upper border of the petrous portion, they lie beneath the superior petrosal sinus, extradural: *i.e.*, between the dura mater and the base of the skull. Upon reaching the front surface of the petrous portion of the temporal bone the sensory root presents a swelling, the Gasserian ganglion. The motor root takes no part in the formation of this ganglion, but lies underneath it. The ganglion rests in the depression upon the front surface of the apex of the petrous portion. It is reddish gray in color, crescentic or semilunar in shape, the anterior convex border looking forward, downward, and outward. It is 14 to 22 mm. wide, 4 mm. from before backward, and 1½ mm. in thickness.

Given off from the anterior border of the ganglion are the three divisions of the fifth nerve. Of these, the first, or ophthalmic, the

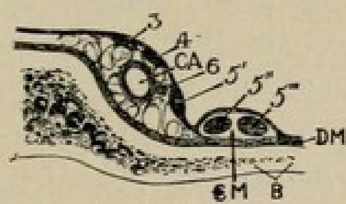

Fig. 32.—Cross-section through Middle Fossa just Anterior to Position of the Gasserian Ganglion. Shows the relation of the cavernous sinus to adjacent structures. *B*, bony floor of middle fossa; *CA*, internal carotid artery inclosed within the trabeculated cavernous sinus; *CM*, cavum Meckelii; *DM*, dura mater forms periosteum covering floor of middle fossa and roofs over the cavum Meckelii; 3, third nerve; 4, fourth nerve; 5′, first division of fifth nerve; 5″, second division of fifth nerve; 5‴, third division of fifth nerve; 6, sixth nerve; the third, fourth, and first division of the fifth nerve are incorporated in the wall of the cavernous sinus. The sixth nerve is wholly within the sinus. The second and third divisions of the fifth nerve are situated within the cavum Meckelii.

longest and thinnest of the three, is the most internal and passes from behind forward and upward along, or rather in, the outer wall of the cavernous sinus, entering the orbit through the sphenoidal fissure. On account of its intimate relation to the wall of the sinus, any attempt to separate it would be likely to tear the wall of the sinus; it is in close relation with the third and fourth nerves, the carotid artery, and the sixth nerve. The second, or superior maxillary division lies external to the preceding, is 8 to 11 mm. long, and passes forward, entering the foramen rotundum, and emerges from this canal in the spheno-maxillary fossa. This branch lies close to the outer edge of the cavernous sinus, but is not joined to it, and may be readily removed without danger to the sinus. The third, or inferior maxillary, division, the most external of the three, is short and thick, and passes forward and outward, leaving the skull through the foramen ovale in company with the motor root. The motor root winds around the third division to get upon its outer side, the two becoming joined just after their exit through the foramen ovale. The ganglion rests in the depression already described upon the front surface of the petrous portion of the temporal bone. The motor root of the nerve takes no part in the formation of the ganglion, but lies beneath it, between it and the bone. At times the bone is absent in this location and under such circumstances the ganglion will be found to be separated from the carotid artery only by the fibrous tissue which intervenes. The surface of bone upon which the ganglion and its three divisions rest is covered by the periosteum. The ganglion and its divisions, as already mentioned, are placed extradural: *i.e.,* between the dura mater and the base of the skull; the dura roofs them over, and is attached to the margins of the depression in which the ganglion rests and to the floor of the middle fossa of the skull, along the inner margin of the second division and along the outer margin of the third division; so that not only the ganglion, but its second and third divisions as well, are thus roofed in. This space, in which the ganglion and its second and third divisions are thus inclosed, is called the cavum Meckelii. Beyond the ganglion and its divisions the dura is, as elsewhere, closely applied to the surface of the bone. The ganglion and its divisions are but loosely attached to the periosteum which covers the surface of the bone upon which they rest (floor of cavum Meckelii) and to the dura mater which covers them and forms the roof of the cavum Meckelii.

The cavum Meckelii is really a space in the floor of the middle fossa of the skull between the bone and the non-attached dura, which lodges the ganglion and its second and third divisions.

The Gasserian ganglion is in relation, internally, with the carotid artery and cavernous sinus. Behind the ganglion is the superior petrosal sinus underneath which the roots of the nerve must pass in order to reach the ganglion as it rests upon the front surface of the petrous portion. The superior petrosal sinus is contained in the edge of the tentorium cerebelli, which is attached to the superior border of the petrous portion.

The middle meningeal artery enters the skull through the foramen spinosum just external to, and a little behind, the foramen ovale (through which the third division passes out of the skull) and would therefore be met with in approaching these structures through an opening in the side of the skull.

The Posterior Fossa.—This is the deepest of the three fossæ. It contains the cerebellum, pons, and medulla. It is formed, for the most part, of the occipital bone, the petrous and mastoid portions of the temporal bone taking part in its formation anteriorly and laterally. About the middle it presents a large opening—the foramen magnum—for the passage of the cord. In front of the foramen magnum is the smooth, shelving, grooved basilar process which supports the medulla and pons. On either side of the foramen magnum is the foramen lacerum posterius. Near the foramen lacerum posterius the lateral sinus is joined by the inferior petrosal sinus to form the internal jugular vein, which leaves the skull through the foramen lacerum posterius. The petrous portion presents the orifice of the auditory canal through which the facial and auditory nerves enter the bone. The posterior fossa is divided in two halves by the internal occipital crest, which occupies the middle line passing from the posterior margin of the foramen magnum to the internal occipital protuberance. It gives attachment to the falx cerebelli and lodges the occipital sinus. The broad grooves for the lateral sinuses are seen passing outward on either side from the internal occipital protuberance. The groove is continued from the occipital bone on to the lower posterior angle of the parietal, where it bends rather sharply downward, "S" fashion, upon the mastoid portion of the temporal, then it curves forward again on to the occipital bone, and ends at the foramen lacerum posterius. Upon the mastoid portion of the groove for the lateral sinus is seen an opening for the passage of a small vein from the occipital vein, from without to the lateral (sigmoid) sinus.

The Dura Mater is a strong, tough, non-elastic, fibrous membrane which lines the inner surface of the skull. It is described as one of the coverings of the brain, but should, in fact, be considered as an appendage of the skull in contra-distinction to the pia mater, or, better, the pia-arachnoid, which is essentially an appendage of the brain. The dura mater is closely attached to the bones, more intimately to those of the base than those of the vault, forming their periosteum; but it may be detached from the bones without much difficulty. It supports the intracranial arteries, veins, and venous sinuses, and, when detached from the surface of the bones, carries these vessels with it.

Anteriorly, ramifying in the dura mater, is the anterior meningeal artery, which is a branch of the ethmoid. Corresponding to the middle fossa of the skull and the temporal region, the middle meningeal artery is found. This is a branch of considerable size, and is of much surgical importance; it is derived from the internal maxillary and enters the skull through the foramen spinosum in the base of the skull. Behind are the posterior meningeal branches which are derived from the occipital and the vertebral.

The dura mater gives off three strong processes, the falx cerebri and falx cerebelli, and the tentorium cerebelli. The falx cerebri occupies the middle line, being attached along the line of the sagittal suture and serves to separate the two hemispheres of the cerebrum. The falx cerebelli is attached to the occipital bone along the line of the internal occipital crest, and separates the two halves of the cerebellum. The tentorium cerebelli is attached to the prominent bony margins of the posterior fossa, to the horizontal portion of the groove for the lateral sinus as far as the point where the groove strikes the angle of the parietal bone, and from this point to the prominent upper border of the petrous portion of the temporal bone. The tentorium presents a large, rounded opening anteriorly to accommodate the mesencephalon—corpora quadrigemina and crura cerebri—that portion of the brain which connects the cerebrum with the parts that are lodged in the posterior fossa. The posterior fossa is partly roofed in by the tentorium cerebelli, the posterior lobes of the cerebrum resting upon the tentorium.

The Venous Sinuses of the Dura Mater.—There are a number of large venous sinuses which are situated between the layers of the dura, and which groove the surface of the bones along their course.

The Superior Longitudinal Sinus runs from before backward along the line of the sagittal suture, a little more to the right of the middle line, from the foramen cæcum in front to the internal occipital protuberance behind, where it becomes the right lateral sinus. It is situated between the layers of the falx cerebri, which are separated along the line of their attachment to the bone in order to accommodate the sinus. The sinus is wedge-shaped on section, and increases in width from before back, from ¼ inch in width in front to ¾ inch in width behind. In the middle of its course the longitudinal sinus gives off a number of processes, the parasinoidal sinuses or lacunæ, that extend outward between the layers of the dura over the surface of the hemispheres for a distance of $1\frac{1}{2}$ to $2\frac{1}{2}$ cm.; therefore within this distance of the sagittal line caution must be exercised to thoroughly separate the dura before gouging away the bone so as not to tear these lateral extensions of the longitudinal sinus. The superior cerebral veins terminate in the longitudinal sinus and parasinoidal lacunæ. The anterior branches pass straight inward, the posterior passing obliquely forward and inward. They unite with branches from the inner surface of the hemisphere before entering the sinus. These veins have to pass from the arachnoid layer across the subdural space to reach the sinuses, and may thus be torn by overlapping of the bones (parietals) in moulding of the head in difficult labor, with resulting hemorrhage and subsequent paralysis, idiocy, etc. The longitudinal sinus communicates with the veins of the scalp and venous channels in the diploë through a variable number of emissaries that pass through foramina in the bones. In detaching the dura from the bone at these places these veins are usually torn and severe hemorrhage may result. Into the parasinoidal sinuses, lacunæ, and into the longitudinal sinus the Pacchionian bodies project, they being suspended and bathed, as it were, in the blood-stream of the sinus.

The Inferior Longitudinal Sinus is situated between the layers of the falx cerebri along its free border. It terminates posteriorly by joining with the vena magna Galeni, which drains the deep parts of the cerebrum, to form the straight sinus.

The Straight Sinus passes backward in the middle line between the layers of the dura in the recess formed by the junction of the falx cerebri with the tentorium cerebelli. It terminates usually in the left lateral sinus.

The Lateral Sinuses are important surgically. They are lodged in the grooves on the occipital bones between the layers of the tentorium cerebelli, which are attached to the margins of the grooves. The right is usually the direct continuation of the superior longitudinal sinus. From the center of the occipital bone that of either side passes transversely outward, grooving the occipital bone and the posteror inferior corner of the parietal. Here the lateral sinus is joined by the superior petrosal, which runs along the superior border of the petrous portion of the temporal bone between the layers of the attached tentorium cerebelli. The sinus then curves downward, grooving the inner surface of the mastoid, and from this bone is continued again over on to the occipital, crossing the upper surface of the jugular process of this bone, to join with the inferior petrosal sinus to form the internal jugular vein. The course of the transverse portion of the lateral sinus corresponds to a line drawn from the external occipital protuberance to the upper margin of the external auditory meatus. That portion of the lateral sinus that corresponds to the mastoid portion of the temporal bone is called the sigmoid sinus. It frequently becomes involved in inflammatory processes that affect the middle ear and mastoid antrum.

THE CAVERNOUS SINUS is lodged in the groove upon the side of the body of the sphenoid bone. The internal carotid artery passes from behind forward, from the orifice of the carotid canal in the apex of the petrous portion of the temporal bone, where the artery enters the cranium, to the point where it divides into its terminal branches. This part of the internal carotid artery is enveloped by the cavernous sinus, the wall of the sinus being, as it were, wrapped around the artery. The sixth nerve is also inclosed entirely within the sinus, lying below and to the outer side of the artery. The third, fourth, and the ophthalmic division of the fifth nerve are located in the outer wall of the cavernous sinus, but are not contained within its lumen as are the internal carotid artery and the sixth nerve. (See Fig. 32.) The sinus may be torn in fracture of the middle fossa. Thrombosis of the cavernous sinus is accompanied by extensive subconjunctival hemorrhage, marked bulging of the eyeball, hemorrhage into the retina, etc.

The blood-pressure within the sinuses is low, and hemorrhage during the course of operation is readily controlled by packing with strip gauze.

The Brain is a semisolid mass which is contained in a solid, nonyielding, bony case—the skull. The skull offers a considerable degree of protection to the vital organs contained within. The brain, with its peculiar covering, pia-arachnoid, occupies completely the space within the skull, so completely that the impressions of the convolutions of the brain and arteries in the dura are evident upon the surface of the bones. In this respect the brain differs from the cord, which does not completely fill the vertebral canal. Ample space exists between the cord enveloped in its pia-arachnoid and the dura and between the dura and the bony canal. The volume (bulk) of the brain increases or diminishes according to the quantity of blood that it contains, and when exposed is seen to pulsate with each heart beat and with each respiration. Any addition to the normal contents of the unyielding, bony, cranial cavity, such as extraversated blood, tumor, abscess, etc., causes increase of the intracranial pressure, which is promptly manifested by characteristic general symptoms, such as headache, dizziness, vomiting, impaired cerebration, etc., and by certain localizing symptoms if certain definite parts of the brain are affected. In the young child this increase of pressure may be

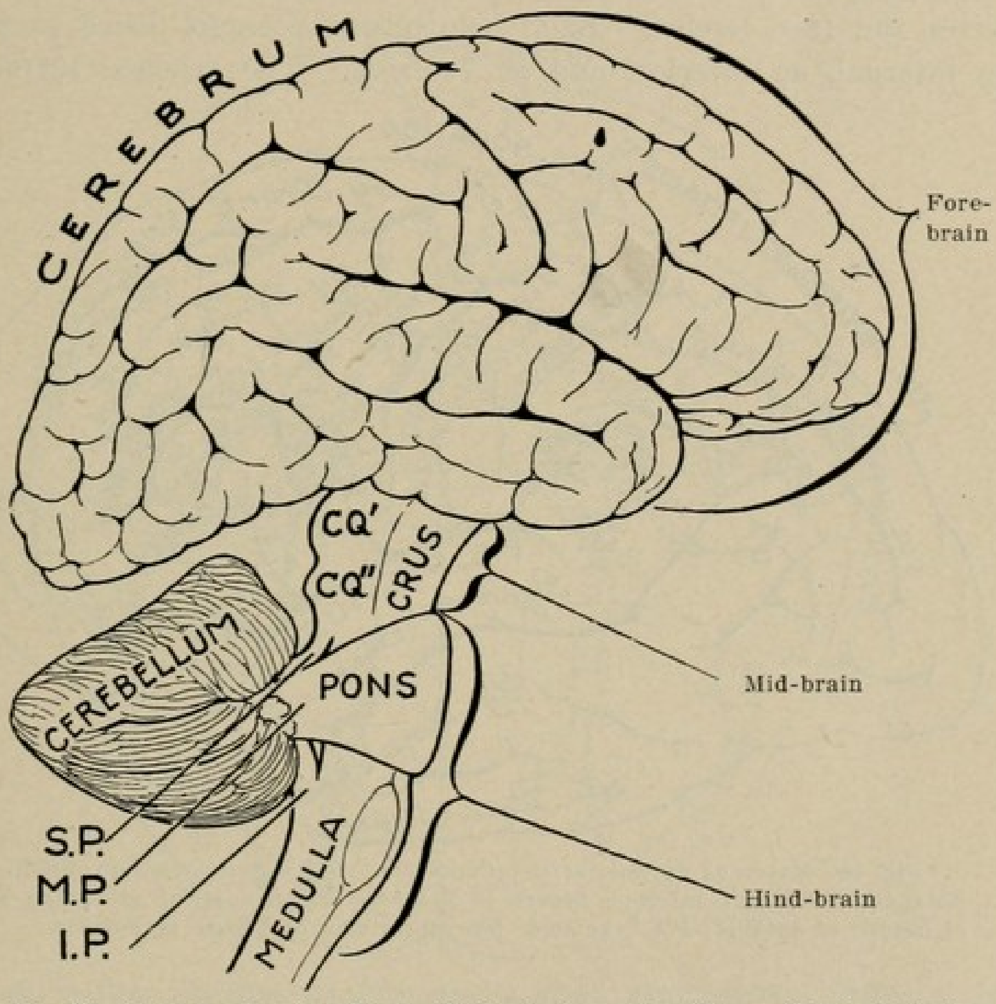

Fig. 33.—Schema showing Parts Derived from the Three Original Brain Vesicles. *CQ'*, *CQ"*, corpora quadrigemina, superior and inferior; *S.P.*, *M.P.*, *I.P.*, superior, middle, and inferior peduncles of the cerebellum.

compensated for by a spreading apart of the bones, and in the adult to a limited extent by displacement of the cerebro-spinal fluid. The interior of the brain is hollowed out by a system of ventricles which communicate with each other, and they in turn communicate with the subarachnoid space through three openings of variable size in the membranous roof of the fourth ventricle. The ventricles also communicate with the subarachnoid space, through a slit-like opening in the anterior part of the descending horn of each lateral ventricle.

The brain may be considered as consisting of three portions: the cerebrum developed from the fore-brain vesicle; the cerebellum, pons Varolii, and medulla derived from the hind-brain vesicle, and the parts that connect the two, the crura cerebri, corpora quadrigemina, which are developed from the mid-brain vesicle.

The two cerebral hemispheres are separated from each other by a deep, narrow fissure, the longitudinal fissure. This fissure receives the falx cerebri. Each hemisphere presents three surfaces: an internal, an inferior, and an external. The external surface of

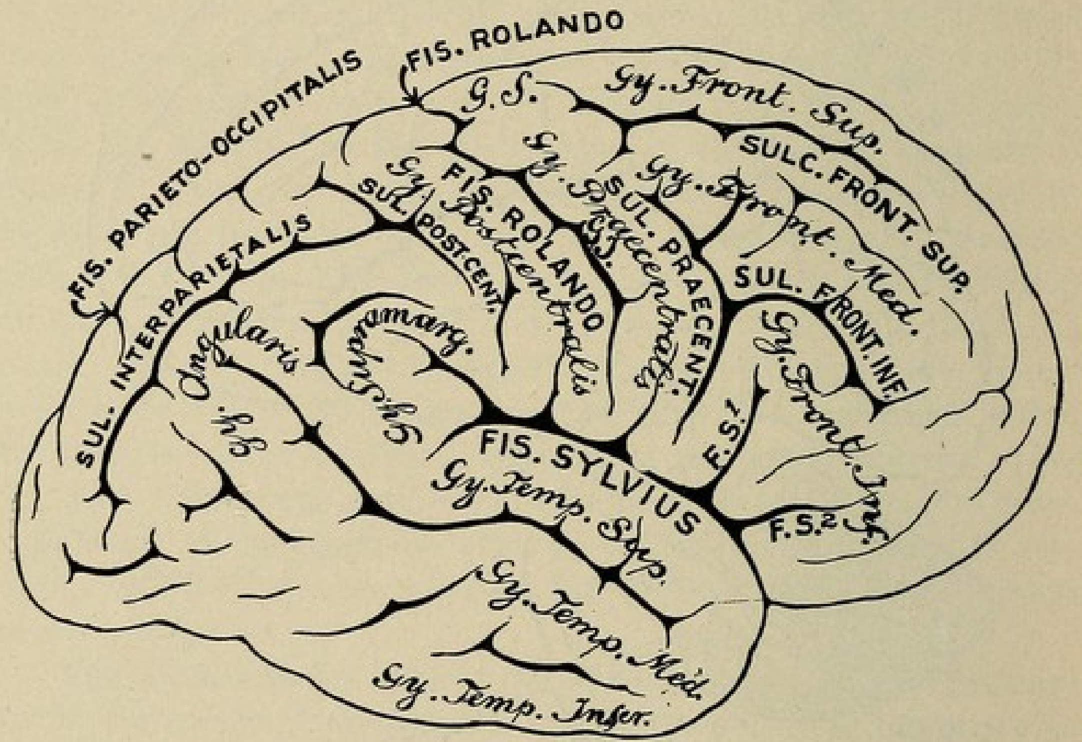

Fig. 34.—External Surface of the Cerebrum. *G.S.*, genu superior, fissure of Rolando; *G.I.*, genu inferior, fissure of Rolando; *F.S.*[1], anterior ascending arm of fissure of Sylvius; *F.S.*[2], anterior horizontal arm of fissure of Sylvius.

the hemisphere presents several well-marked fissures which serve to divide it into its several lobes, and are of guiding importance to the surgeon for operative purposes. The three main fissures are: the fissure of Rolando, the fissure of Sylvius, and the parieto-occipital fissure. The fissure of Rolando separates the frontal lobe from the parietal. It commences above a little behind the mid-point of the inner border of the cerebrum, is directed downward and forward, and terminates just above the lower end of the fissure of Sylvius. It forms an angle of 67° to 70° with the inner border of the cerebrum. This angle varies within a range of 4° or 5° in different cases. The line described by the fissure of Rolando is not straight, but curved with the concavity looking forward and corresponding roughly to its middle third. The points limiting this curved portion of the fissure of Rolando are called the genu superior and the genu inferior.

The fissure of Sylvius is the most conspicuous and striking. It corresponds to the upper border of the anterior portion of the temporo-sphenoidal lobe. It spreads out in three radiating arms, a posterior horizontal which passes backward, separating the temporo-sphenoidal

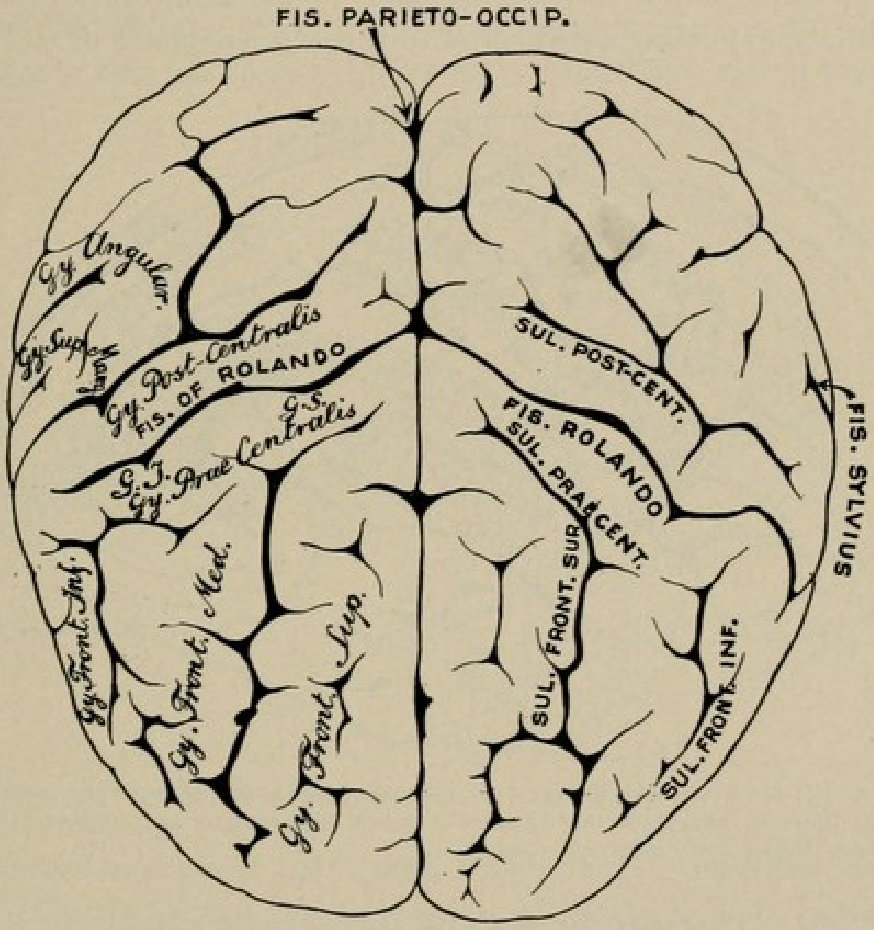

Fig. 35.—Surface of Cerebrum from above. *G.S.*, genu superior, fissure of Rolando; *G.I.*, genu inferior, fissure of Rolando.

lobe from the parietal, and which is really the continuation of the fissure proper; an anterior ascending, which passes upward into the third, inferior, frontal convolution, and an anterior horizontal, which passes forward into the same convolution.

The parieto-occipital fissure, as seen upon the external surface of the cerebrum, is little more than a notch upon the inner border of the cerebrum, and serves to mark the boundary line between the parietal and occipital lobes. The parieto-occipital fissure is well marked upon the inner surface of the hemisphere.

If the edges of the fissure of Sylvius are separated, that portion of the cerebrum called the island of Reil is exposed to view. This area is not covered in the fœtus, but becomes covered over as a result of the overgrowing of the frontal, parietal, and temporo- sphenoidal lobes during the course of their development.

The convolutions immediately anterior and posterior to the fissure of Rolando are called the gyrus præcentralis and the gyrus postcentralis. The motor area corresponds to the anterior of these two convolutions, extending forward on to the adjacent parts of the frontal

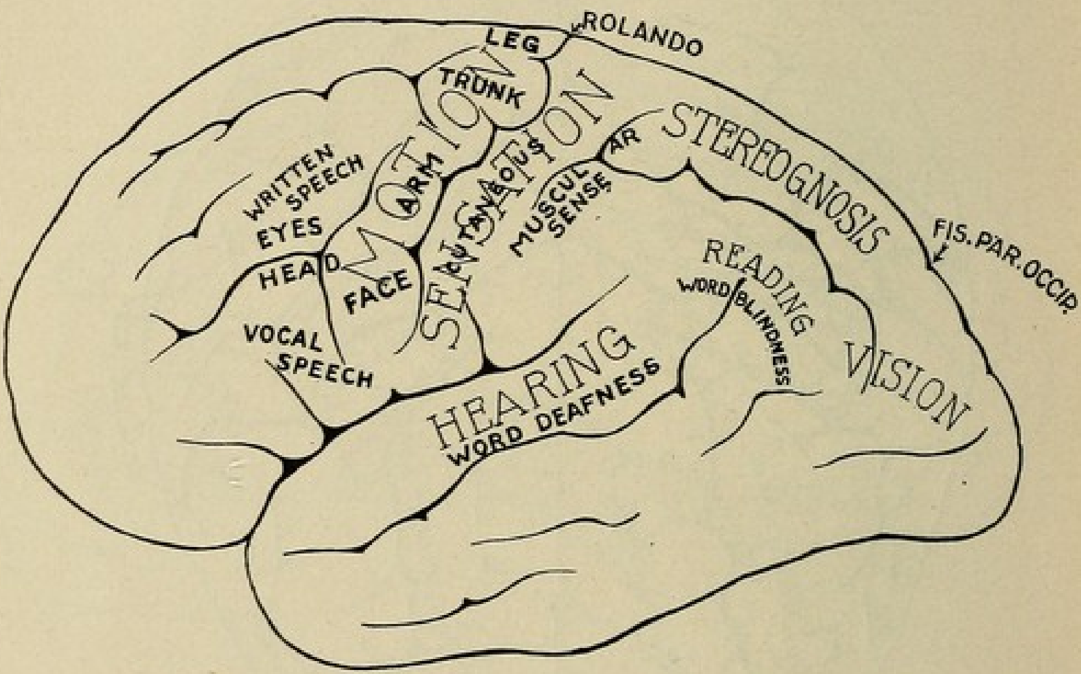

Fig. 36.—Showing the Motor Area; Sensory Area (cutaneous and muscular sense); Stereognosis; Hearing; Speech (Speech Expression and Speech Understanding, Vocal and Written); Vision.

convolutions. The area for the arm corresponds roughly to the middle third, to that portion of the convolution which lies anterior to the concave part of the fissure of Rolando between the genu superior and the genu inferior; the portion for movements of the leg and trunk above this area and for movement of muscles of face, tongue, etc., below this area.

The third inferior frontal convolution on the left side corresponds to the center for motor speech—Broca's convolution. The areas concerned in other known centers are shown in the picture from Krause.

The internal surface of the cerebrum is flat, presents several fissures, and is separated from that of the opposite hemisphere by the falx cerebri.

The inferior surface—base of the brain—rests in the anterior and the middle fossæ, the posterior portion being supported upon the tentorium cerebelli, which separates it from the cerebellum.

The cerebellum is lodged in the posterior fossa, which it occupies in common with the pons and medulla. The cerebellum consists of two hemispheres joined together in the middle by a rather constricted portion called the vermis. The two hemispheres are divided up into a number of lobes by fissures, etc.

The Pia Mater.—The brain is inclosed within its own peculiar membrane: the pia mater. This is a connective tissue membrane

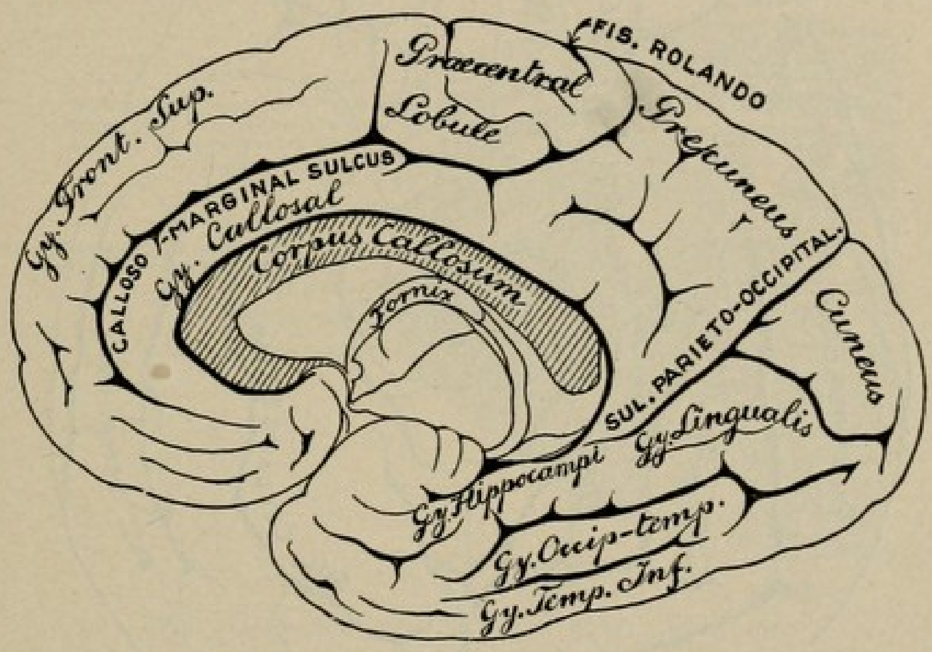

Fig. 37.—Internal Surface of the Cerebrum.

which serves to support the vessels which supply the brain, and contains within its meshes the cerebro-spinal fluid. It acts like a water cushion, preserving the blood-vessels from pressure, and also permits intracranial tumors, etc., to acquire an appreciable thickness before they begin to cause pressure symptoms. The brain can accommodate itself to slow-growing tumors until they reach a considerable size by crowding out the cerebro-spinal fluid. The pia mater is not a simple flat membrane, but is really made up of two layers joined together by septa which divide it up into a mesh-work of cellular spaces within which is contained the cerebro-spinal fluid. It has been compared to a water-soaked connective tissue with a superficial surface, which is described as the arachnoid, and a deep surface which is applied directly to the surface of the brain—the pia mater proper.

The space between these two layers is called the subarachnoid space. The pia mater or, better called, the pia-arachnoid, has no connection whatever with the dura mater; so that between the inner surface of the dura and the external surface of the pia-arachnoid there is a narrow free space, or crevice, which contains a minute quantity of fluid. This is called the subdural space. Collections of blood may

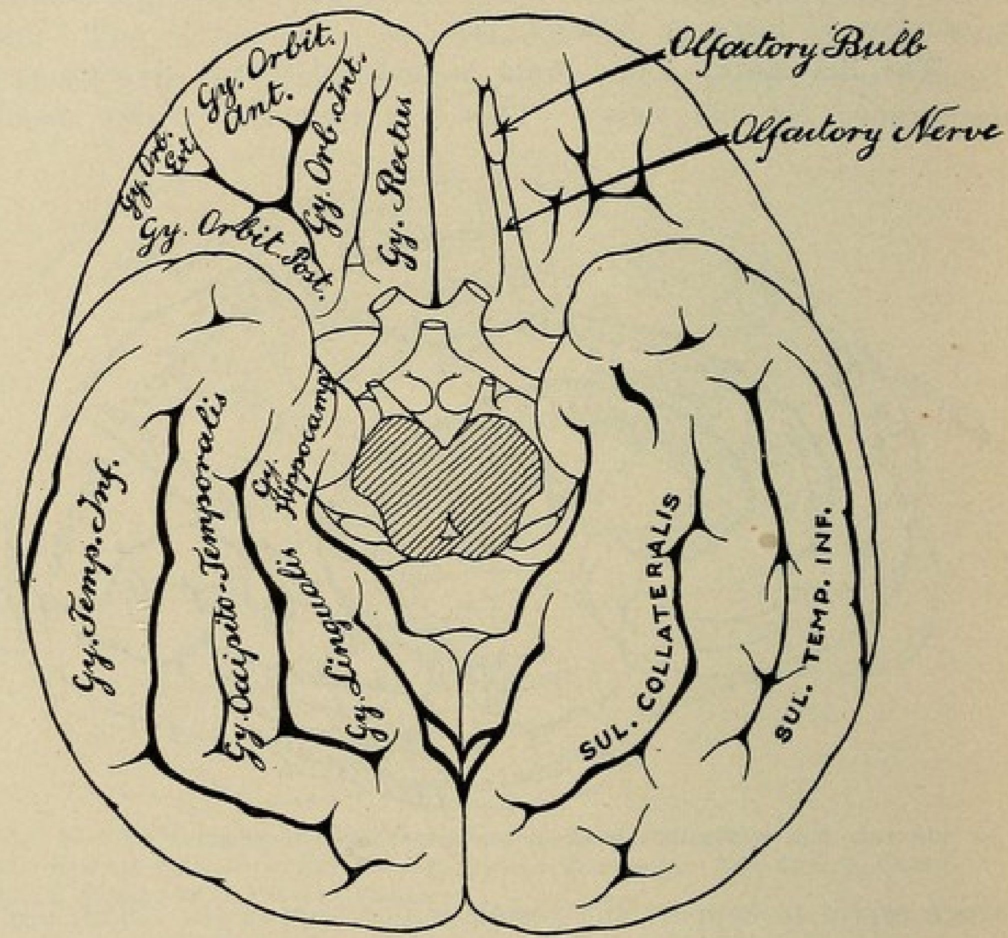

Fig. 38.—Under Surface of the Cerebrum.

be found in the subdural space, especially in connection with fracture of the base of the skull. The dura is more firmly attached to the bones of the base, and is therefore more apt to tear when this part of the skull is fractured, and thus extravasated blood is allowed to enter the subdural space.

As already mentioned, the pia mater may be described as consisting of two layers, the arachnoid layer and the pia mater proper. The superficial layer is called the arachnoid and the deeper layer, that which is applied directly to the surface of the brain, is called the pia mater. This latter layer is intimately adherent to the surface of the brain, it dips down into all the sulci between the convolutions, and a process is projected forward into the transverse fissure of the brain as the velum interpositum, between the body of the fornix above and epithelial roof of the third ventricle below. The venæ Galeni emerge posteriorly from between the two layers of the velum interpositum, where they join to form the vena magna Galeni, which is continued into the straight sinus. The pia accompanies the small vessels that enter the cortex for a short distance and it cannot be detached from the surface of the brain without causing small lacerations and hemorrhages corresponding to the points where

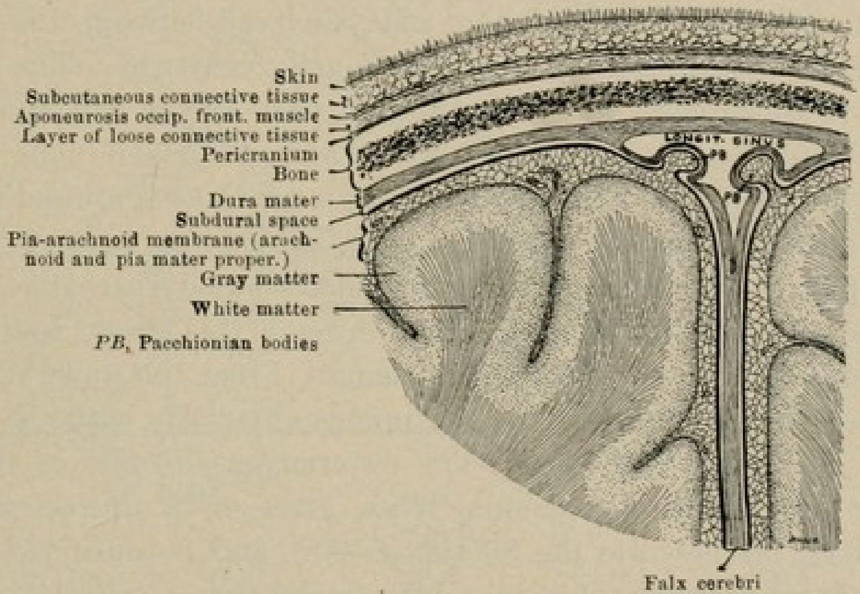

Fig. 39.—Section through Scalp, Skull, Brain, etc.

the blood-vessels penetrate. The space between the two layers of the pia mater, between the arachnoid and the pia mater layer proper, is called the subarachnoid space. It contains the cerebro-spinal fluid and supports the blood-vessels that supply the brain. These vessels ramify in the subarachnoid space, between the two layers of the pia mater, between the arachnoid layer and the pia mater proper.

The subarachnoid space is not a free space, but is broken up into a number of cellular spaces by a system of trabeculæ that extend between the two layers. All these spaces communicate freely with one another and with the ventricular system through several well-defined openings in the tela choroidea. Three of these openings are found in the membranous roof of the fourth ventricle: one, the foramen of Majendi, in the middle line near the lower angle, and two others, one in each lateral recess. Still two other communications exist between the ventricles and the subarachnoid space, one in the anterior extremity of the descending horn of each lateral ventricle. Thus free communication exists between the ventricles and the subarachnoid space. Where the pia covers a convolution the two surfaces or layers, arachnoid and pia proper, are close together, but where the pia bridges over a sulcus the layers are farther apart owing to the dipping of the pia layer proper down into the bottom of the sulcus. Corresponding to certain parts of the base of the brain the two layers of the pia mater are very widely separated, forming water cushions and spaces of considerable size; these spaces are called cisternæ subarachnoidales. Of the cisternæ the largest is the cisterna magna. This is found in the wide interval between the inferior surface of the cerebellum and the fourth ventricle. The cisterna pontis is continuous with the anterior part of the arachnoid space of the cord; it is situated between the medulla and pons and the basilar process of the occipital bone. It is continuous around the sides of the medulla with the cisterna magna, so that this part of the brain is completely surrounded by a wide subarachnoid space like a water cushion. The basilar artery ascends through this space, resting upon the basilar process of the occipital bone. From the upper border of the pons the cisterna pontis is continuous anteriorly with the cisterna basalis or interpeduncularis. The cisterna basalis fills in the space between the temporo-sphenoidal lobes, gives off a process on either side which reaches into the Sylvian fissure, and is continued forward into a space anterior to the optic chiasma and thence into the subarachnoid space above the corpus callosum in the great longitudinal fissure. In this space, the cisterna basalis, are contained the arteries that form the circle of Willis and the nerve-roots that arise from the corresponding portion of the brain, the optic tracts, and the commencement of the two terminal branches of the internal carotid artery, the anterior and middle cerebral. That portion of the arachnoid space which lies anterior to the infundibulum is called the cisterna chiasmatis. Processes of the arachnoid are prolonged for a short distance upon all the nerve-roots.

Pacchionian Bodies.—These are appendages of the arachnoid. They consist of a number of tuft-like processes arranged along the course of the superior longitudinal sinus on either side of the middle line, and in fewer numbers along the course of the lateral, straight sinuses, etc. These processes grow from the arachnoid, and as they grow they project into the lumen of the sinuses and the parasinoidal lacunæ, so that they float in and are bathed in the blood-stream. They are separated from the blood by a very much attenuated layer of dural endothelium, which covers them. The Pacchionian bodies are not well developed in children. They become better developed as age advances. When the blood-pressure is low in the sinuses the cerebro-spinal fluid may exude from the subarachnoid space through the Pacchionian bodies into the blood-stream. Their function may thus be to balance the pressure between the cerebro-spinal fluid and the blood in the dural sinuses.

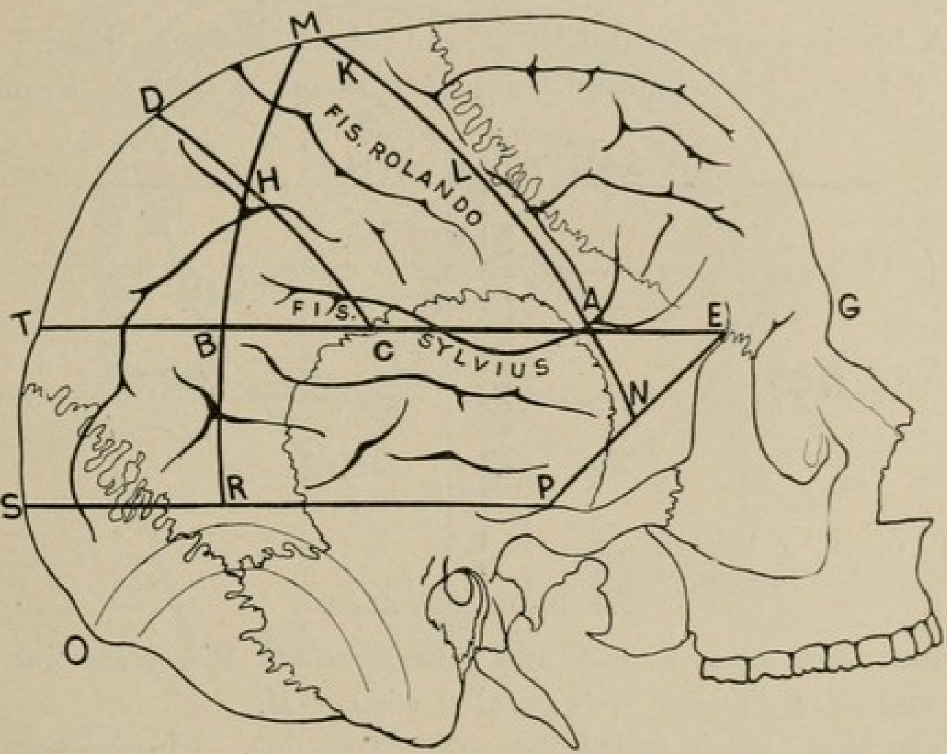

Fig. 40.—Chiene's Schema to Locate the Fissure of Rolando, etc.

Cranio-cerebral Topography.—In order to expose certain definite parts of the brain and in so doing to avoid venous sinuses, meningeal arteries, etc., it is necessary to study the relations that exist between certain constant markings upon the brain, grooves upon the inner surface of the skull, etc., and certain fixed points that may be readily determined upon the exterior of the skull or upon the scalp. The important bony landmarks have been described and, taking these as guides, certain lines and angles are marked upon the skull (scalp) to indicate the position of various parts of the brain, venous sinuses, arteries, etc.

There are a number of methods employed: Chiene's, Krönlein's, Kocher's.

CHIENE'S METHOD.—According to Chiene a line is drawn from the glabella, *G*, to the external occipital protuberance, *O*. This is called the sagittal line, and upon this the following points are found:—

1. Mid-point, *M*
2. Three-quarter point, *T*.
3. Seven-eighth point, *S*.

In addition to these the external angular process, *E*, is located and the preauricular point, *P*, corresponding to the upper surface of the root of the zygoma, just above and in front of the external auditory meatus.

A line is drawn from *E* to *P*, and other lines from *E* to *T* and from *P* to *S*. Find the mid-point of *E-P* and of *P-S* at *N* and *R*,

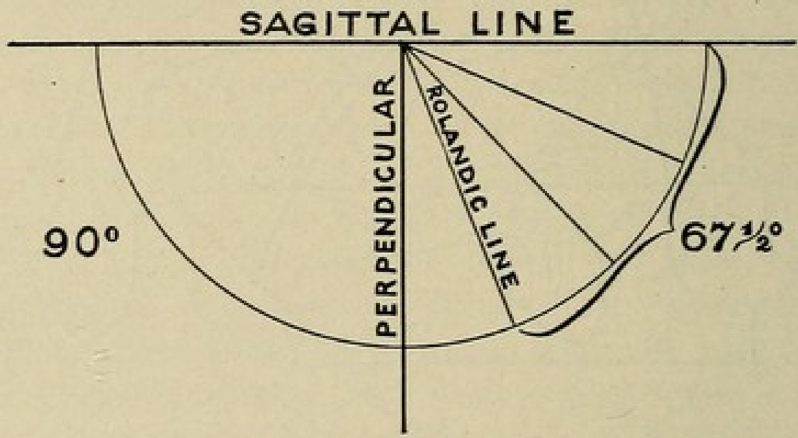

Fig. 41.—Rolandic Angle.

and draw lines from *M* to *N* and from *M* to *R*. Bisect the line *A-B* at *C* and draw the line *C-D* parallel with *A-M*.

The line *C-D* is called the postcentral line. It corresponds to the position of the superior and inferior postcentral sulci. The line *M-A* is called the precentral line. It corresponds to the sulci præcentralis superior and inferior. Divide the line *M-A* in thirds, *K-L*, and we have thus indicated the position of the superior and inferior frontal sulci. The line *E-T* is called the Sylvian line. It crosses the precentral line at the point *A*, which corresponds to the pterion and to the Sylvian point, and the anterior branch of the middle meningeal artery. *A-C* corresponds to the posterior, horizontal limb of the Sylvian fissure, which terminates behind in the triangle *H-B-C*. The point where the Sylvian line *E-T* strikes the sagittal line, *T*, marks the location of the parieto-occipital fissure. A line drawn from *T* to *R* and from *R* to *O* marks a triangle that corresponds to the external surface of the occipital lobe. The line drawn from *R* to *O* corresponds to the attachment of the tentorium and to the upper margin of the lateral sinus. The space included between the precentral line *A-M* and the postcentral line *C-D* corresponds to the Rolandic area, and includes the gyrus centralis anterior and the gyrus centralis posterior, which are separated from each other by the fissure of Rolando—sulcus centralis.

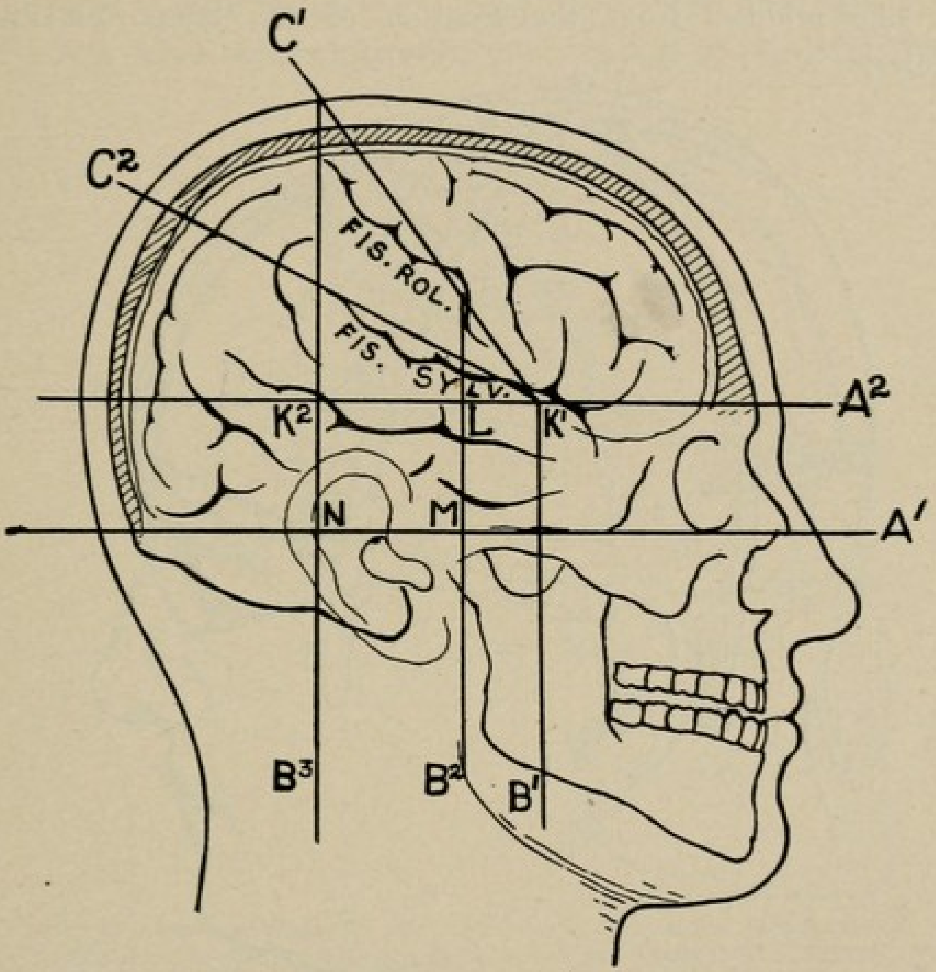

Fig. 42.—Krönlein's Schema, to Locate the Fissure of Rolando, etc. A^1, A^2, the horizontal lines; B^1, B^2, B^3, the vertical lines; C^1, C^2, the oblique lines, fissure of Rolando and fissure of Sylvius; K^1, K^2, the course of the anterior and posterior branches of the middle meningeal artery. Site of exposure for ligation. The quadrilateral space K^2, L, M, N, corresponds to portion of bone to be removed to gain access to abscess in the temporo-sphenoidal lobe.

The fissure of Rolando may be mapped out upon the scalp by drawing a line from a point ½ inch behind the mid-point *M*, upon the sagittal line, downward and forward at an angle of 67½° with the sagittal line.

Krönlein's Schema consists of two horizontal parallel lines, three vertical parallel lines, and two oblique lines.

A. *Horizontal Lines.*— 1. The German base line passing from the inferior border of the orbital cavity through the upper border of the external auditory meatus.

2. The superior horizontal line running parallel with the base line backward from the upper margin of the orbital cavity.

B. *Vertical Lines.*—1. The anterior, erected from the middle of the zygomatic arch.

2. The middle, from the location of the temporo-maxillary articulation.

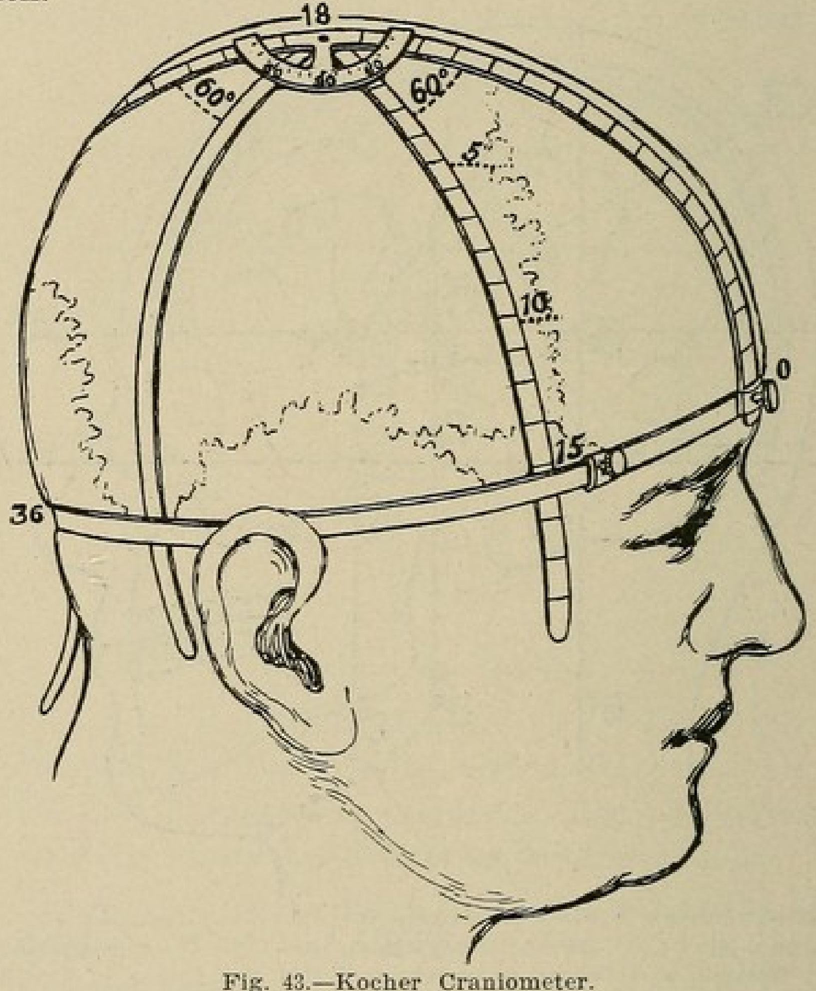

Fig. 43.—Kocher Craniometer.

3. The posterior, erected from the base line from a point corresponding to the posterior border of the mastoid process.

C. *Oblique Lines.*—1. The Rolandic line drawn from the point of intersection of the superior horizontal line, with the anterior vertical to the point where the posterior vertical line strikes the sagittal. The lower end of the fissure of Rolando corresponds to the point where the Rolandic line crosses the middle vertical line.

2. The Sylvian line is a line that bisects the angle between the Rolandic line and the superior horizontal line. It indicates the posi-

tion of the fissure of Sylvius, which extends upward and backward as far as the posterior vertical line.

Kocher's Method.—According to the plan of Kocher the object is to locate the sulcus præcentralis rather than the fissure of Rolando as the guide to the motor area. Fig. 43 shows the Kocher apparatus, which consists of several flexible metal bands. One, equatorial, that passes around the head just above the ears; another, that passes from before backward over the top of the head, from the

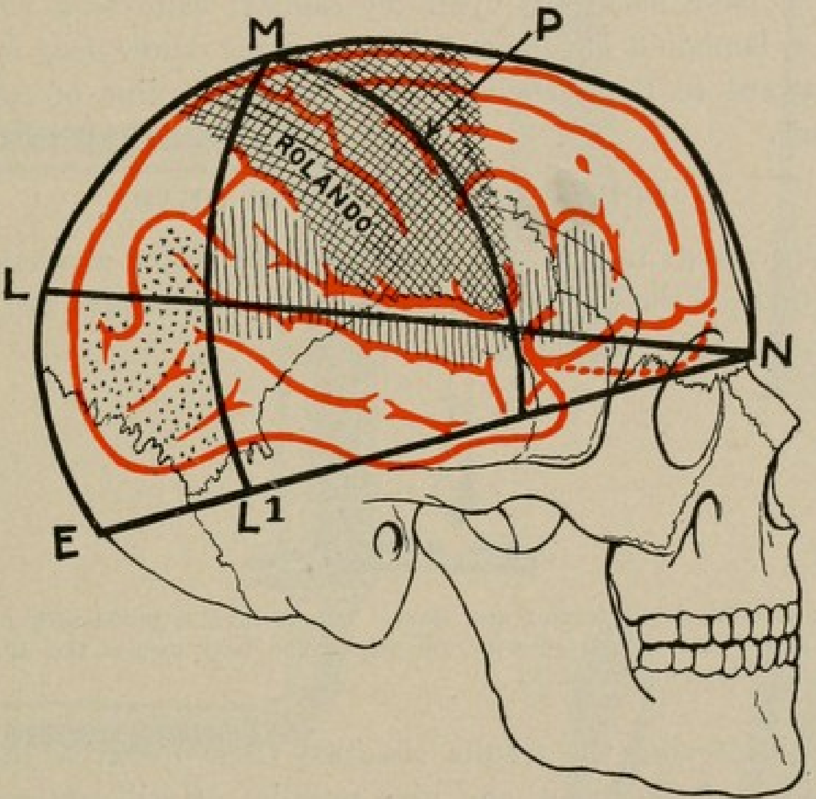

Fig. 44.—Various Fissures, etc., Indicated by Kocher Craniometer. *E-N*, equatorial line; L^1, linea limitans; *M*, point on the sagittal line midway between the glabella and the external occipital protuberance.; *N-L*, linea naso-lambdoidea; *P*, linea præcentralis. Motor, speech, and visual areas indicated by cross lines, parallel lines and dotted area.

glabella to the external occipital protuberance, the sagittal band, and a third, meridional, band which can be adjusted to determine and indicate various meridional lines at different angles with the sagittal line.

Fig. 44 shows the lines and areas. If the movable meridional band is placed at a point upon the sagittal band midway between the glabella and external occipital protuberance, and its lower end then moved forward so as to make an angle of 60° with the sagittal line, we will have indicated the position of the sulcus præcentralis.

This line may be called the linea præcentralis. If the linea præcentralis is divided in thirds the location of the two sulci frontalis, superior and inferior, will be indicated. If the meridional band is moved backward so as to form an angle posteriorly with the sagittal line of 60°, we will have the line called by Kocher the linea limitans. This line marks the boundary between the gyrus angularis and gyrus supra-marginalis above and the occipital lobe and temporo-sphenoidal lobe below. The linea naso-lambdoidea is formed by moving the meridional band backward upon the sagittal band to a point 1 cm. above the lambdoid suture and bringing the lower free end of the band forward to the glabella. This shows the line of the Sylvian fissure, etc.

OPERATIONS UPON THE HEAD.

Improvement in operative technique and better understanding of the functions of the different portions of the brain have had the effect

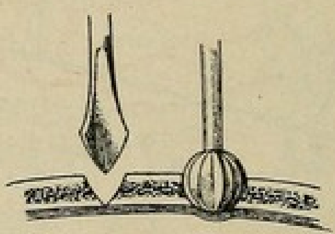

Fig. 45.—Doyen Perforator and Burr. The opening is made with perforator and enlarged and completed with the burr. The burr pushes the dura mater before it without injuring it.

of vastly improving the results obtained from operative interference in affections of the brain, and give promise of still greater advance in this branch of surgery. In deciding to interfere in lesions of the skull and brain, the surgeon is often guided by the presence of very evident physical signs, such as depression of bone, etc.; at other times he must depend upon symptoms, general or focal, that point to the presence of some intracranial lesion.

Trephining.—By trephining we mean, in a general way, making an opening into, or resecting a portion of, the skull. This operation is done to relieve compression either from depressed bone or from extravasated blood, and to treat intracranial conditions, as abscess, tumor, etc.

The patient is placed upon the back with a thin sandbag under the head. The table upon which the patient rests should be so constructed that the head end can be raised or lowered during the course

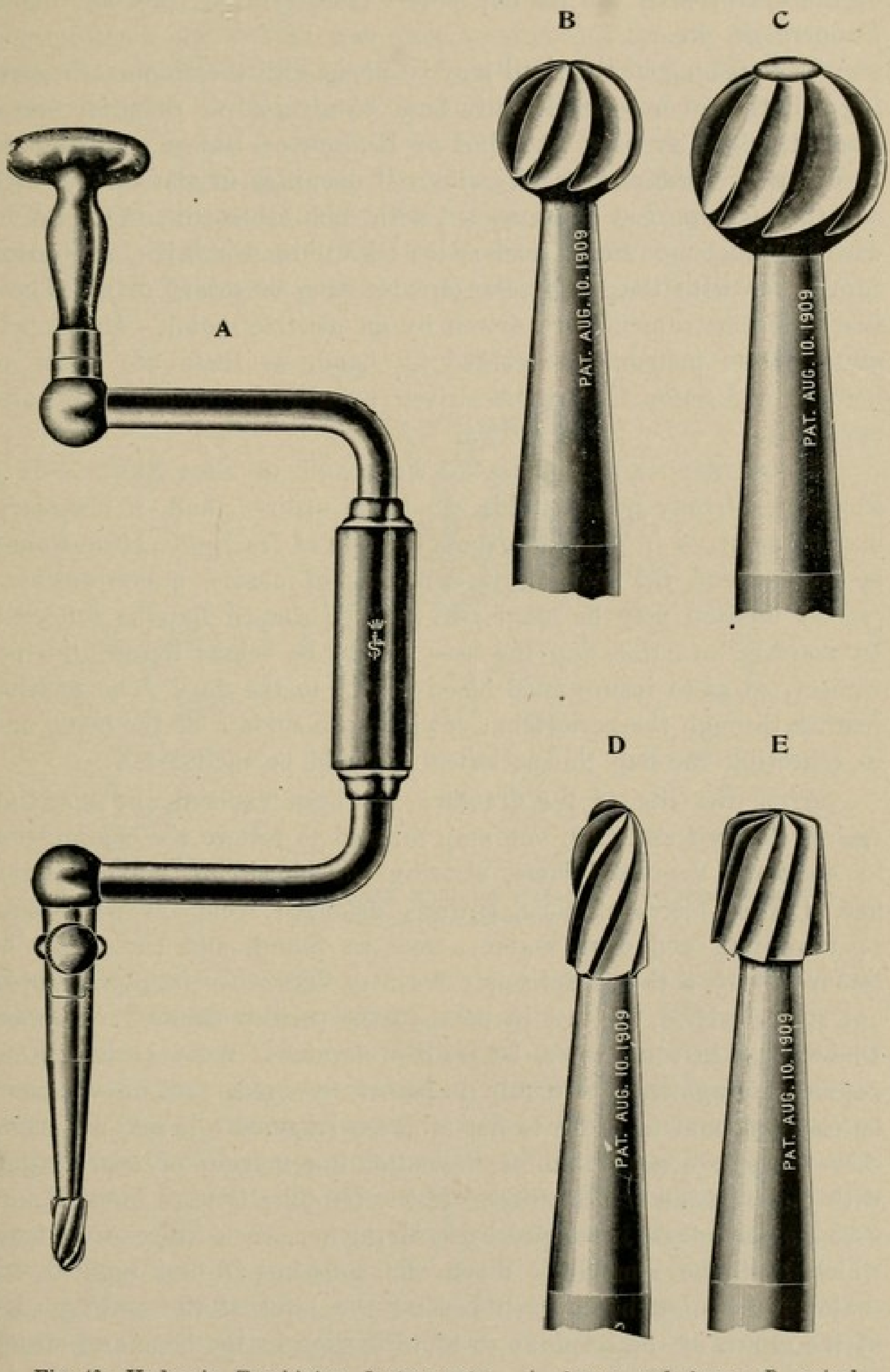

Fig. 46.—Hudson's Trephining Instruments: *A*, brace and burr; *B*, spiral perforator; *C*, spiral follower; *D* and *E*, small and large enlarging burrs.

of the operation if the patient suffers from syncope, profuse venous hemorrhage, etc.

The opening in the skull may be made with the trephine, removing a button of bone sufficiently large to give ample room, or else a small trephine or burr like that of Hudson or Doyen may be used in order to make one or several small openings in the skull, which can then be enlarged or connected with each other with the chisel or with a biting bone forceps, such as the De Vilbiss, Dahlgren, or Hudson forceps, or with the Gigli saw, circular saw, or rotary drill. These two latter instruments are driven by an electric motor. Most operators prefer instruments worked by hand, as these are easier to manage and safer than those driven by electric power. (See also page 86.)

Trephining for Depressed Fracture of the Skull.—If a wound is already present, this should be utilized, and, if necessary, may be enlarged in order to expose the site of fracture. If no wound is present and the incision is a matter of choice, a crescentic or crucial incision may be employed, or a U-shaped flap be reflected. In marking out this flap the base should be below, toward the periphery, so as to insure good blood-supply to the flap. The incision reaches through the periosteum down to the surface of the bone, and in reflecting the flap the periosteum should be included.

After the site of the fracture has been exposed and spurting vessels clamped and tied, one may proceed to relieve the compression by elevating depressed bone, clearing out blood-clot, etc. A number of loose pieces of bone, entirely detached from the periosteum (pericranium and dura mater), may be found, and these may be removed with a thumb forceps. We may find other fragments loose, but still attached, at least in part, to the periosteum or dura mater. These may, in some cases, be readily elevated. We may find other depressed fragments so firmly impacted, wedged, that they cannot be elevated, and in order to get at these fragments it may be necessary to remove a portion of the adjoining margin of bone, either with the trephine or the chisel. If the trephine is used for this purpose the periosteum is scraped back, laying bare the surface of the bone which is to be removed. When the trephine is first applied the center pin should be lowered beyond the level of the cutting edge of the crown of the trephine so as to engage in the bone and steady the trephine until the crown has cut a groove within which it may work without slipping, when the pin may be again raised. The trephine should be so placed that its crown will partly overlap the edge of the bone, so that less than a whole button will be removed from the margin adjoining the impacted fragment. The trephine is worked with a firm, steady wrist movement, and the groove occasionally probed to ascertain if the bone is cut through at any point. The use of such force as would result in sudden, abrupt penetration of the skull is to be avoided. The button may be loosened by gently prying with the elevator. If the Hudson perforator and burr are used there is little or no danger of injuring the dura mater. Bleeding

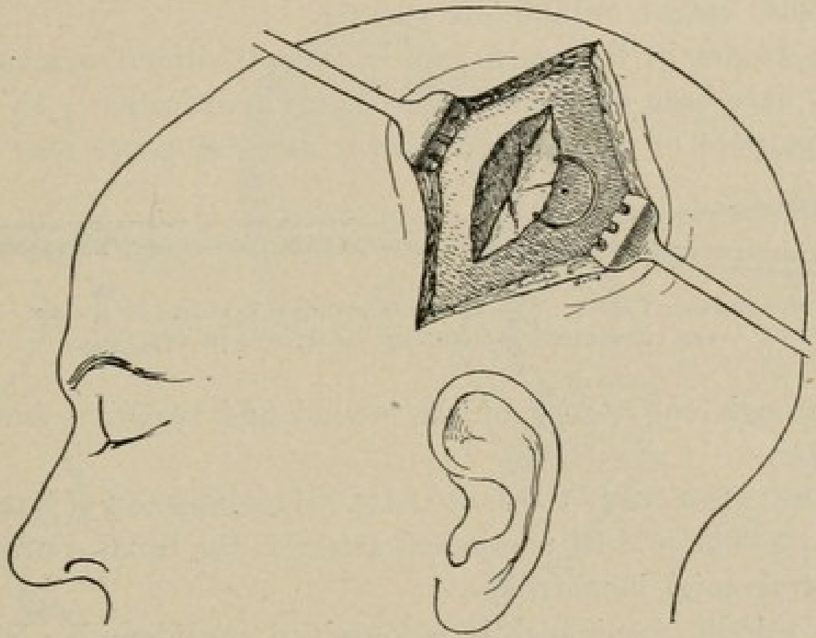

Fig. 47.—Depressed Fracture of the Skull. A button of bone removed at the edge of the depressed area.

from the edge of the bone in the trephine opening ceases after a few moments' pressure with a hot gauze pad.

In many cases the liberation of an impacted fragment is best accomplished by using the chisel to cut away the margin of the bone that holds it fast; often, with a few strokes of the mallet, the fragment is freed or a space is made to allow the use of the elevator.

Having removed all loose fragments and elevated those which are still attached to the pericranium and dura mater and rounded off the edges of any defect left in the skull, one should search carefully for any loose fragments or spiculæ which may be concealed under the edge of the opening in the bone. The finger or probe should be used for this purpose. Small pieces may be washed out by irrigation with hot saline solution or they may be picked out with a forceps. Careful examination should be made as to the condition of the internal table, as this is often more extensively fractured than is indicated by the appearance of the external table. The internal table is at times extensively fractured and depressed when the corresponding part of the external table is apparently uninjured. Extravasated clotted blood, between the dura and the inner surface of the bone, or beneath the dura, between it and the pia-arachnoid, subdural space, should be removed with a scoop and by irrigation, and any severed vessels tied with fine catgut. If the dura mater has been torn the edges of the opening may be brought together with fine chromic catgut or fine silk sutures.

The wound in the scalp may be closed without drainage unless the parts have been exposed to the chance of infection. In this case, for the purpose of drainage, a narrow strip of gauze may be intro-

Fig. 48.—Hartley Chisel. This chisel is pointed, V shape on section, and is very convenient for cutting the groove in the bone.

duced through one corner of the wound and reaching down to the dura mater.

Trephining for Intracranial Hemorrhage (Middle Meningeal).—The middle meningeal artery is the usual source of traumatic intracranial hemorrhage.

The middle meningeal is a vessel of considerable size, and is given off from the upper aspect of the first part of the internal maxillary a short distance beyond its origin from the external carotid, as it (the internal maxillary) lies beneath the neck of the condyle of the jaw, between it and the internal lateral ligament. The middle meningeal passes directly upward between the two roots of the auriculo-temporal nerve, which surround the commencement of the artery, toward the base of the skull, and enters the skull through the foramen spinosum. This part of the middle meningeal artery is concealed beneath the external pterygoid muscle, the tendon of which is attached to the front of the neck of the condyle of the jaw. In front and internal to this part of the artery is the inferior maxillary division of the fifth nerve and its motor root, these nerve branches emerging from the skull through the foramen ovale.

After entering the skull the middle meningeal runs a short distance outward in a groove in the floor of the middle fossa and then divides into two branches. The anterior, the larger branch, passes forward and outward across the floor of the middle fossa of the skull and across the anterior angle of the parietal bone just behind the outer extremity of the lesser wing of the sphenoid, and may be exposed as it ascends upon the side of the skull at a point which corresponds to the intersection of two lines (Vogt), one ver-

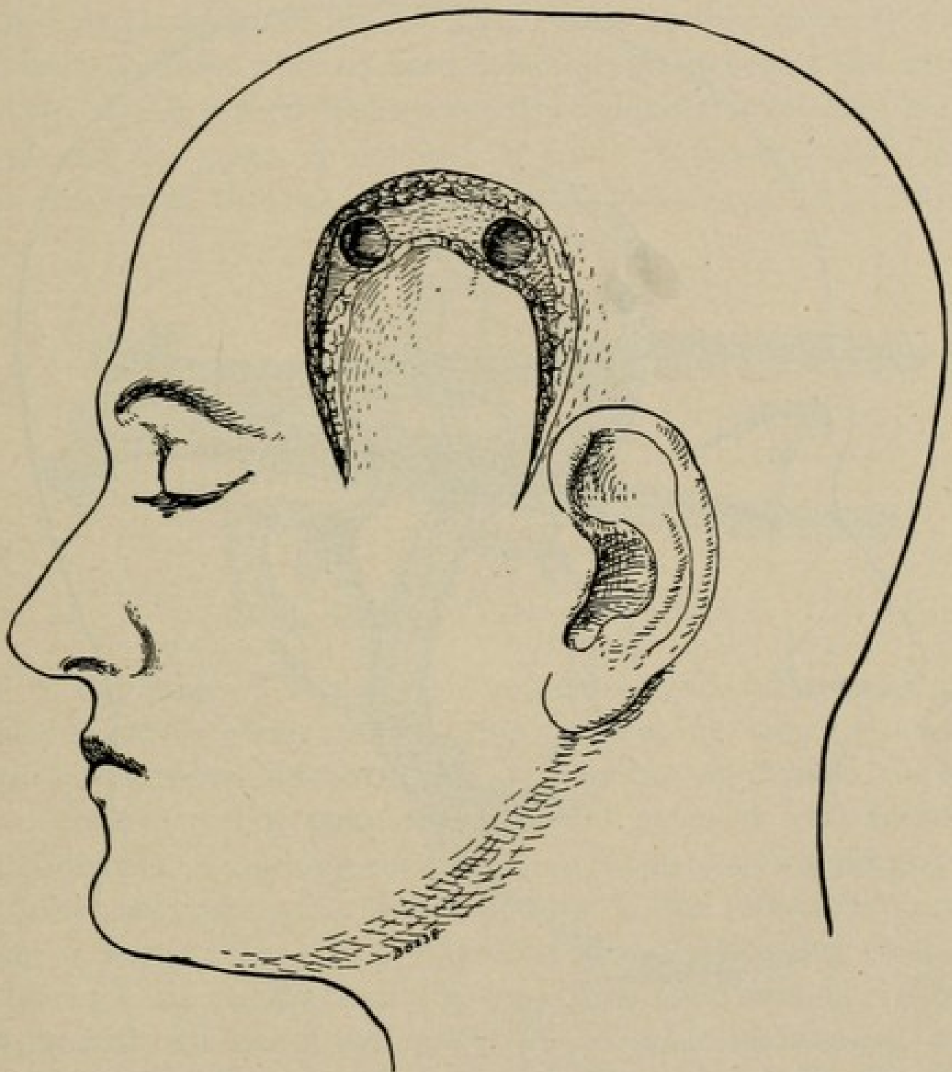

Fig. 49.—Temporary Resection of the Skull. Holes have been bored in the bone preparatory to the use of the biting bone-forceps or Gigli saw.

tical, a thumb's breadth behind the external angular process, and, the other, horizontal, placed two fingers' breadth above the zygoma. By measurement the location of the anterior branch of the middle meningeal is found one and one-half inches behind and one-quarter inch above the external angular process, or it may be located by finding the point two inches above the middle of the zygomatic arch. The posterior branch of the middle meningeal passes outward across the squamous portion of the temporal bone and then ascends upward and backward upon the inner surface of the posterior inferior portion of the parietal bone above, and in front of, the groove seen here for the lateral sinus. The posterior branch may be exposed by removing a button of bone whose center is one inch above and one-half inch behind the external auditory meatus. (See Fig. 69.)

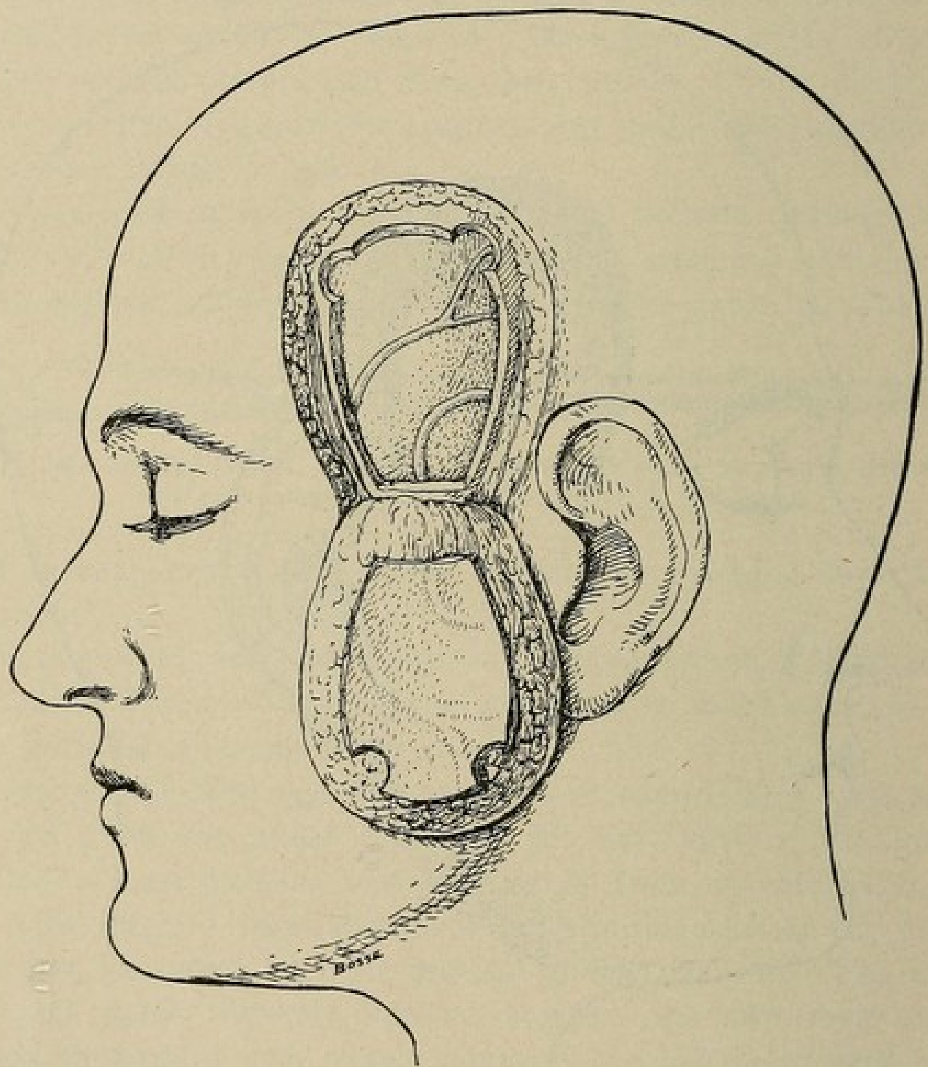

Fig. 50.—Temporary Resection of the Skull. The osteo-tegumentary flap has been reflected, exposing the dura mater.

The middle meningeal and its branches ramify in the dura and groove the surface of the bones against which they are applied. The anterior branch, as it approaches the anterior inferior angle of the parietal bone, is lodged in a deep groove, which is occasionally converted into a complete bony canal.

Temporary Resection of the Skull.—When the skull is intact, it is preferable, in order to gain access to the cranial cavity, to do a temporary resection of the skull (Wagner), turning back a flap, which consists of the soft parts, periosteum, and corresponding piece of bone, rather than to remove a button of bone, which leaves a permanent defect in the skull. This method of opening the skull has marked a great advance in head surgery, in providing ample room for operations upon the brain, etc. To reach the middle meningeal artery or its divisions this is a most satisfactory method.

A horseshoe-shaped flap is marked out in the temporal region, with its arch above and its base below at the zygoma, the anterior leg being placed a good finger's breadth behind the external angular process and the posterior leg just in front of the tragus. The incision penetrates through the soft parts, including the periosteum,

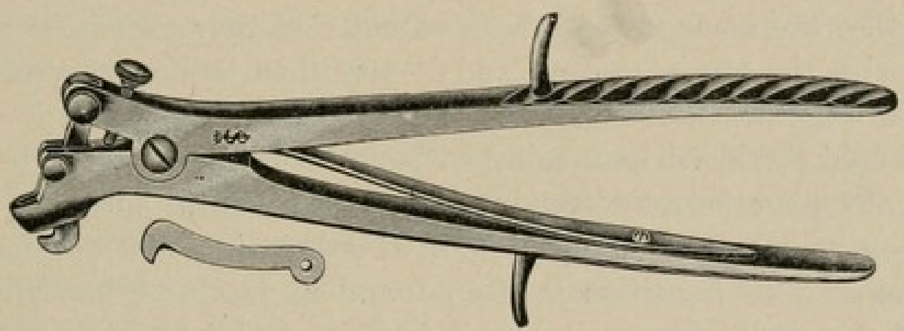

Fig. 51.—Hudson-De Vilbiss Bone-forceps.

down to the bone. The flap thus marked out should measure in its vertical diameter about three inches, and about two and one-half inches across its widest part. At its base the flap should be about two inches wide. The temporal artery and some of its branches are usually divided in marking out the flap and must be clamped and tied.

Corresponding to the line of incision in the soft parts the periosteum is scraped away from the bone for a distance of about one-quarter inch all around, and the bone then cut through. This can be done with the chisel and mallet if no other instruments are at hand, although this method is rather tedious and entails considerable danger of injuring the dura mater. A very convenient way of dividing the bone is to make two openings in the bone, one in either corner of the upper part of the flap. These openings may be made with the Doyen burr or the Hudson trephine. Working from either hole downward along the sides of the flap toward the base, the bone is divided with biting bone forceps (Dahlgren, De Vilbiss, Hudson type). The bone in the temporal region is thin and is easily cut. The bone corresponding to the upper part of the flap may be divided with the Gigli saw. After the bone has been divided all around the elevator is introduced between the edges of the bone and the segment of the bone pried out, breaking it below through its base, near the zygoma. Additional details in making the osteo-tegumentary flap will be found on page 82.

The extravasated blood is usually found between the dura and the bone, so that as soon as the plate of bone has been turned back we expose the blood, which is, as a rule, partly clotted. This may be cleared out with a scoop and irrigation with hot saline, after which the ends of the divided vessel are sought and tied. Ordinarily they may be seized with a clamp and ligated in the usual manner; there may, however, be some difficulty in securing the ends of the divided vessel, as they may have retracted within the canal in the dura in which they are situated to such an extent that they cannot be readily seized with the artery forceps, and it may then be necessary to carry a ligature around the vessel with a curved needle.

Should the blood have collected beneath the dura mater, between it and the pia-arachnoid membrane, in the subdural space, it would be necessary to make an opening in the dura in order to clear out the blood. This condition is often found in fractures involving the base of the skull, because here the dura is more intimately adherent to the bones and is therefore more apt to tear when this part of the skull is fractured, and thus the extravasated blood is permitted to find its way within the dura, into the subdural space.

Usually the anterior branch of the middle meningeal is the vessel which is torn, but through the opening made in the skull the posterior branch or the main trunk may be readily reached if necessary.

Having entirely removed the blood, tied the ruptured vessel, and sutured the dura if it has been incised or torn, we replace the osteo-tegumentary flap and without drainage unite the edges of the soft parts all around with interrupted catgut sutures. At times, especially in fractures involving the base, the oozing continues, and it may be necessary to pack loosely with strip gauze or leave a strip of rubber tissue for drainage. If a drain is thus left it will be necessary to leave a small opening in the edge of the flap for its exit.

Removal of a Button of Bone with the Trephine.—By removing a button of bone with the trephine the anterior and posterior branches of the middle meningeal may be exposed and ligated.

To reach the anterior branch of the middle meningeal, an incision, vertical, is made through the skin, muscle, and periosteum down to the bone, and with the periosteum elevator the surface of the bone, corresponding to the intersection of Vogt's lines, is laid bare (see Fig. 69). Instead of using the vertical incision this area of bone may be exposed by turning down a U-shaped flap with its base below near the zygoma. This flap includes all the tissues of the scalp and the periosteum, and is detached from the surface of the bone with an elevator.

The trephine is then used to remove a button of bone, and thus the dura is exposed. If the opening is not sufficiently large it may be enlarged with the rongeur bone forceps. After clearing out the clot, etc., the ends of the vessels are secured and the incision in the soft parts closed. This operation may be performed more quickly than the temporary resection of the skull, but it does not give as much room, and a further disadvantage is that it usually leaves a permanent defect in the skull.

To expose the posterior branch of the middle meningeal a button of bone may be removed with its center one inch above and one-half inch posterior to the external auditory meatus, as described above. This branch is but seldom injured. (See Fig. 69.)

Decompression.—The object of this operation is to diminish intracranial pressure, which may have become greatly increased as the result of the presence of a tumor or of a considerable quantity of extravasated blood oftentimes in connection with fracture of the base of the skull. By the operation of decompression in the case of tumor we relieve the symptoms due to the increased intracranial pressure, headache, vomiting, choked disk—impending blindness. In fracture of the base the pressure caused by the presence of the extravasated blood is diminished and fatal compression upon the vital centers in the medulla oblongata is avoided. The operation must be done promptly when indicated, and not withheld until irreparable damage has been done. The operation consists in the removal of a portion of the vault of the skull and excision of the corresponding portion of the dura. As a matter of choice the operation is usually done in the temporal region, on the right side in right-handed people. The operation may be done upon both sides if the indications warrant. In connection with fracture of the base of the skull the operation is done upon the injured side. An osteotegumentary flap may have been reflected for the purpose of exploring or removing a tumor from the brain and the condition found to be inoperable. Under these circumstances decompression may be practiced by trimming away the edges of the piece of bone in the flap for a distance of 2 cm., including the periosteum, all around, and leaving the flap of dura mater unsutured or else excising it. The bone-scalp flap is then replaced and sutured in position. If the decompression is done for hemorrhage in cases of fracture of the base it may be necessary to leave a drain consisting of a strip of gauze and a strip of rubber tissue.

Decompression may be practiced in the suboccipital region for subtentorial lesions.

Decompression, Cushing.—The opening is made in the bone in the temporal region, beneath the temporal muscle. The temporal

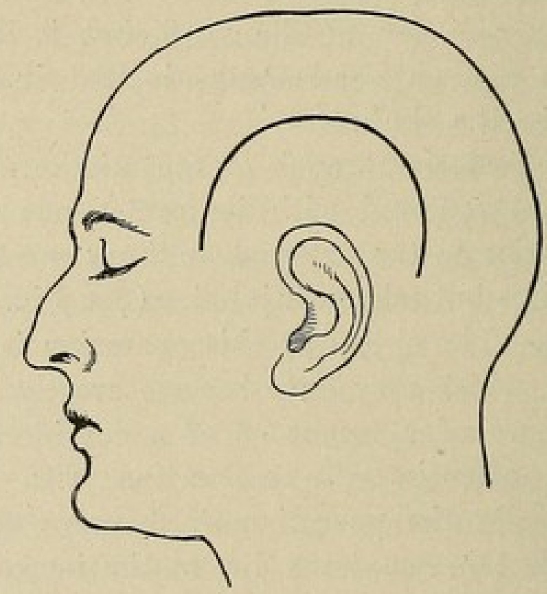

Fig. 52.—Incision for Temporal Decompression.

muscle is a good protection against the bulging and protrusion of the brain that occur often to a marked degree after the operation.

A curved incision with the convexity upward is made upon the side of the head. The incision commences behind the ear, at the base of the mastoid process, and follows the line of origin of the temporal muscle and terminates anteriorly just above the anterior part of the zygomatic arch. The flap thus marked out, and consisting of the skin and subcutaneous tissue, is dissected downward away from the fascia covering the temporal muscle. A vertical incision is made in the temporal fascia and the bone then exposed by penetrating bluntly between the fibers of the temporal muscle down to the bone. The edges of the muscle are retracted with sharp retractors. The periosteum covering the bone is incised and detached with the elevator and cut away. An opening is made in the bone which has been thus denuded. The bone is very thin. The opening may be made with the Hudson or Doyen burr, etc., or it can be made with the chisel and mallet. Through the small opening thus made in the skull the bone is gouged away with a rongeur, etc., until an open-

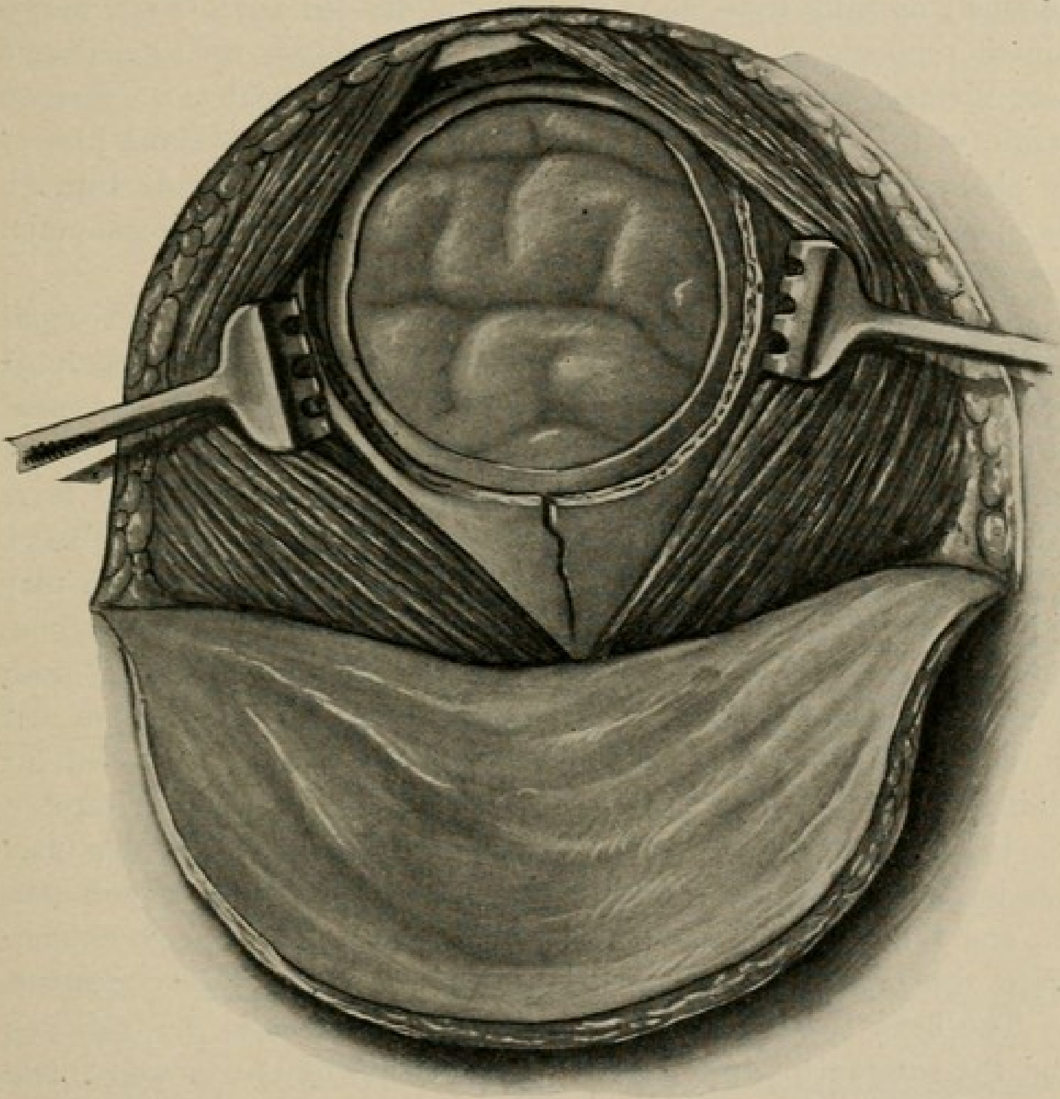

Fig. 53.—Decompressive Operation in Temporal Region (*Cushing*). The temporal muscle has been split and the fibers drawn apart to expose the bone. A large piece of bone has been gouged out and the dura cut away.

ing sufficiently large has been made. Usually a circular opening with a diameter of 6 to 8 cm. is made. Care is exercised not to injure the middle meningeal artery when biting the bone away with the rongeur. This opening uncovers the temporo-sphenoidal lobe and the lowest part of the motor area. Hemorrhage from the bone is controlled by means described on page 88. The dura is opened by a crucial incision. Arterial branches in the dura are secured before incising the dura by passing sutures around the vessels in a small, curved needle. Care must be exercised not to injure any of the vessels of the pia-arachnoid when incising the dura. The dura is picked up with small tenaculum forceps and nicked with the knife. Through the small opening thus made the dura is divided with small, blunt-pointed scissors. The dura is excised, all around, up to within a short distance of the edges of the opening in the bone. Enough margin of the dura is left to cover the edges of the bone and protect the pia-arachnoid and the brain, as they tend to protrude through the opening in the skull on account of the increased intracranial pressure.

The edges of the split muscle and the temporal fascia are brought together and accurately sutured with a sufficient number of interrupted chromic catgut sutures, and finally the skin flap is sutured all around without drainage. If the operation has been done for fracture of the base and the hemorrhage persists, it may be necessary to leave a strip of gauze and one or two strips of rubber tissue for drainage.

Cerebellar Decompresson.—The decompression operation may be practiced in a similar manner in the region of the cerebellum, by removing a part of the bony wall in the occipital region in order to relieve pressure in this part of the skull. The skin incision and the several steps of the operation are similar to those described for gaining access to the cerebellum for the purpose of excising tumors, etc., in this part of the brain. (See page 92.) An opening may have been made in the skull for the purpose of removing a tumor, etc., and the condition found to be inoperable. Under these circumstances decompression may then be practiced as a palliative measure.

The bone is extensively removed from mastoid to mastoid, and from the external occipital crest to the margin of the foramen magnum, including the posterior half of the margin of the foramen magnum itself. The flap of dura mater is excised and the flap of scalp sutured back in place without drainage. (See Fig. 61.)

Craniotomy, Osteo-tegumentary Flap Method.—To expose different parts of the brain for the purpose of removing tumors, etc. The location of the flap will vary according to the position of the lesion.

A great advance in the surgery of the brain has been made possible by the introduction of the osteo-tegumentary flap method of opening the skull and by the better understanding of methods of localizing processes affecting particular areas of the brain.

Operations involving incision of the brain or much handling or manipulation of the brain may be done in two acts separated by an interval varying from several days to several weeks. The first act consists in making the opening in the skull and incising the dura mater. If the loss of blood has been very great it may be wise to discontinue the operation after the osteo-tegumentary flap has been turned down and before opening the dura. The second act consists

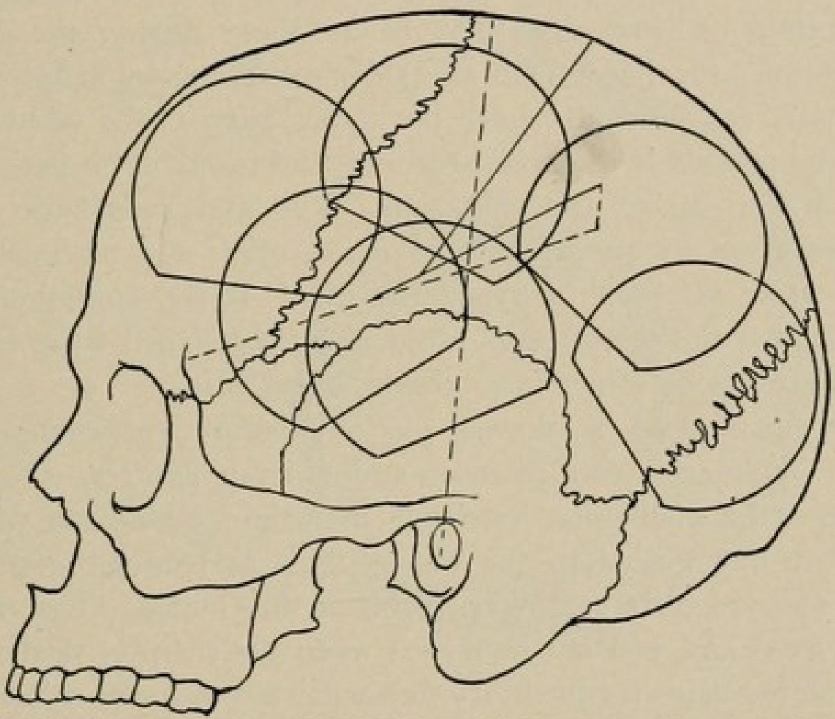

Fig. 54.—Location of Various Skull Flaps (*Mills*). To gain access to certain definite parts of the brain.

in incising the brain for the removal of tumor; for cyst, abscess, epilepsy, etc., or in retracting or lifting the brain away from its bed to gain access to tumors, etc., lying deep in the skull, underneath the lobes of the brain, and extirpation of the same; excision of the Gasserian ganglion, etc.

The decision to complete the operation in one *séance* will depend upon the patient's condition after completion of the first act,—after the dura has been opened,—as indicated by the blood-pressure, amount of blood lost during the first part of the operation, shock, etc. Operators of large experience strongly advocate the plan of postponing the second act if any doubt exists at all as to the patient's ability to withstand the shock of the entire operation. Where the operation is done in two separate acts the second may be postponed for a period of several days or several weeks, until the patient has fully recovered from the effect of the first operation. If it is decided to postpone the second act the opening in the dura is sutured and the osteo-tegumentary flap replaced and sutured accurately. After the lapse of several days or weeks the flap may again be readily turned down. The bone segment will be found to be still loose, so that this first step of the operation can be accomplished without shock and without loss of blood.

The patient lies upon a table, the upper part of which may be readily raised or lowered as may be necessary during the course of the operation; the head upon the side, resting upon a flat sandbag. It is usually convenient to have the upper part of the table elevated so that the patient is in a semi-reclining position. The patient must be kept warm during the operation. The best anæsthetic is probably ether given by an experienced anæsthetist, and preceded by the administration of morphin hypodermically. If the operation is done in two *séances* the second may often be accomplished with very light ether anæsthesia or under local cocain anæsthesia.

The entire head is shaved the day before operation, and the principal landmarks, the Rolandic and Sylvian fissures, etc., marked upon the scalp with some indellible material—a solution of nitrate of silver, thirty grains to the ounce. This is brushed over with a solution of pyrogallic acid, five grains to the ounce. The markings are thus fixed and will not be erased when the scalp is washed. The location of the osteo-tegumentary flap will vary according to the position of the lesion, in the frontal, parietal, occipital lobes, etc.

In the Parietal Region to Expose the Motor Area, etc.—A horseshoe-shaped flap with the base below, or the flap may be rectangular in shape, is marked out in the parietal region. The incision penetrates through all of the soft parts, including the periosteum, down to the bone.

As a rule the flap will measure about 3 inches in its long (vertical) diameter, 2½ to 3 inches across its widest part, and 2 to 2½ at its base. Bleeding points are secured with strong, narrow-nosed hemostats. At times the hemorrhage from the soft parts is very profuse, especially in the presence of the increased intracranial pressure that accompanies tumor, large blood and pus collections within the skull, and means must be taken to prevent excessive loss of blood. According to the plan of Cushing, this is accomplished by encircling the head, just above the ears, with a strong elastic constricting band, which is prevented from slipping down over the face by a strip of tape which occupies the middle (sagittal) line and secures the constricting band in front and behind. This arrangement may be adapted to the size of the patient's head before operation, and is then sterilized and ready for use. It is applied over a sheet of gauze which covers the patient's head. The sheet of gauze may be cut into four quarters by a crucial cut, and the four ends of the gauze turned down over the patient's ears, face, etc.

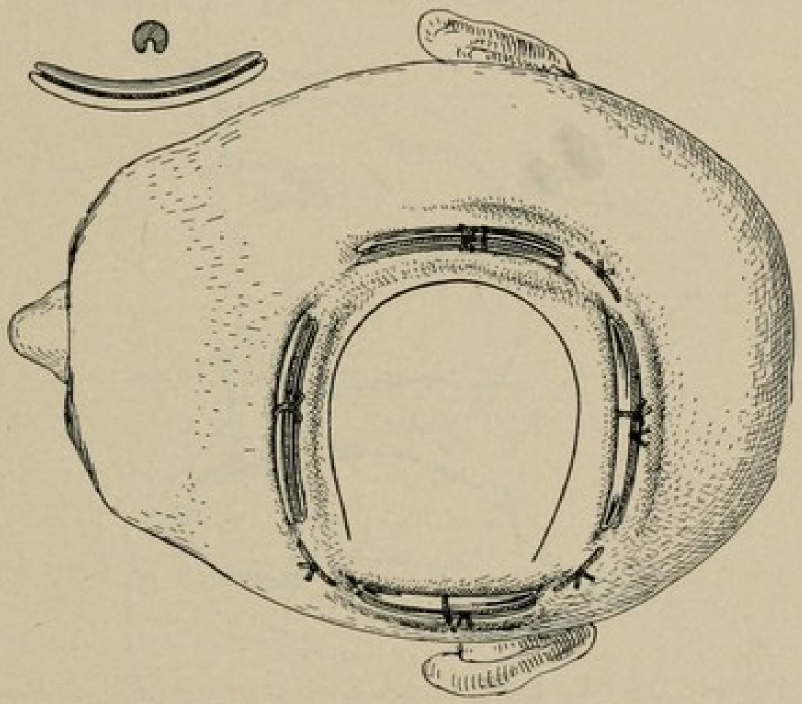

Fig. 55.—Kredel's Blocks in Position. Above a single block and a cross-section of the same.

The method of Heidenhain for controlling hemorrhage consists in applying a line of suture with a heavy silk thread—back-stitch fashion—beyond and all around the line of the proposed incision in the scalp. This suture is introduced with a heavy, curved needle, and each stitch penetrates the entire thickness of the scalp down to the bone, taking a good, secure bite. Kredel's metal blocks may be used. These are grooved and notched at the extremities and are applied all around, beyond the line of the proposed flap. Long stitches of heavy silk are carried under the scalp so as to secure its entire thickness, and these are tied over the blocks. The sutures are prevented from slipping by the grooves and notches in the blocks. Hemorrhage from the edges of the flap itself is controlled by hemostats and ligatures. Corresponding to the edges of the flap, the periosteum is scraped away from the bone for a distance of about 1/4 inch all around in order to make way for the trephine, saw, etc., in dividing the bone.

Different operators employ different methods for making the cut in the bone. The most convenient plan is to make two openings

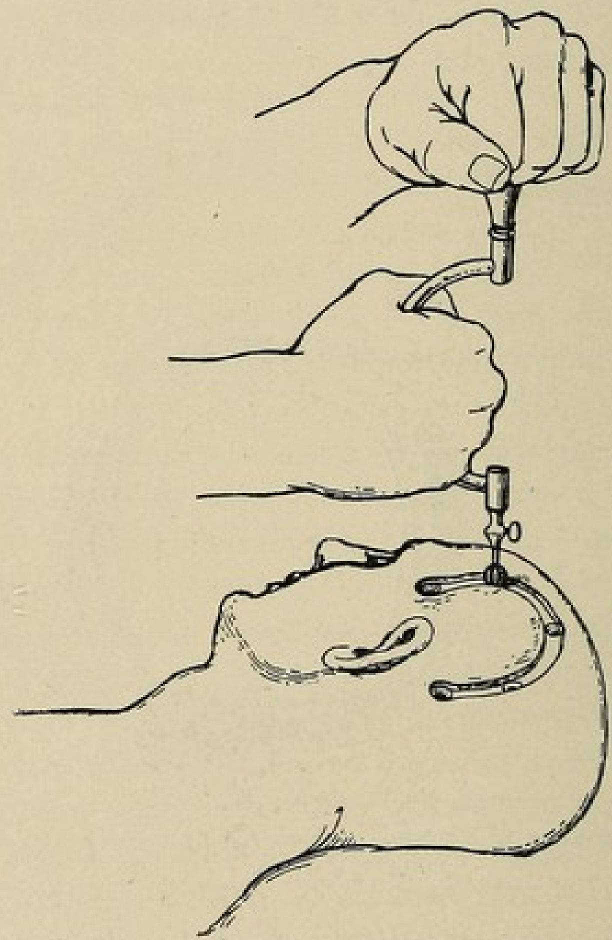

Fig. 56.—Formation of the Osteo-tegumentary Flap (*Marion*).

in the bone corresponding to either end of the upper part of the incision. These openings may be made with the Doyen or the Hudson perforators and burr. With these instruments the danger of abruptly penetrating and injuring the dura and underlying structures is eliminated. The Doyen burr is smooth, non-cutting on its under side, and will push the dura away without injuring it, and the Hudson instrument stops working automatically just as soon as the bone has been penetrated. Working from either hole downward along the sides of the flap toward the base, the bone is divided with a biting bone forceps of the Dahlgren, De Vilbiss, Hudson type. The bone corresponding to the upper part of the flap may also be cut with the bone forceps, but it is better to do this with the Gigli saw. The Gigli saw is passed through from one hole to the other and the bone between the two holes sawn through. The section through the bone at this part should be made upon an oblique plane so that, when the flap is replaced, the segment of bone will present a beveled edge to rest upon the corresponding broad, beveled edge of bone, and thus prevent it from being pressed inward upon the dura or brain. Before using the bone forceps and before passing the Gigli saw the dura must be separated from the under surface of the bone. This is ac-

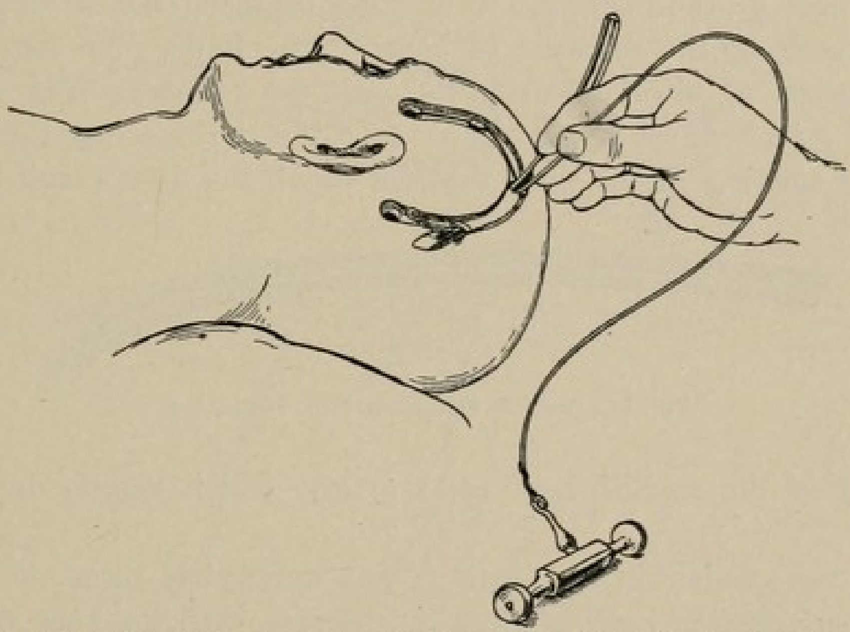

Fig. 57.—Formation of the Osteo-tegumentary Flap (*Marion*). Passing the Gigli saw from hole to hole.

complished by introducing the separator through one of the trephine openings and working it cautiously between the dura and bone as far as the next opening or in the direction that is to be cut with the forceps. The grooved separator of Marion, which is elastic and bendable, so that its extremity can be bent to suit the immediate necessities of the case, is a very satisfactory instrument for the purpose. If the Gigli saw is used it is carried through from hole to hole upon the grooved separator, or it may be drawn through if necessary with a silk thread in the eye of the separator. The separator is left *in situ* while the bone is being sawn through with the Gigli saw, in order to protect the dura, etc., from injury. Several openings —four or five—may be made in the bone with the trephine, one at each end of the base of the flap (each lower corner), one at each upper corner, and one between these two latter, and the bone between the openings cut through from hole to hole with the Gigli saw. The opening in the skull should not reach to within $\frac{3}{4}$ to 1 inch of the sagittal line, on account of the danger of injuring the parasinoidal lacunæ. After the bone has been divided all around, the elevator is introduced between the edges of the bone in the upper part of the flap and the piece of bone pried out, breaking it below, through its base. The fracture through the base may be facilitated by one or two blows with the chisel and mallet. A guarded chisel is used for this purpose, similar to the Doyen (Fig. 60). During the course of this part of the operation care must be taken not to detach the soft parts from the segment of bone in the flap. The flap, which thus consists of all the soft parts with the corresponding segment of bone attached, is turned down over the zygoma, leaving a considerable opening in the skull through which the dura mater and the

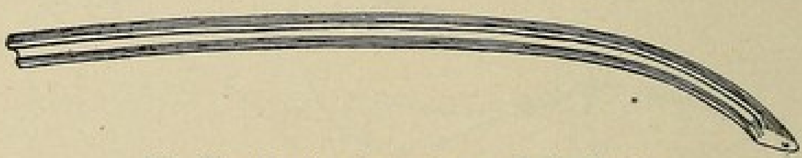

Fig. 58.—Marion Separator and Conductor.

branches of the middle meningeal artery, which ramify in it, are exposed.

If the opening in the skull is not sufficiently large, it may be further enlarged by cutting away its margins with the bone forceps.

There may be considerable hemorrhage from the edges of the bone. This is usually readily controlled by packing temporarily with gauze. If it persists and is coming from one or several larger openings in the bone, it may be controlled by crushing the bone with a blow of the blunt-end chisel or with Krause's hooks, ivory pegs, or with Horsley's wax—a putty-like mass made up of vaselin and paraffin, each 50 parts, and carbolic acid 5 parts. It may be necessary to interrupt the operation before opening the dura if the hemorrhage has been very severe.

After the osteo-tegumentary flap has been reflected the dura is incised. The dura is incised, flap-fashion, usually with the base of the flap below. It should not be divided too close to the edges of the opening in the bone in order that there may be ample margin left for suturing. If the upper part of the opening in the skull is quite close to the middle (sagittal) line it will be advisable to incise the dura around the lower part of its circumference in such a way that the base of the dura flap is above, in order to avoid injuring the parasinoidal lacunæ which often spread out over the hemispheres for some distance—$^3/_4$ to 1 inch—away from the middle line. Care must be exercised in incising the dura not to injure the pia-arachnoid. A hemorrhage may result, small in itself, but very annoying in that it spreads in the subarachnoid space and may obscure the fissures and convolutions. The dura is picked up with a fine tenaculum, nicked with the knife, and then carefully incised with the blunt-

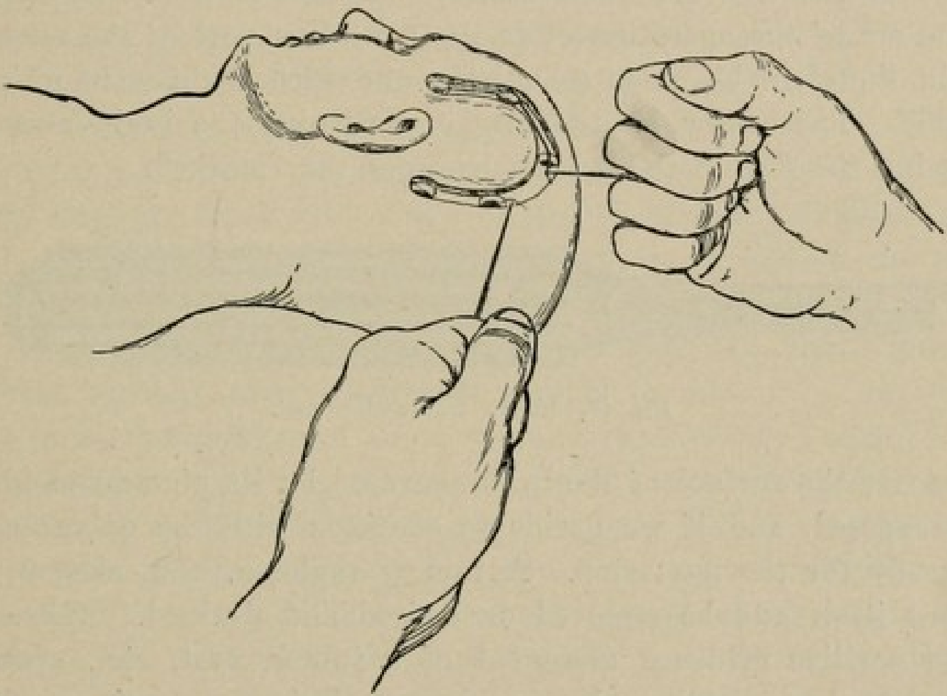

Fig. 59.—Formation of the Osteo-tegumentary Flap (*Marion*). Cutting from hole to hole with the Gigli saw.

pointed scissors. This may be rather difficult on account of the very marked degree of bulging and tension of the dura. If the opening in the skull is found to be not large enough, more room may be obtained by gouging away the edges of the bone or by reflecting an additional osteo-tegumentary flap from either one side or the other. In gnawing away the upper edge of the opening in the bone great care must be taken to carefully detach the dura (including the parasinoidal lacunæ, longitudinal sinus, etc.) before applying the forceps to the bone. If necessary to enlarge the opening in the dura incisions may be made in the corners of the dura radiating from its cut edges toward the edges of the bone. A tumor may be found growing from the dura against the surface of the brain or the dura may be adherent to the pia-arachnoid or involved in a new growth in the brain. Under these circumstances the dura must be carefully separated and excised if necessary. Occasionally the brain bulges decidedly just as soon as the opening is made in the dura on account of the greatly increased intracranial pressure, and this bulging may become very much increased during the course of the operation through the œdema and swelling of the arachnoid, which may result from exposure, handling, etc. It may be necessary to puncture and express the fluid or to resort to lumbar puncture, etc. The examination with the object of determining whether to continue with the second act of the operation or to postpone this part of the operation should therefore be made as quickly and with as little handling as possible. There may be difficulty in returning the brain mass and replacing the flap if the œdema becomes very marked.

Fig. 60.—Doyen Guarded Chisel.

After the surface of the brain, covered by its pia-arachnoid, has been exposed, and if we decide to continue with the operation, we are ready for the next step. A tumor, angioma, cyst, abscess, may present itself and be removed or incised and drained. There may be no positive evidence presented of a tumor, cyst, etc., upon exposing the brain. The color, consistence, lack of pulsation, bulging, etc., may be of assistance in this case, or it may be necessary to search for evidence of disease by puncture, aspiration. A large-bore needle (2 mm. diameter) and a syringe of capacity of 2 to 3 c.c. are used for this purpose. Cystic, bloody, or purulent fluid may be withdrawn, or a cylinder of brain or tumor tissue may be withdrawn for immediate examination. Tumor may be encapsulated and may thus be readily enucleated with the finger or blunt dissector. Cysts, abscesses, may be incised, emptied, the wall dissected out, and the cavity packed. This must all be done in the gentlest manner possible. If necessary to incise the cortex, the incision should be confined to the summit of a convolution, and should not cross a sulcus. Before making the incision the blood-vessels of the pia-arachnoid corresponding to the proposed line of incision must be tied double with very fine silk, which is passed around them in a fine, curved needle. It is practically impossible to define the limits of diffuse tumors, and it is very questionable whether the effort should be made to remove them. The walls of the cavity which is left after enucleation of a tumor, evacuation of a cyst, etc., usually collapse, and thus the cavity is obliterated to a considerable extent. Hemorrhage from the cavity is controlled by packing it temporarily with strip gauze. After a few minutes the hemorrhage usually ceases. If the cavity is small, clean, and there is no hemorrhage, the opening in the skull may be closed without drainage. If the cavity is large, or if oozing continues, it will be necessary to leave the packing in place for forty-eight hours. Abscess and cyst cavities must be packed and drained.

For Epilepsy.—After the dura has been opened it will be necessary to accurately locate the area which is to be excised. This is done by faradization. A long, sterilizable, glass, unipolar electrode 30 cm. long, provided with a fine platinum-wire core, twisted into a spiral at the end, is used. The other pole is applied to the trunk or to one of the extremities, preferably upon the homo-lateral side. The current should not be strong—just strong enough to give appreciable burning, sour taste when applied to the tip of the tongue or to cause contraction of some exposed muscle-fiber; some of the temporal fibers in the flap may be available for this purpose. If the pia-arachnoid contains too much cerebro-spinal fluid it may be necessary to prick the pia where it bridges over a sulcus and allow some of the fluid to escape. The patient should not be too deeply anæsthetized. The portion of the cortex which is to be excised is thus marked out. All the blood-vessels leading to the area which is to be excised are tied double with fine silk ligatures carried around them in a fine curved needle and the area of the cortex then excised, cutting well into the white substance.

Closure of the Wound.—If no drainage is necessary the wound is closed by suturing the dura all around with very fine chromic catgut or fine silk. The flap is replaced and the edges of the skin are sewn together very accurately with interrupted silk sutures. These sutures take as deep a bite as possible in the edges of the flap, are placed close together and drawn tight to control any tendency to hemorrhage from the scalp. If it is desired to drain, an opening is left in the lower posterior corner of the dura and a piece of bone bitten out to correspond. Occasionally the bulging is so great that it is impossible to suture the dura or to replace the flap. Under these circumstances it may be necessary to leave the wound open. The swelling and bulging will often subside in a few days so as to permit replacement of the flap.

To Expose the Cerebellum and Other Parts Contained in the Posterior Fossa (Cushing).—The patient lies upon the table, face downward, with the head projecting over the end of the table and supported upon an extension with a rest adapted to receive the head. The shoulders are raised from the surface of the table upon sandbags in order to permit free respiratory movement of the chest. The operation may also be done with the patient in the semiprone position, with the shoulder raised upon a sandbag to permit of freedom of respiration.

The cross-bow incision is made. The upper part of the incision is curved, passing across the back of the head from the base of one mastoid process to the base of the other, above and parallel with the superior curved line of the occipital bone. Another incision is made in the middle line, which reaches from the upper incision downward as far as the spine of the second or third cervical vertebra. The flaps, which consist of all the soft parts and including the periosteum, are detached from the bone, which is thus denuded as far as the foramen magnum. In detaching and cutting the muscular attachment (of the trapezius) to the superior curved line of the occipital bone, care is taken not to divide it too close to the bone so that a sufficient margin may be left for suturing in closing.

The bone on both sides of the middle line is perforated with the trephine and the bone then gouged away, upward as far as the lateral sinus so that the course of the sinus is exposed, inward across the middle line, but leaving intact the portion of bone over the torcular, and finally downward as far as and including the posterior half of the margin of the foramen magnum. The posterior arch of the atlas is thus exposed in the wound. The dura is incised all the way across and turned down flap-fashion. It will be necessary, before carrying the incision across the middle line, to ligate the occipital sinus. This is done by incising the dura on each side of the middle line and carrying a ligature, double, around the sinus in a curved carrier. The ligature passes around the entire width of the falx cerebelli (which is easily done, as the falx is quite narrow). The ligature is divided and tied double, one above and the other below, and the sinus and falx cerebelli cut between the two ligatures and the dura flap turned down. Both cerebellar hemispheres are thus freely exposed.

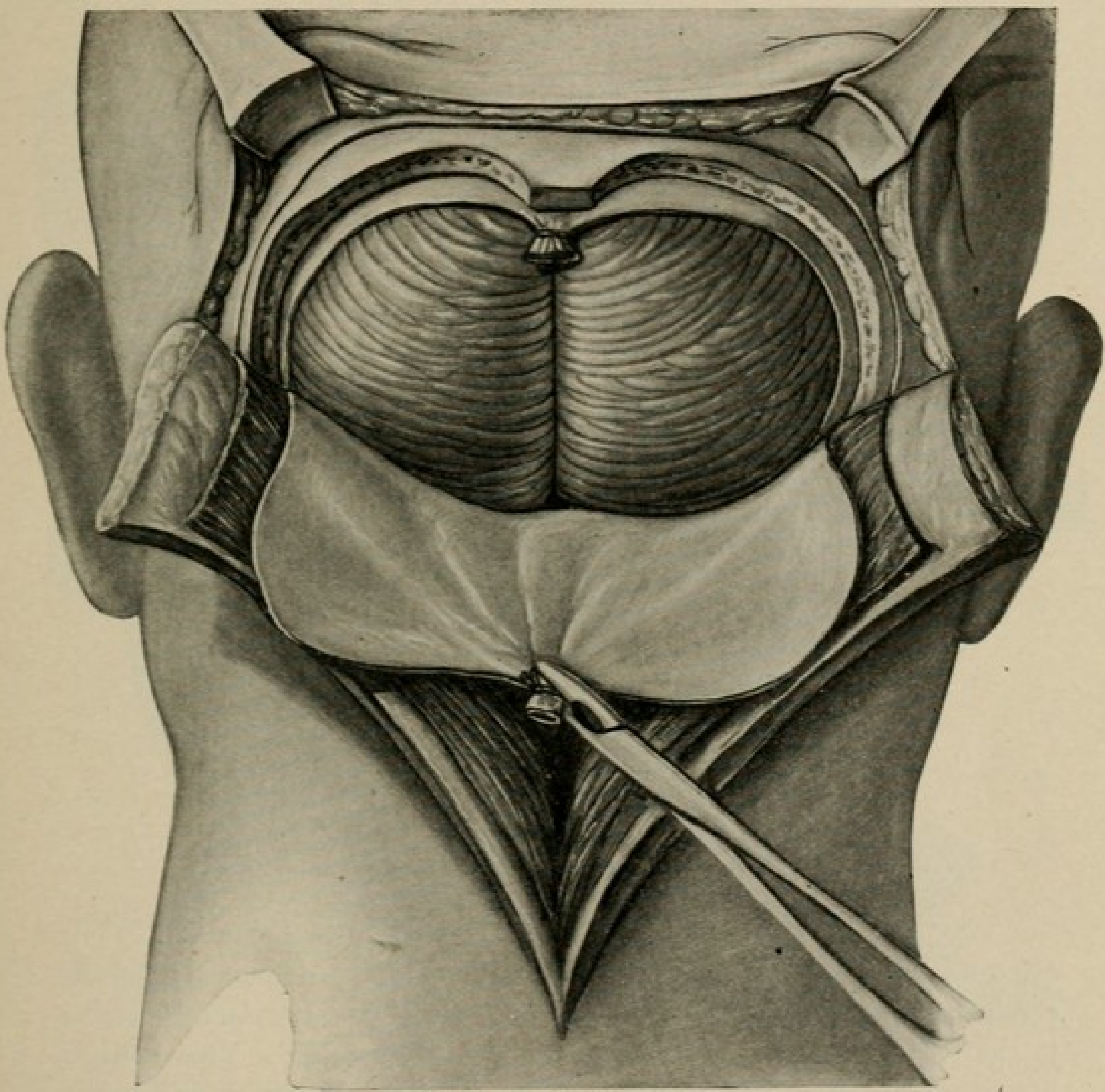

Fig. 61.—Exposure of Cerebellum. Bone has been cut away. The occipital sinus ligated and a flap of dura turned down.

The second act of the operation is proceeded with or postponed for a later day, according to the condition of the patient, as indicated by blood-pressure, amount of blood lost, shock, etc. If the operation is to be done in two separate stages the flap of dura is sutured and the muscle-skin flap is replaced and accurately sutured, and the patient allowed to recover fully—several days to several weeks are allowed to elapse—before proceeding with the second step. Decompression may be done here if an inoperable condition is found, by resecting the flap of dura.

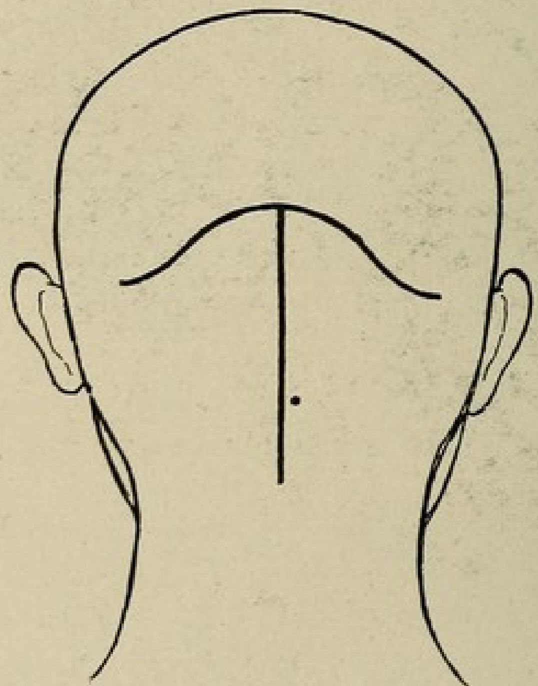

Fig. 62.—Cushing Cross-bow Incision.

Exposure of One Half of the Cerebellum (Krause).—The osteo-tegumentary flap method may be used to expose one half of the cerebellum. It has no advantages and gives less satisfactory access to the posterior fossa than where the bone is sacrificed. This method may be employed, however, where a definitely localized and easily accessible tumor has been diagnosticated.

A quadrangular flap is marked out, the upper border of which corresponds to a line that passes transversely outward across the back of the head from a point one-half inch above and to the other side of the external occipital protuberance to the base of the mastoid process. From either end of this transverse incision, two other incisions, one on each side, are carried straight downward, the outer one corresponding to the posterior border of the mastoid process,

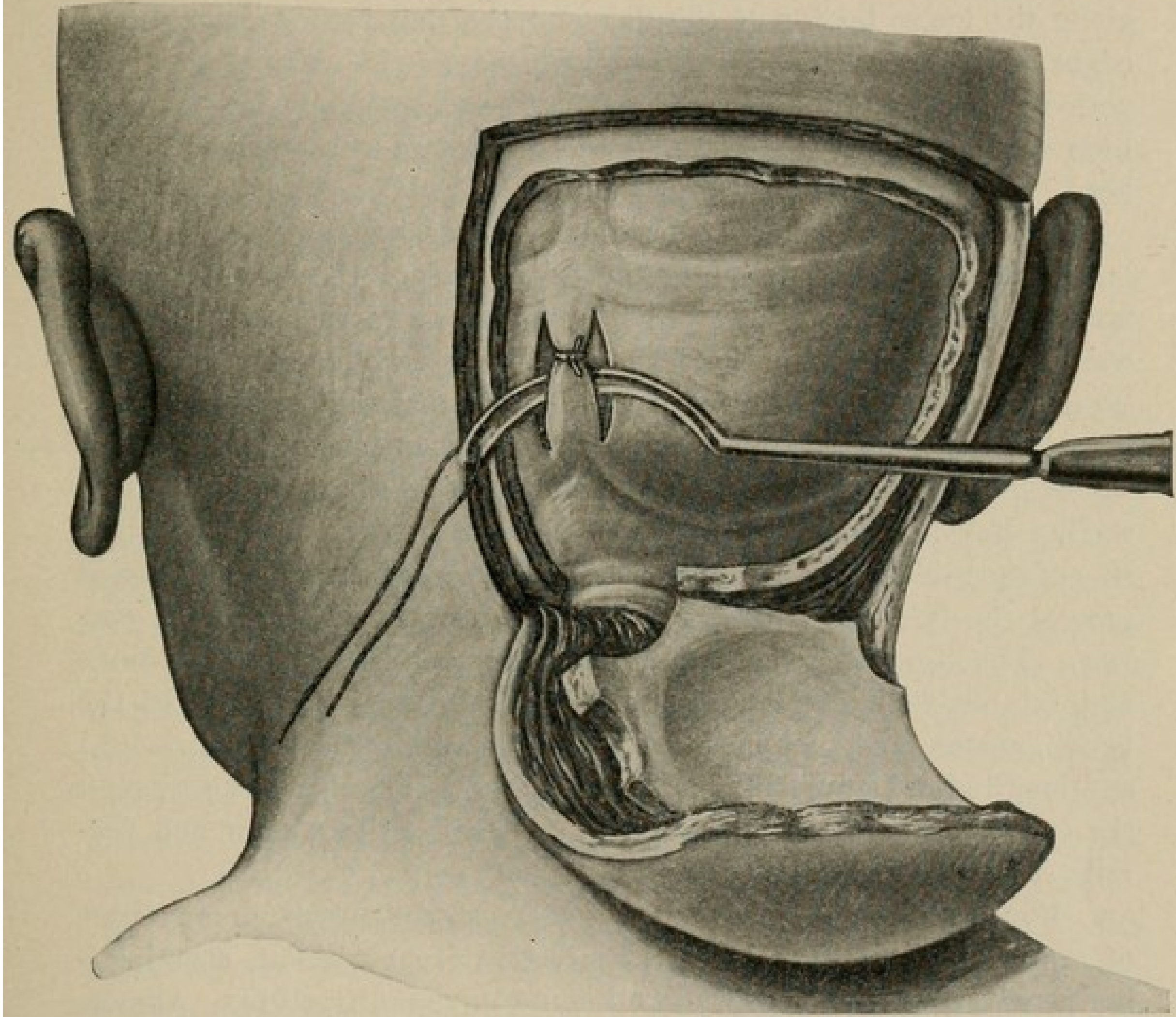

Fig. 63.—Exposure of One-half of the Cerebellum. Osteo-plastic Flap (*Krause*). Ligature of occipital sinus preparatory to turning down a flap of dura.

the inner one running parallel with and just a little to the other side of the external occipital crest. Two trephine openings are made, one in either upper corner. These expose the lateral sinus or the dura mater just above the course of the sinus. The dura is carefully separated and the bone cut with the biting forceps from hole to hole, and then downward along either lateral incision. The bone is broken along the lower border of the flap and the flap turned down. The edges of the opening in the bone should be gouged away so as to expose the position of the lateral, sigmoid, and occipital sinuses. The dura is incised, not too close to the margin of the opening in the bone, and reflected downward, flap-fashion.

To obtain still more room in the suboccipital region a much larger flap, reaching well into the other half of the occipital bone, may be reflected and the division of the bone carried as far downward and forward into the floor of the posterior fossa as possible. When this flap is turned down it will be seen that the segment of bone includes the posterior margin of the foramen magnum. It may be necessary to ligate and divide the occipital sinus and falx cerebelli. For this purpose an incision is made in the dura upon either side of the middle line (falx cerebelli) and the ligature, double, carried around the falx cerebelli and occipital sinus with a full-curved carrier. The ligature is cut and tied above and below and the sinus and falx cerebelli divided between the ligatures. The upper of the two ligatures must not be too close to the confluence of the lateral and longitudinal sinuses—at least 1 cm. away. The ligatures surround the entire width of the falx cerebelli, which is quite narrow and permits easy passage of the carrier.

For Abscess of the Brain.—Abscess may occur in any part of the brain as a result of direct infection from without, complicating penetrating wounds of the skull, and compound fractures. Abscess of the brain may occur in head injuries without local wound, the infectious elements gaining access to the damaged parts through the blood-stream. Abscesses of the brain may be metastatic, secondary to general pyæmic conditions—abscess of the lung, liver, osteomyelitis, etc. Most commonly abscess of the brain results from extension of a septic process from the nasal cavity and the air sinuses adjacent to it or from the middle ear and mastoid antrum. The inflammatory process extends through the thin, bony partitions, which separate these spaces from the cranial cavity, or septic material may be carried by means of the blood-current, infected, thrombosed, emissary veins, etc. These abscesses have a characteristic predilection for certain definite parts of the brain. Those secondary to suppuration in the frontal, sphenoidal sinuses are found in the frontal lobe; those secondary to inflammatory processes in the middle ear and mastoid antrum in the temporo-sphenoidal lobe. Abscesses located in the cerebellum are secondary to inflammation in the mastoid antrum and cells and to thrombosis of the sigmoid sinus.

Abscesses due to direct infection from without, complicating a penetrating wound or compound fracture, necrosis and suppuration of the bones of the skull, are treated by enlarging the original wound, freely opening the skull by gouging away the bone, and very freely incising and packing the abscess cavity. It is not advisable to irrigate the abscess cavity, nor should its wall be curetted except in the case of chronic (tubercular) abscess, with a distinct, well-marked abscess wall—pyogenic membrane.

The pia-arachnoid will usually be found adherent to the dura, and the abscess may be opened without danger of the escaping pus entering the subdural space and being distributed over the adjacent parts of the brain surface. If the subdural space has not already been closed off by adhesion between the dura and pia-arachnoid, strip gauze should be packed into the space before opening the abscess.

Plan of operation upon abscesses secondary to infectious processes in the paranasal sinuses, frontal, sphenoidal, etc., or in the middle ear, mastoid antrum, etc., is discussed in connection with the operations upon these several parts. It might be well to mention here, however, that the cardinal rule is to first freely and thoroughly lay open and explore the cavity which is the seat of the primary infection, find the path of infection if possible, and evacuate and drain the brain abscess through the incision and wound thus made; or else, after laying open, exploring, and packing the cavity which is the original focus of infection, approach and evacuate the abscess in the brain through a more convenient route—through an independent opening in the side of the skull, etc.

PUNCTURE OF THE BRAIN AND VENTRICLES FOR DIAGNOSTIC PURPOSES.—A small incision is made in the scalp under cocain or ethyl chlorid anæsthesia. The opening is made in the skull with a drill driven by a motor, the drill held lightly and steadily against the skull. At the moment the skull is penetrated the fact is readily appreciated by the operator. There is but little danger of going through the dura abruptly with the drill, but even if this occurs no damage will be done. A very small burr—2 mm. in diameter—is used. The aspirating needle is introduced through the hole in the skull and then pushed through the dura into the brain. A needle 7 cm. in length with a calibre 1 mm. in diameter, and provided with a steel mandrin, is used. The needle is graduated in cm. in order to determine the depth of fluids and tissues withdrawn. The needle is introduced to various depths, the mandrin withdrawn, and the syringe applied. The needle is then slowly withdrawn, making suction with the syringe at the same time. Fluid or pus or a cylinder of brain or tumor tissue may thus be withdrawn for examination.

A larger incision may be made in the scalp and a larger opening made in the skull with a larger burr if desired. The place where the aspiration is made will vary according to the location of the suspected abscess, cyst, tumor, etc.

For Tapping the Lateral Ventricles.—The needle may be introduced, according to Keen, at a point, 3 cm. above and 3 cm. behind the external auditory meatus. The needle enters the posterior part of the temporo-sphenoidal lobe. It is pushed in a direction toward the top of the pinna of the ear of the opposite side. The needle enters the ventricle at a depth of 5 cm.

According to Kocher the ventricle is entered through the frontal lobe at a point just anterior to the bregma and 2½ cm. away from the middle line. The needle is directed downward and backward and enters the ventricle at a depth of 5 to 6 cm.

The more the ventricle is distended, the easier it is to strike it. The amount of fluid removed is governed by the symptoms, the effect on the pulse, blood-pressure, etc.

Permanent Drainage of the Lateral Ventricles (Krause).—Permanent drainage of the lateral ventricles may be established by introducing a cannula into the lateral ventricle and fixing the outer end of the cannula, which emerges through an opening in the skull in such a manner that the fluid from the ventricle is able to escape continuously through the cannula into the loose connective tissue underneath the scalp.

A small incision is made in the scalp down to, but not through the periosteum. The periosteum is incised and detached from the surface of the bone on either side of the incision so as to form two little pockets, one on either side, between the periosteum and the bone. A hole 2 mm. in diameter is drilled through the skull. A flexible silver cannula, 2 mm. in diameter, is fitted snugly over an aspirating needle. The aspirating needle carrying the silver cannula is introduced through the opening in the skull and pushed through the substance of the brain until fluid is reached. The aspirating needle is then withdrawn, leaving the end of the cannula in the ventricle. The cannula is withdrawn a little and then again pushed in a little to make certain that the end presents just within the ventricle. The free end of the cannula which protrudes through the

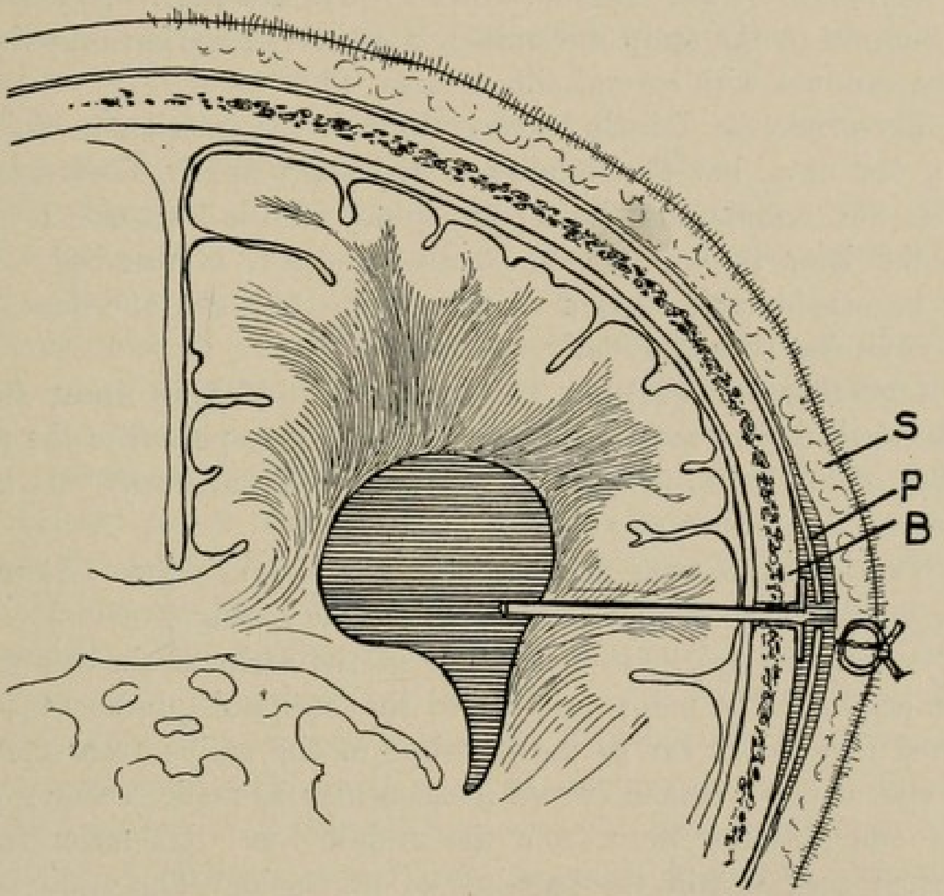

Fig. 64.—Drainage of the Lateral Ventricle. Cannula in the lateral ventricle for continuous drainage. *B*, skull; *P*, periosteum; *S*, scalp.

opening in the skull is cut off except for a portion about 1 cm. in length. The protruding portion of the cannula is bitten off, without damaging its lumen, in the following manner: A hard-steel stylet is introduced into the cannula and the cannula then cut off with the scissors at the desired point. The stylet within the cannula forms a hard, resistant countersurface to cut upon, and prevents the walls of the cannula from being crushed together, thus interfering with its lumen. The stylet is withdrawn. The protruding end of the cannula, about 1 cm., is split with a narrow-bladed scissors so that the two split portions may be bent back, "T" fashion, against the surface of the skull. Thus the cannula is prevented from being forced farther into the brain or lost within the cranial cavity. In order to prevent the cannula from coming out the two bent arms corresponding to the split end of the cannula are fitted into the two little pockets between the periosteum and the surface of the bone that have been formed by detaching the former, and are secured thus by suturing the edges of the periosteum together just above and just below the mouth of the cannula. Silk sutures are used. The edges of the incision in the scalp are united, accurately covering over the end of the cannula with several silk sutures.

There may be a little leakage through the incision in the scalp for a few days, but the incision in the scalp finally closes over the end of the cannula and the cerebro-spinal fluid is thus able to escape into the loose tissue under the scalp, where it is absorbed. There may be considerable œdema of the soft parts, head and face, for a few days, but this gradually subsides.

Craniectomy (Linear Craniotomy).—Making linear furrows in the skull for the purpose of providing space to permit of the proper growth of the brain, in cases of microcephalia and idiocy. It is very questionable whether operation is of any value.

This operation was first performed by Lannelongue. It may be done on one or both sides of the skull at one sitting.

A longitudinal incision is made in the scalp in the middle line commencing at a point just above the occipital protuberance and carried forward as far as the hair-line of the scalp; from the anterior end of this a second curved incision may be made reaching downward and outward away from the middle line; this latter incision is also placed within the hair-line of the scalp. The scalp is then raised from the skull with the elevator.

Posteriorly, just above the occipital protuberance, an opening is made in the skull with the trephine, about one-half inch in diameter, and through this opening, with the bone-forceps (a De Vilbiss or Hudson bone forceps serves the purpose very satisfactorily), a furrow is cut which is carried forward to within an inch of the supra-orbital ridge. This channel should be one-fourth of an inch wide and will vary from five to six and one-half inches in length and should be placed about three-fourths of an inch away from the middle line in order to avoid the longitudinal sinus. The dura is detached from the inner surface of the skull to permit the use of the bone forceps, but it should not be incised.

From either end of the longitudinal furrow in the bone an additional channel may be cut, reaching downward and outward for one or two inches away from the middle line.

The periosteum is cut away from the margins of the furrows in the bone to prevent reproduction of the bone. If any of the branches of the meningeal are injured during the course of the operation, they may be surrounded by ligatures carried in a curved surgeon's needle and tied. It is often difficult to secure these branches with the artery forceps, and thus the necessity of carrying the ligatures around them in the needle.

The edges of the incision in the scalp are accurately approximated without drainage, to insure primary healing.

The longitudinal furrow in the skull is usually placed to the left of the middle line, but may be placed upon the right side instead, if this appears to be the less developed side.

Trephining of Frontal Sinuses.—For purpose of providing drainage in cases of empyema. A curved incision commencing in the middle line above the root of the nose and passing outward along the upper margin of the orbit corresponding to the line of the eyebrow. The incision passes through the soft parts, including the periosteum down to the bone. The bone is denuded with the periosteum elevator.

The anterior bony wall of the sinus is penetrated with the chisel and mallet. The opening is placed to the outer side of the middle line and above the margin of the orbit. The mucous lining of the sinus which is thus exposed is incised. The opening in the bone may be enlarged if necessary with the bone-forceps or chisel. The sinus may be curetted with the sharp spoon; but this is not necessary in all cases. A probe is passed into the sinus and down through the infundibulum into the nasal cavity. This passage should be free so as to permit drainage. The infundibulum takes a curved course from the frontal sinus first downward and somewhat backward and then forward, and opens under the front portion of the middle turbinated bone. Drainage is provided by drawing a tube or a strip of gauze from the incision down through the infundibulum and out through the nose. In addition the sinus is loosely packed through the skin incision. The incision is closed in part. If both sinuses are involved the incision can be carried across and above the other orbit, and the sinus of that side also opened in a similar manner by gouging away its front wall. The septum between the two sinuses is broken down with the chisel.

Killian's Operation.—This operation is performed for chronic suppuration of the frontal sinus. It consists in removing the anterior wall and floor of the frontal sinus, freely curetting the sinus and establishing drainage into the nasal cavity. A bridge of bone, the supra-orbital margin, is left for cosmetic effect and to support the soft parts and prevent falling-in of the eyebrow.

It is not necessary to shave the eyebrows; it suffices to trim the hairs quite short. The nasal cavity is plugged with strip gauze.

The incision is made along the line of the eyebrow, hair-line, from the root of the nose outward as far as the outer end of the supra-orbital margin. From the root of the nose the incision is carried downward upon the side of the nose and then curved outward, terminating at a point about one-half inch below the junction of the inner and middle thirds of the inferior orbital margin. This incision goes down to, but does not include the periosteum. The edges of the incision are retracted with sharp-pronged retractors. Spurting vessels are secured with hæmostats and ligated. The periosteum is incised along a line parallel with and about one-quarter inch above the supra-orbital margin. A second periosteal incision commences just below the inner end of the supra-orbital margin—just inside the orbit—and just internal to the point where the pully of the superior oblique muscle is attached to the roof of the orbit, and is continued inward and downward along the line of the corresponding part of the skin incision. The contents of the orbit are held away and retracted with the Killian spatula. With the periosteum elevator the periosteum is detached from the surface of the bone, upward, away from the supra-orbital incision, thus denuding the surface of bone corresponding to the anterior wall of the frontal sinus, and downward, away from the lower periosteal incision, denuding the bone corresponding to the inner part of the roof of the orbit. The periosteum covering the bridge of bone which it is proposed to leave to support the soft parts is thus left undisturbed. The front wall of the sinus is penetrated with a chisel and mallet, and a considerable opening made with the rongeur bone-forceps. The mucous membrane lining of the sinus is freely incised—it is at times found very much thickened—and the sinus is thus entered. The interior of the sinus is explored with the probe to discover its dimensions, extent, etc., and then the entire contents removed with the sharp curette. The floor of the sinus is perforated with the chisel and mallet, and the entire floor of the sinus then gouged away with the rongeur forceps, working

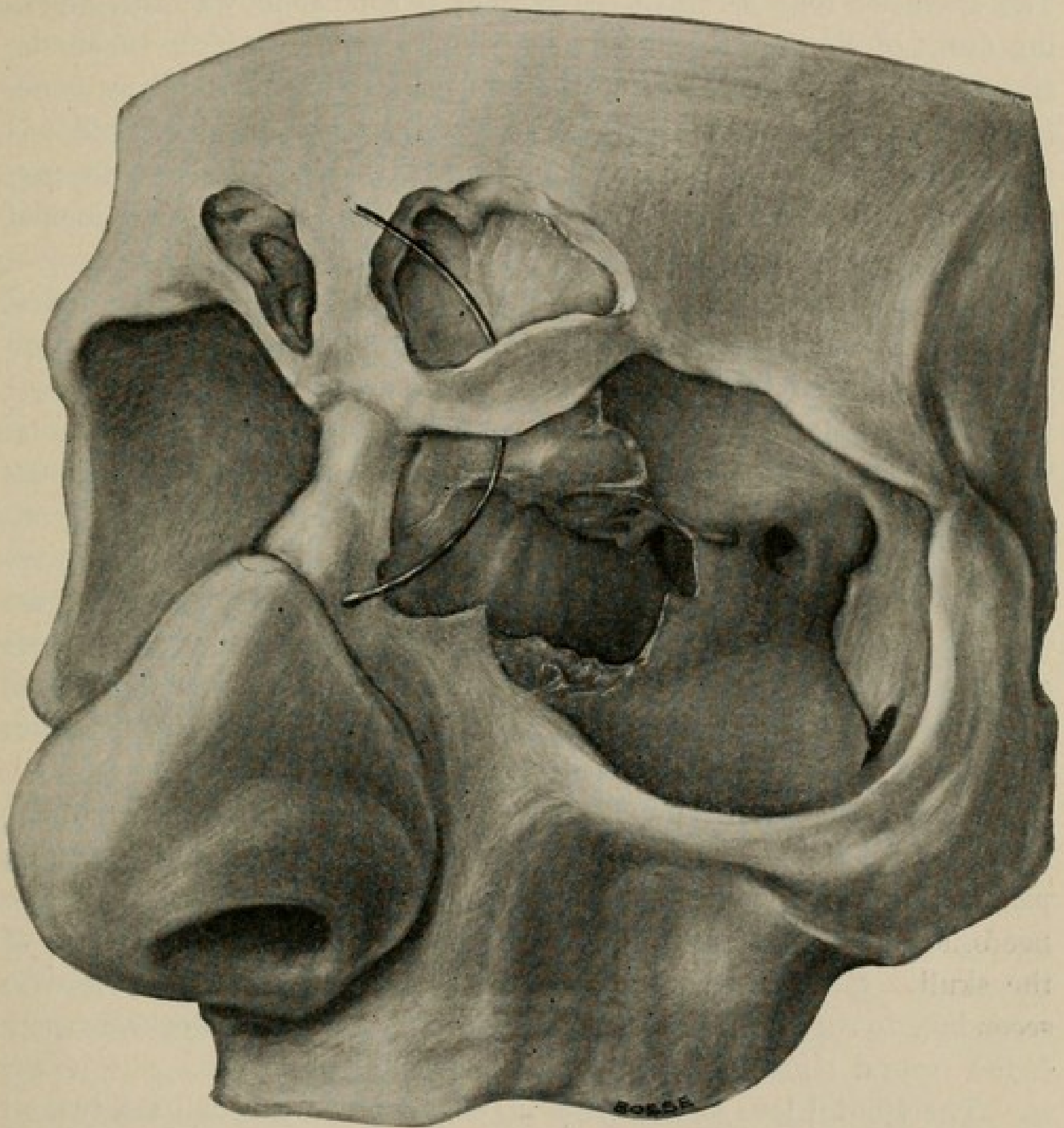

Fig. 65.—Frontal Sinus. Right Side, Simple Operation; Left Side, Killian Operation. Shows bridge of bone. Probe is passed under bridge of bone through from opening in frontal sinus into orbit.

toward the front and downward and sacrificing the frontal process of the superior maxillary bone. The anterior ethmoidal cells are thus freely uncovered and may be curetted if diseased, and a large opening established into the nasal cavity for the purpose of drainage. The operation may be continued farther if conditions warrant, breaking down of all the ethmoidal cells, removal of the middle turbinate, and opening and curettage of the sphenoidal sinus. A biting bone-forceps of the Grüning type is used, and great care must be exercised in using the curette and other instruments—especially not to perforate the cribriform plate of the ethmoid or the roof of the sphenoidal sinus.

The posterior cranial wall of the frontal sinus may be found necrosed, and it may be necessary to remove a considerable portion of this wall with the rongeur, exposing the dura.

After the operation has been completed the resulting cavity is wiped dry and packed with strip gauze. The first end of the gauze strip is passed through the wound, down into the nasal cavity, so that later it may be readily seized and removed through the nose. The orbital contents are gently replaced and the incision very accurately closed with interrupted silk sutures, which include the edges of the detached periosteum. The entire external wound is thus closed and the frontal sinus drains into the nasal cavity. The gauze packing is removed and replaced after two or three days.

For Abscess in the Frontal Lobe.—Abscess of the frontal lobe may be due to direct infection through a compound fracture, penetrating wound of the skull; or it may occur in connection with necrosis and chronic suppuration of the bones of the front part of the skull. Most commonly, however, abscess of the frontal lobe is secondary to suppuration in the air sinuses adjacent to the nasal cavity —the frontal sinuses, ethmoidal and sphenoidal sinuses.

The frontal lobe of the brain may be exposed through the frontal sinus during the course of an operation upon the sinus; or subsequent to such an operation if the symptoms continue and point to abscess in the frontal lobe. The posterior wall of the sinus is gouged away until an opening in the skull sufficiently large has been obtained. If abscess of the frontal lobe occurs independent of frontal-sinus infection, an opening may be made in the frontal bone with the trephine and rongeur forceps, or an osteo-tegumentary flap reflected in this part of the skull.

After the dura mater has been incised and before opening the abscess the subdural space should be packed with strip gauze if the space has not already been shut off by adhesions between the dura and the pia-arachnoid. The abscess is incised, the pus evacuated, and the cavity is packed with strip gauze. The abscess cavity is not irrigated.

THE MIDDLE FOSSA OF THE SKULL.

Extirpation of the Gasserian Ganglion (Hartley-Krause).—The operation may be done in one or two sittings. The patient is placed in a semirecumbent position with the head turned partly to one side. A horseshoe-shaped flap, consisting of the integument and the underlying muscle and the corresponding segment of bone, is turned down.

The incision passes through the whole thickness of the soft parts, including the periosteum, down to the bone. This incision commences anteriorly, just above the zygoma, and about a finger's breadth behind the external angular process; it is carried upward upon the temporal region describing an arc, its posterior limb terminating just in front of the tragus. Bleeding points are secured with artery forceps and ligatures. The flap thus marked out measures in its vertical diameter three inches, about two inches across its widest part, and from one and one-half to two inches at its base, which is just above the zygoma. Corresponding to the skin incision a groove is chiseled all around in the bone. The Hartley chisels are probably the best for this purpose, as they cut a distinct groove; if an ordinary narrow chisel is used, it should be held quite obliquely and only its corner engaged in the bone while cutting. Care should be taken not to injure the dura with the chisel. The bone may be cut more conveniently and with less danger of injuring the dura with the biting bone-forceps—the De Vilbiss, Hudson, etc., or with the Gigli saw, as described on page 86.

The elevator is introduced as a lever into the upper part of the cut in the bone and the segment of bone, with the soft parts still attached, is broken through at its base and turned well down over the zygoma; if the opening is not sufficiently large, more bone may be cut away from the lower margin of the opening with the bone forceps. Through this opening in the skull the dura mater is exposed, the anterior branch of the middle meningeal ramifying upon it toward the front; at times this branch is torn when the plate of bone is reflected, especially if the groove in the bone in which the vessel is lodged is unusually deep; if injured, it should be ligated.

Now, with the fingers or the blunt periosteum elevator, the dura is separated from the bone, from the floor of the middle fossa. This step of the operation may be executed without much difficulty until the middle meningeal artery, as it enters the skull through the foramen spinosum, is encountered. When this vessel is exposed it should be secured with a double catgut ligature and divided. If difficulty is experienced in ligating the artery, or if it is torn off close to the foramen through which it enters the skull, the hemorrhage may be controlled by plugging the opening with a wooden peg or by introducing a Krause hook into the opening and twisting it within the opening until the bleeding is controlled. The field of operation is kept clear of blood with gauze wipes on holders. After the middle meningeal artery has been disposed of and still working inward, but rather more cautiously, the dura mater is detached from the base of the skull with a blunt elevator or with a small gauze pad in a forceps, at the same time lifting the brain away from the base of the skull toward the vault. This is best accomplished with the aid of a narrow, polished, right-angle retractor. A very appropriate instrument for the purpose is shown in Fig. 66. The flat, flexible retractor is also very useful. The blade may be bent at any angle desired. With these instruments the brain can be very conveniently lifted away from the base of the skull. A pad of gauze may be interposed between the retractor and the brain; by this means the hemorrhage may be very much diminished. The hemorrhage caused by separating the dura mater from the bone is sometimes considerable. It may be controlled by a few minutes' pressure with a gauze pad or by shifting or withdrawing the retractor for a few minutes and allowing the brain to drop back upon the surface of the bone. Thus gradually working inward we reach the third division of the fifth nerve, which may be seen passing out of the skull through the foramen ovale. This trunk is seized with a narrow forceps and isolated as far back as the ganglion; it serves as a guide to the ganglion. Without cutting this trunk, we then work a little farther inward, toward the middle line, until we meet the second division of the nerve. This is likewise isolated and followed backward from the foramen rotundum as far as the ganglion. The upper surface of the ganglion is then gradually freed from the dura. While the work of isolating the ganglion is being accomplished the brain should be well retracted: lifted away from the base of the skull. The ganglion can be separated from the overlying dura with a blunt periosteum elevator. The third division of the nerve may be seized and pulled upon as a guide to the ganglion. It may be necessary to cut a few connective-tissue bands, between the ganglion and the dura, with the scissors, and in doing this the operator may accidentally cut into the dura; this accident, however, is of no serious significance; some cerebro-spinal fluid will escape, but, according to Tiffany, this is

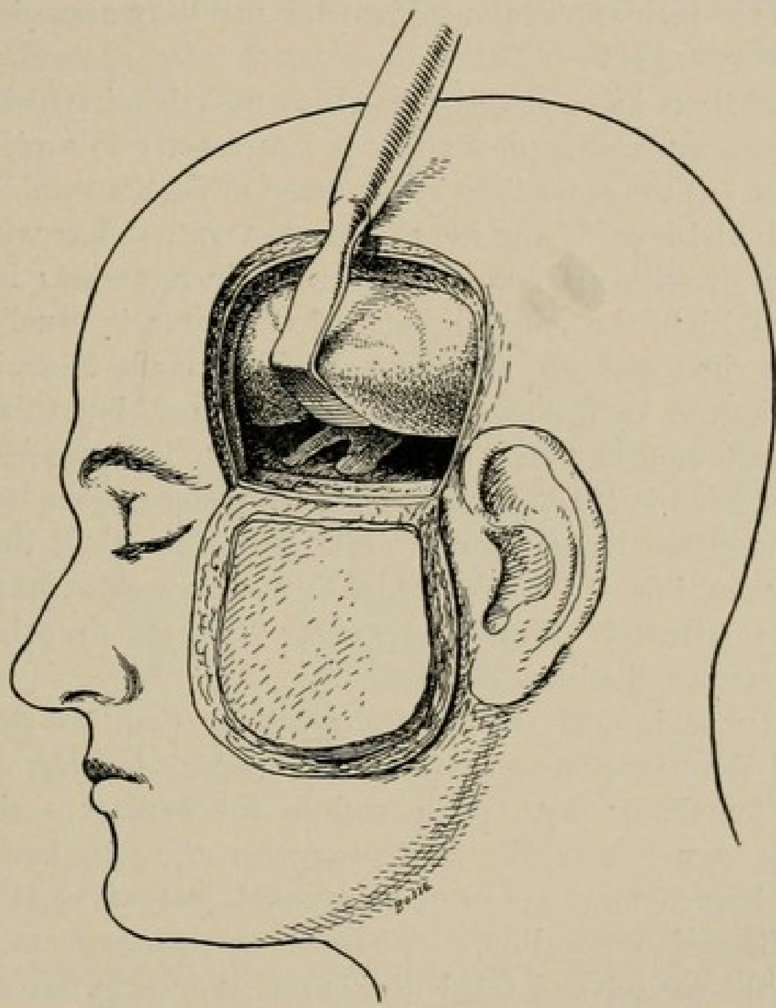

Fig. 66.—Hartley-Krause Operation. Brain within the dura lifted away from floor of middle fossa. The second and third division of the fifth nerve exposed.

rather an advantage. There may be considerable hemorrhage occasioned in isolating and detaching the ganglion, but this may again be controlled by pressure with the gauze pad or by shifting the retractor or allowing the brain to drop back in place upon the bone temporarily. The ganglion should be freed as far back as the superior border of the petrous portion of the temporal bone, so that the operator may be able to see the white trunk of the nerve showing beyond the ganglion. Care should be exercised in freeing the inner part of the ganglion, on account of the proximity of this part of the cavernous sinus and the carotid artery. The operator should finally be able to raise the detached ganglion away from the surface of the bone upon which it rests with the periosteum elevator. Occasionally this surface of bone is absent, and the ganglion is then separated from the carotid artery as it lies in its canal by only a thin, cartilaginous or fibrous layer; therefore one should avoid any roughness during this step of the operation.

The ganglion, being finally free all around, is seized with a long, thin artery clamp, and in doing this it is necessary to avoid catching the dura, etc., at the same time in the grasp of the forceps. The third and second divisions of the nerve are then cut, either with a long thin scissors or with a tenotome close to their foramina; in cuttting the third division, the motor branch of the nerve is usually divided at the same time with it. An effort should be made to avoid cutting the motor branch as the third division is severed, but this is oftentimes difficult and in many cases its division is excusable. When the third division is cut there may be considerable venous hemorrhage from the small meningeal branch which enters the skull through the foramen ovale; this can be controlled by packing temporarily or by shifting the retractor or by allowing the brain to drop back for a few minutes upon the base of the skull.

No attempt is made to isolate or cut the first, the ophthalmic, division of the nerve on account of the danger of doing damage to the third, fourth, or sixth nerve and to the cavernous sinus, and, besides, this branch is readily torn away when the ganglion is twisted out. This branch may, however, be exposed just where it comes off from the Gasserian ganglion.

After the second and third division of the nerve have been severed the ganglion, in the grasp of the long, narrow forceps, is slowly twisted free, tearing it away from the first division and usually bringing away with it a portion of the trunk of the nerve for a greater or less distance beyond the ganglion. Should the cavernous sinus be torn, the hemorrhage is profuse, but this can be controlled by temporarily packing with a strip of gauze and allowing the brain to drop back into place upon the base of the skull.

The bone is finally replaced and the incision in the soft parts closed with suture. A strip of gauze is introduced through the posterior part of the opening in the skull if there is considerable oozing.

This operation may be followed by ulcer of the cornea or conjunctivitis, due to infection or the entrance of dirt which is not appreciated by the patient on account of the loss of sensation in the eye. This may be avoided by bandaging the eye aseptically or sealing it with a watch-crystal.

Ptosis, paralysis of the muscles of the eye, etc., may occur as a result of injury to the third, fourth, and sixth nerves. These complications may be avoided by keeping away from the first division of the fifth nerve and the immediately adjacent third, fourth, and sixth nerves during the course of the operation.

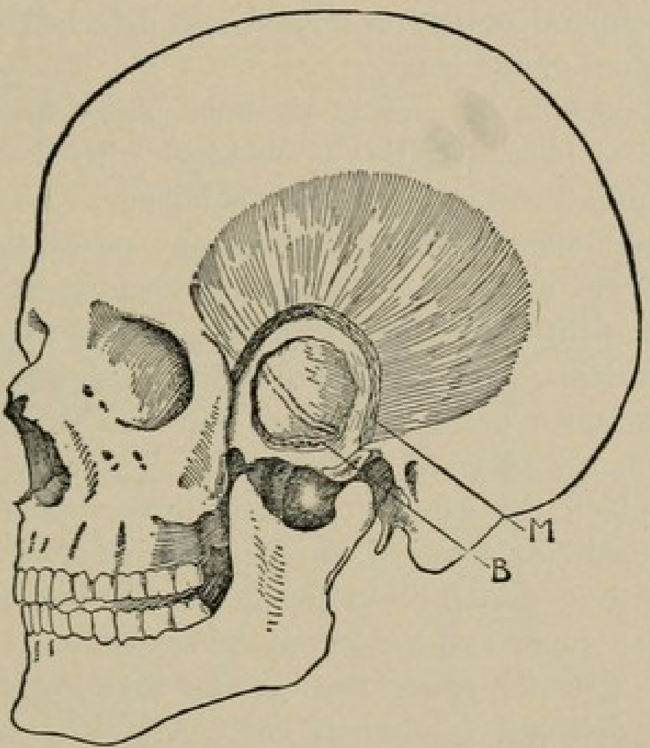

Fig. 67.—Zygomatic Arch Resected (*Cushing*). Opening in lower anterior part of temporal fossa. Dura supporting anterior branch of middle meningeal exposed. *B*, edge of opening in skull; *M*, cut edge of temporal muscle.

The operation may be done in two sittings: first, turning down the osteo-tegumentary flap; second, exposure and removal of the ganglion.

Method of Cushing.—The zygomatic arch is divided and dislocated downward and the ganglion is approached through an opening made in that portion of the great wing of the sphenoid that forms the lower, forward part of the temporal fossa. It is not necessary to divide or ligate the meningeal artery in this operation.

A horseshoe-shaped incision is made upon the side of the head; its base, 4 cm. long, corresponds to the zygoma; its arch reaches upward for a distance of about 5 cm.; the highest part of the incision is just above the pinna of the ear. The flap of skin and fat is detached and reflected downward below the level of the zygoma, in this way exposing the fascia covering the temporal muscle. Concentric to and just inside the skin incision, the temporal fascia is divided. The periosteum corresponding to the outer surface of the zygomatic arch is incised and peeled off the bone, leaving the attachment of the masseter to its under surface intact and the arch then divided with bone-forceps or Gigli saw, both anteriorly and posteriorly, and dislocated downward. Again, corresponding to and inside the skin incision, the temporal muscle is incised and detached downward away from the surface of the bone.

A small opening is made in the bone in the lower anterior part of the temporal fossa, and this is enlarged with the rongeur forceps until an opening 3 cm. in diameter is obtained. The dura mater supporting the middle meningeal artery is thus exposed, the artery passing obliquely forward and upward across the opening in the skull.

The dura with the artery uninjured is raised away from the base of the middle fossa, working inward with the elevator until the location of the foramen ovale is reached. In this situation the dura is found more firmly attached to the bone. The dura mater envelope underneath which the ganglion and its three intra-cranial branches are lodged is split or detached, working from before backward, from the region of the foramen rotundum to the foramen ovale, continuing until the three trunks and the ganglion back as far as its sensory root are exposed. With the periosteum elevator the ganglion and the three branches are detached from their bed. After the second and third trunks, the superior and inferior maxillary branches, have been separated the operator proceeds to separate the first, the ophthalmic branch. This is the innermost of the three and lies in close relation with the cavernous sinus and the sixth nerve. The separation of this branch is commenced behind the ganglion near the sensory root, working forward with the elevator and avoiding the cavernous sinus and the sixth nerve. Finally the ganglion and the three trunks can be lifted free upon the elevator.

The ganglion is grasped behind near its sensory root with a long, thin forceps and raised up out of its bed, and the three branches are then cut close to their foramina, etc., and the ganglion and sensory root twisted free, bringing the ganglion, the three divisions of the nerve, and part of the sensory root away in the grasp of the forceps.

The soft parts are sutured back in place; it is unnecessary to wire the detached piece of zygoma. The eye is protected with a sheet of gutta percha and dressings applied. As a rule, it is not necessary to make any provision for drainage.

Extirpation of the Gasserian Ganglion (Rose-Andrews).—The incision commences at a point near the external angular process,

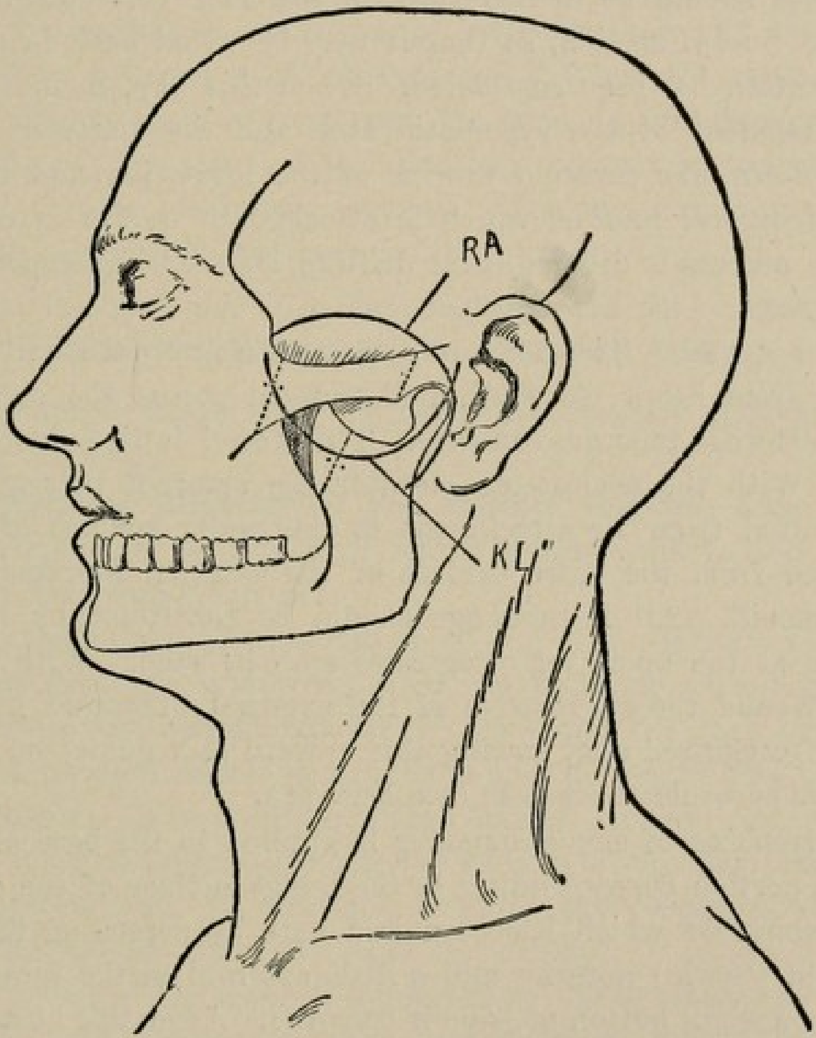

Fig. 68.—Resection of the Gasserian Ganglion, etc. *KL*, Krönlein-Lücke incision; *RA*, Rose-Andrews incision. Dotted lines represent the lines of division through the bones; drill holes for subsequent wiring of the fragments.

curving backward above the zygoma to a point just in front of the ear, whence it extends downward to near the angle of the jaw. This incision penetrates through the skin and fat only, and pains should be taken to avoid injuring the parotid gland, Stenson's duct, and the facial nerve. The temporal artery, as it ascends in front of the ear, may be divided, in which case it will be necessary to ligate it. The flap which is thus outlined is reflected downward sufficiently to expose the zygomatic arch. The temporal fascia is incised along the upper border of the zygomatic arch.

The next step of the operation is the division of the zygomatic arch with the Gigli saw, both in front and behind, and the segment of bone which is thus resected, together with the attached masseter muscle, is then reflected downward. Before dividing the zygomatic arch holes should be drilled through the bone corresponding to the intended line of section, so that it may be wired back in place after the operation has been completed. When this flap, including the detached segment of the zygomatic arch and the masseter muscle, is turned down, the coracoid process of the lower jaw and the tendon of the temporal muscle, which is attached to it, are exposed. The coracoid process is divided, first drilling holes for subsequent wiring, and, together with the attached tendon of the temporal muscle, this is turned upward. There is now exposed the internal maxillary artery passing from below, forward, and upward across the outer surface of the external pterygoid muscle. This vessel is tied double and divided. With the periosteum elevator the external pterygoid muscle is separated from its attachment to the under surface of the great wing and from the outer surface of the external pterygoid plate of the sphenoid. All hemorrhage should be controlled by ligature or pressure as the operation progresses step by step. With the finger in the wound the sharp edge of the external pterygoid plate is felt for and recognized and, tracing this upward as a guide, we feel or see the foramen ovale at its base (see Fig. 74).

A trephine of small diameter is applied to the base of the skull (to the portion corresponding to the under surface of the great wing of the sphenoid which has been laid bare by detaching the external pterygoid muscle) anterior and a little external to the foramen ovale, and here a small button of bone is removed. After this button of bone has been removed the bridge of bone remaining between the trephine opening and the foramen ovale is cut away with a rongeur bone-forceps. The third division of the fifth nerve is seized with a hook and drawn out through the opening in the skull to serve as a guide to the Gasserian ganglion, and then the second division of the nerve is also seized with the hook and pulled out through the same opening. These trunks are both divided and used as guides to the ganglion, which lies in a direction backward and inward from the foramen ovale, within the skull, upon the apex of the petrous portion of the temporal bone. The cut ends of the nerves, still attached to the ganglion, are steadied in the grasp of a long, narrow artery forceps, and with a curette which is introduced through the opening in the skull, the ganglion is destroyed and scooped out.

The technique of this operation is difficult, as it is almost impossible to reach the ganglion. There is liability to profuse hemorrhage which may be extremely difficult to control and also to injury of the Eustachian tube. If the Eustachian tube is injured during the course of the operation, the danger of infection is great. Oozing can be stopped by pressure with a gauze pad. When the operation has been finished, the parts are replaced, the coracoid process being wired to the ramus of the jaw and the detached segment of the zygomatic arch fixed in place with wire sutures. The incision in the skin is closed with a sufficient number of silk sutures.

THE MASTOID REGION AND THE EAR.

The mastoid region and the ear are intimately associated with each other clinically.

The Surgical Anatomy of the Mastoid Region.—The mastoid region is that part of the skull which corresponds to the mastoid portion of the temporal bone.

The integument of this region is thin and contains very little fat; its blood-supply is derived from the posterior auricular artery, which ascends just behind the ear. This vessel lies just anterior to the line of incision which is usually made for operations upon the mastoid antrum. The occipital artery ascends beneath the tendon of the sterno-mastoid muscle and becomes superficial midway between the mastoid process and the external occipital protuberance, whence it is continued upward upon the back of the skull.

The surface of the mastoid is uneven and perforated by a variable number of small vascular openings. At the back part of the mastoid portion, at or just in front of the suture line between it and the occipital bone, there is an opening, the mastoid foramen. Through this a small vein passes into the lateral sinus and a small arterial branch from the occipital artery to the dura mater.

The inner surface of the mastoid portion presents a wide groove, curving from above downward with the convexity forward, which lodges the sigmoid (lateral) sinus. This groove is located about half an inch behind the posterior border of the external auditory meatus, and presents the opening of the mastoid foramen.

The mastoid portion is prolonged below in a teat-like process, the mastoid process. The mastoid process is larger in muscular subjects; it is comparatively small in the child. The structure of this process varies. Its cortex may be thin or may be thick and very hard like ivory. The mastoid process is usually made up of a number of cellular spaces, the pneumatic mastoid, all lined with mucous membrane and communicating through the antrum with the middle ear (tympanum); these reach to the tip of the process and often penetrate beyond the limits of the mastoid process into the occipital bone or zygomatic process or they may extend backward into the mastoid portion proper, pretty close to the groove which lodges the sigmoid sinus, so that there may be but a very thin shell of bone separating the mastoid cells from the sinus. Mastoids vary in different people and upon opposite sides in the same person as to the extent to which these cells are developed. They begin to develop early in life, but the age differs at which they are found fully developed. From five years on they are fairly well marked, and it is said that at the age of fifteen years they are all developed down to the tip of the process. Some say that they do not reach complete development until a few years later. The cellular spaces are all lined with mucous membrane and communicate with each other, and, through the antrum, with the middle ear. The mastoid process may be composed of ordinary spongy bone, or it may be found occasionally very dense and hard, resembling ivory. Occasionally the bone undergoes a process of rarefaction, the septa gradually disappearing and the spaces opening into one another until they are all combined in one large space represented by the antrum. There is always present, even in the newborn, at least one space,—the *antrum*.

The mastoid antrum is a space varying in size from a small pea to a small bean, which is found in the mastoid process just behind and above—on a higher level than—the tympanic cavity. The mastoid antrum communicates with the tympanic cavity through an opening in the upper part of the posterior wall of the tympanum,—the *iter* or *aditus ad antrum*. This passage is partly occupied by the ossicles. The roof of the antrum is formed by the same plate of bone that forms the roof of the tympanic cavity. The antrum is lined with mucous membrane which is continuous with that of the tympanum. The antrum is practically a part of the tympanic cavity and an inflammatory process originating in the tympanum may very readily extend and involve the antrum and adjacent air spaces in the mastoid process.

In the adult the mastoid antrum is found at a depth of from 12 to 18 mm. (½ to ¾ inch) beneath the external surface of the bone. The position of the antrum corresponds externally to the small triangular depression which is found just behind the posterior margin of the external auditory meatus. This little triangular space is called

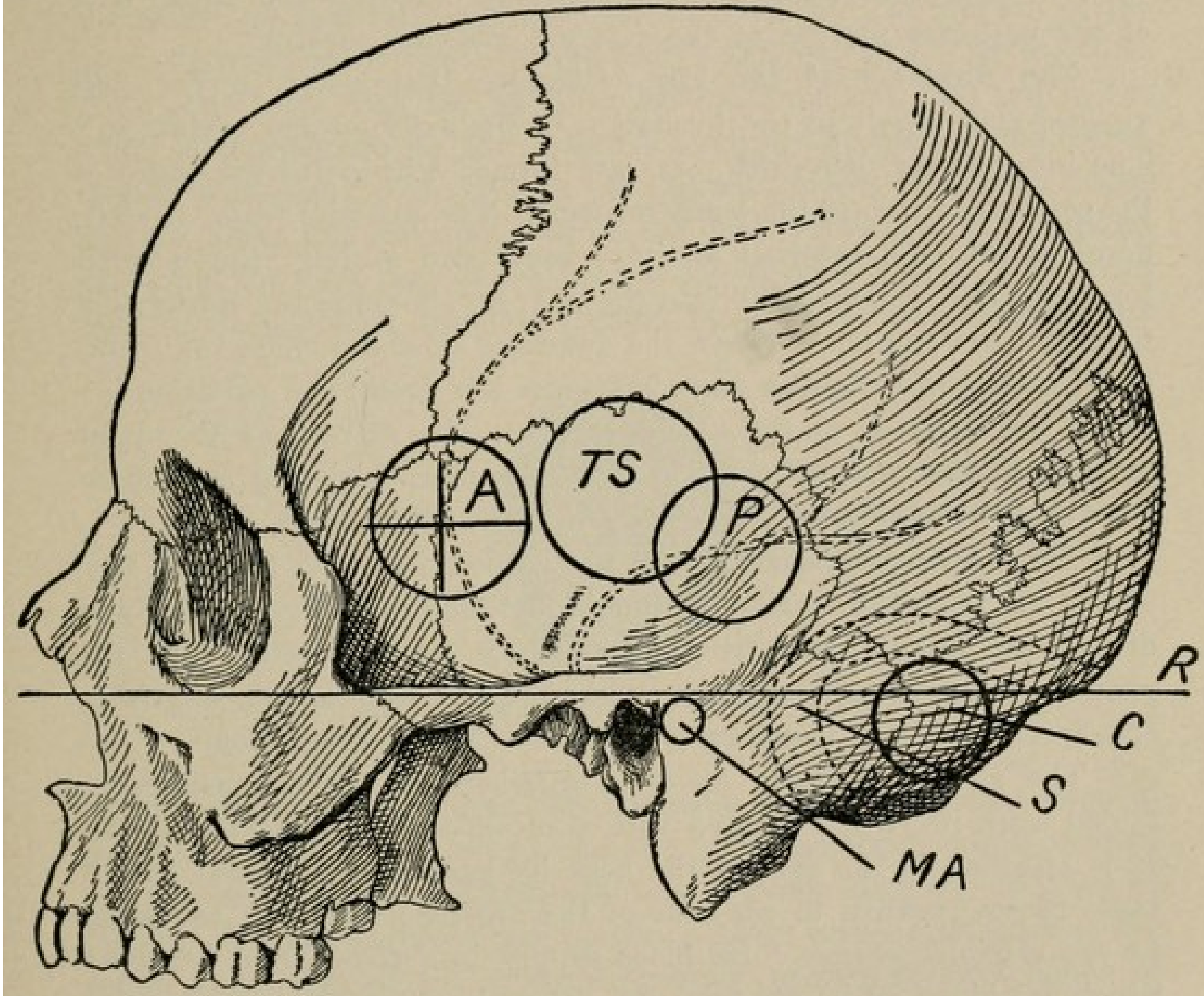

Fig. 69.—Side of Skull. *A*, position of opening in skull to expose the anterior branch of the middle meningeal (Vogt's lines); *C*, position of opening for cerebellar abscess; *MA*, location of mastoid antrum (directly in front of circle *MA* is the spina supra meatum); *P*, opening to expose the posterior branch of middle meningeal; *R*, Reid's base-line continued backward to external occipital protuberance; *S*, dotted lines represent course of lateral (sigmoid) sinus; *TS*, opening in the skull for abscess of the temporo-sphenoidal lobe.

the *fossa mastoidea*. It is bounded above by the line that marks the posterior root of the zygoma, anteriorly by the posterior margin of the external auditory meatus; the third side of the triangle may be supplied by drawing a tangent upward and backward from the lower posterior portion of the margin of the external auditory meatus. The posterior margin of the external auditory meatus is marked above by a spine, the *spina supra meatum*, or spine of Henle. This spine is readily recognized after the soft parts have been incised and separated from the bone, and is a very useful landmark in locating the level of the antrum, etc.

In very young children the antrum is comparatively large and very close to the surface of the bone, just behind the upper part of the posterior margin of the external auditory meatus.

The Anatomy of the Ear.—Changes that occur in the first visceral cleft result in the formation of the external and middle ear. The internal ear, labyrinth, etc., are formed within the substance of the petrous portion of the temporal bone. The external fossa, or cleft, develops into the external auditory canal and auricle; the internal fossa, or cleft, which opens into the pharynx, becomes the Eustachian tube and tympanum. Where the funduses of these clefts, or fossæ, meet, their walls coalesce and thus form the drum, the partition between the external and the middle ear. The margin of the outer opening of the external cleft, or fossa, becomes thickened and nodulated, and these nodules, coalescing, form the external ear.

The hearing apparatus may be divided into the external ear, which includes the auricle (pinna), external auditory canal, and drum; the middle ear, tympanum, which communicates with the pharynx through the Eustachian tube; and the internal ear, labyrinth, etc., inclosed within the petrous portion of the temporal bone.

The auricle is made up of a cartilaginous plate considerably folded upon itself and covered with skin; it consists of several parts. It is attached to the side of the head by ligamentous bands; one of these passes forward to the root of the zygoma; the other backward to the mastoid process. Its blood-supply is derived from branches which are given off by the temporal artery in front and the posterior auricular behind. The supply is very abundant, and therefore wounds of the ear heal kindly.

The external auditory canal is about one inch (24 mm. Trölsch) in length; its outer portion, comprising one-third of its length, is cartilaginous and continuous with the auricle; the inner part, comprising two-thirds of its length, is bone. The course of the canal is transverse, but it suffers two curves: one, in its cartilaginous part, with its convexity forward; the second at the junction of the cartilaginous and bony parts, with its convexity backward; this junction is the narrowest part of the canal, and is called the isthmus.

To expose the drum, the auricle is drawn upward, backward, and outward away from the side of the head.

In the newborn child there is no bony portion to the external auditory canal, this part being represented only by a ring of bone into which the drum is fitted. This bony ring, the auditory process, is incomplete, and is applied against the depressed, hollowed-out under surface of the squamous portion of the temporal, which thus completes the ring. At this early age the drum is very near the surface of the body, there being no depth to the bony auditory canal. As the child grows, the bony ring, the auditory process, broadens out, and in the adult is represented by the external auditory process, which corresponds to its outer edge, and by the vaginal process, this latter forming the lower and anterior wall of the bony portion of the auditory canal and the back part of the floor of the glenoid cavity. The upper wall of the auditory canal is formed by the grooved under surface

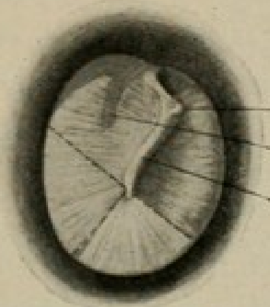

Fig. 70.—Right Membrana Tympani Viewed through the Auditory Canal.

of the squamous portion of the temporal bone. The outer edge of the auditory process is rough and the upper posterior angle presents a spine, usually well marked,—the *spina supra meatum,* or spine of Henle. The cartilaginous part of the auditory canal is attached to the rough outer edge of the external auditory process by firm bands of connective tissue.

The skin which lines the interior of the auditory canal is continuous with that which covers the surface of the drum.

The bony part of the external auditory canal is in relation, above, with the middle fossa of the skull, from which it is separated by a thin, cellular plate of bone, part of the squamous portion of the temporal; behind, it is in relation with the mastoid system of cells, and, in front, with the condyle of the lower jaw and the parotid gland.

Blows upon the chin may be transmitted through the lower jaw to the condyle, and in this way may injure the auditory canal, so that there may be an issue of blood from the external auditory meatus.

Purulent processes involving the auditory canal may present cerebral complications, especially in children, without the middle ear being involved, the infecton in these cases passing through the roof of the auditory canal directly into the cavity of the skull.

The drum is the septum between the external and the middle ears. It is made up of skin externally, and, internally, of the mucous membrane of the tympanum; interposed between those two is a layer of connective tissue. The drum is set in a bony ring, and forms the greater part of the external wall of the tympanum. It is set obliquely and in such a way that its outer surface looks downward, forward, and outward; the anterior wall of the external auditory canal is thus longer than the upper, posterior wall.

The drum, viewed through the external auditory canal, is grayish in color. At the upper anterior part, close to the periphery, is a whitish point corresponding to the position of the short process of the malleus. Passing downward and backward from this point is a slight elevation corresponding to the handle of the malleus. The handle of the malleus is firmly attached to the inner surface of the drum, and tends to draw it inward, thus presenting a concave surface to the auditory canal. The deepest part of this surface corresponds to the lower end of the handle of the malleus and is called the *umbo membranæ*. The long process of the incus may be seen posterior to the upper part of the handle of the malleus if the drum is quite transparent. A line continued downward and backward in the direction of the handle of the malleus, and another line drawn at right angles to the former and upon a level with the umbo, serve to divide the drum into four quadrants. Paracentesis of the drum is performed in the lower, posterior quadrant.

The Middle Ear consists of the tympanum and adjoining air-cells and the Eustachian tube.

The tympanum is a wedge-shaped cavity separated from the external auditory canal by the drum and communicating by an opening in its anterior end, through the Eustachian tube, with the pharynx. In the anterior part is also seen the Glaserian fissure, through which the middle ear communicates with the glenoid cavity and through which the chorda tympani leaves the tympanum. The upper part of the tympanum, the portion above the level of the membrana tympani, is called the attic. In this space the ossicles are lodged.

The carotid artery, surrounded by a venous plexus, traverses a canal, in the temporal bone, which is located just in front of the tympanum and which is separated from this cavity by a very thin

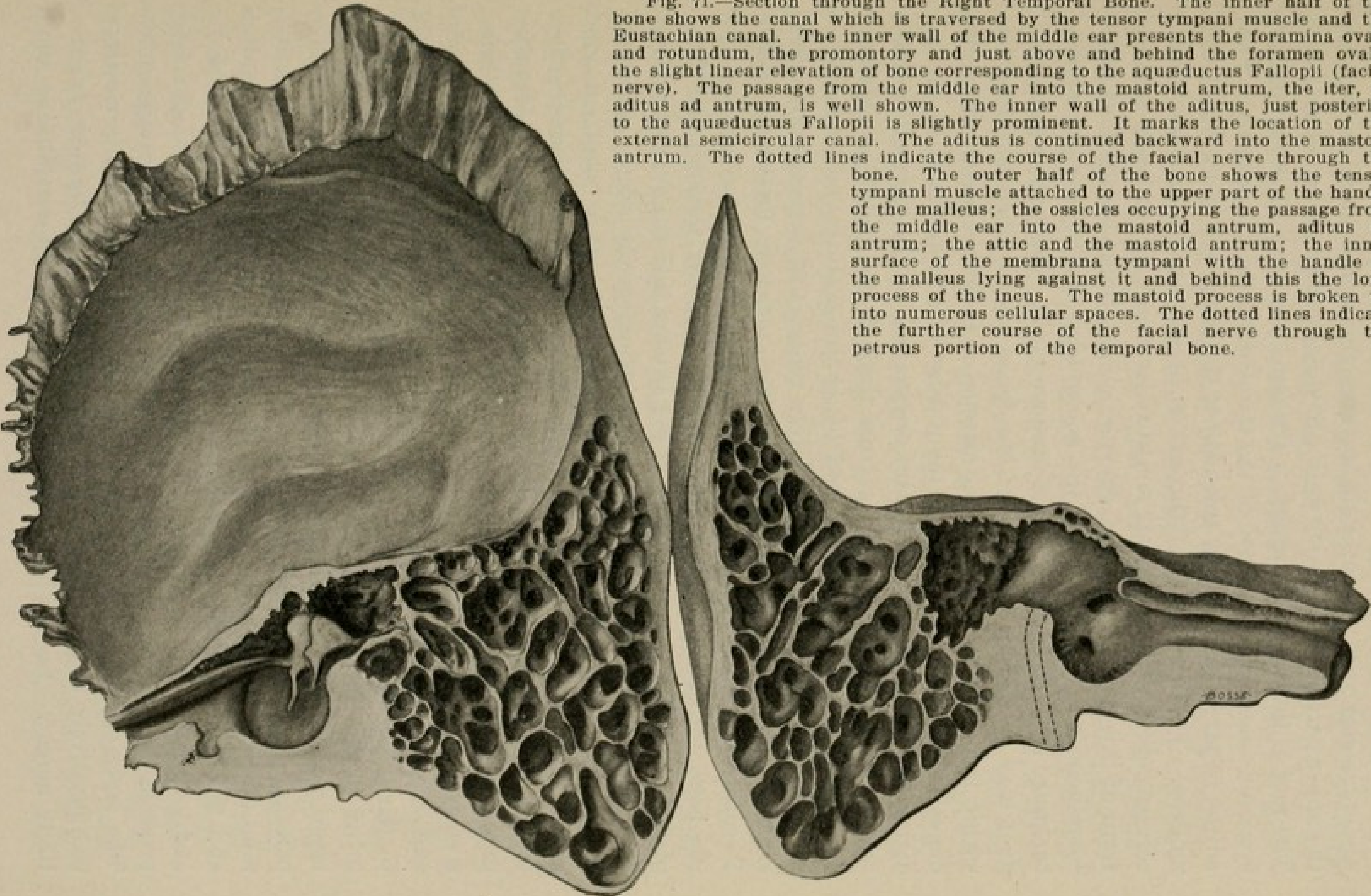

Fig. 71.—Section through the Right Temporal Bone. The inner half of the bone shows the canal which is traversed by the tensor tympani muscle and the Eustachian canal. The inner wall of the middle ear presents the foramina ovale and rotundum, the promontory and just above and behind the foramen ovale, the slight linear elevation of bone corresponding to the aquæductus Fallopii (facial nerve). The passage from the middle ear into the mastoid antrum, the iter, or aditus ad antrum, is well shown. The inner wall of the aditus, just posterior to the aquæductus Fallopii is slightly prominent. It marks the location of the external semicircular canal. The aditus is continued backward into the mastoid antrum. The dotted lines indicate the course of the facial nerve through the bone. The outer half of the bone shows the tensor tympani muscle attached to the upper part of the handle of the malleus; the ossicles occupying the passage from the middle ear into the mastoid antrum, aditus ad antrum; the attic and the mastoid antrum; the inner surface of the membrana tympani with the handle of the malleus lying against it and behind this the long process of the incus. The mastoid process is broken up into numerous cellular spaces. The dotted lines indicate the further course of the facial nerve through the petrous portion of the temporal bone.

plate of bone that is, at times, perforated. Behind, the tympanum communicates with the mastoid antrum through a short passage in the upper part of its posterior wall, called the *iter* or *aditus ad antrum*. The roof of the aditus is formed by the same thin plate of bone, tegmen tympani, that forms the roof of the tympanum and the antrum. The aditus is partly occupied by the body of the incus and the head of the malleus. The inner wall of the aditus presents an eminence of bone corresponding to the external semicircular canal. Just below and in front of this there is a second, smooth, curved, linear elevation of bone corresponding to that part of the aquæductus Fallopii, which arches backward and downward over the foramen ovale. The wall of the aqueduct may be thin or absent, and the facial nerve which is contained within it may thus readily become affected in inflammation of the middle ear. The aditus will permit the passage of a probe about ½ cm. in diameter. Inflammatory processes originating in the tympanum may readily extend to the mastoid antrum through the aditus ad antrum. The passage may become blocked by swelling of the mucous membrane, and the presence of granulation tissue, and drainage from the antrum into the tympanum may be thus seriously interfered with. Purulent material imprisoned in the antrum may cause necrosis of the bone and may spread to the sigmoid sinus or through the thin plate of bone that forms the roof of the antrum into the cranial cavity. The inner wall of the tympanum, that opposite the drum, presents, toward the front, the promontory; behind this, two openings, one above, the foramen ovale, and another below and a little behind, the foramen rotundum. The labyrinth is located beneath the inner wall, in the petrous portion of the temporal bone. This inner wall presents a smooth, curved ridge above the foramen ovale which runs backward and downward toward the back of the tympanum; it corresponds to the position of the Fallopian canal which lodges the facial nerve in its course through the petrous portion of the temporal bone. The layer of bone which separates the nerve from the cavity of the tympanum is sometimes very thin or perforated. The tympanum communicates with the posterior fossa of the skull through the labyrinth and the internal auditory canal, which is traversed by the facial and auditory nerves. The bulb of the jugular vein is lodged in the depression in the temporal bone beneath the floor of the tympanum. The layer of bone which forms the floor of the tympanum is usually comparatively thick, though it may be very thin, perforated, or entirely absent. In the latter case the mucous membrane lining the floor of the tympanum and the wall of the internal jugular vein would be in direct contact with each other. Through small openings in the floor of the tympanum, Jacobson's nerve, a branch from the glosso-pharyngeal, and some small arterial and venous branches enter the tympanum.

The roof of the tympanum, the most common link between disease of the ear and intracranial complications, is a thin, cellular plate of bone; it may be very thin, perforated, or entirely absent. This plate of bone reaches from the petrous portion of the temporal bone over to the inner surface of the squamous portion, where a suture line, petroso-squamous, exists. In the child this suture line is open and contains a process of dura mater which joins with the mucous membrane lining of the tympanum and carries blood-vessels which take part in the supply of both these membranes. This condition, although not so visible, continues to exist in the adult. This same thin layer of bone, which forms the roof of the tympanum, reaches backward and forms also the roof of the mastoid antrum. The roof of the tympanum and antrum forms part of the floor of the middle fossa of the skull, and is in relation with the dura mater, etc., and with the temporo-sphenoidal lobe of the brain.

The course of the facial nerve through the temporal bone and its relation to the tympanum and the mastoid antrum are important. The nerve enters the internal auditory canal in company with the auditory nerve, and passes in a direction forward and outward, reaching the inner wall of the middle ear, tympanum, just above the foramen ovale; here it makes a turn and runs backward and downward in the aquæductus Fallopii. The course of this canal is indicated by a prominent linear elevation upon the inner wall of the tympanum just above the foramen ovale; at the back of the tympanum, the nerve, as it curves downward and still contained within the aquæductus Fallopii, is situated but a short distance in front of the antrum. It continues its course through the substance of the petrous portion of the temporal bone, emerging, externally, upon the base of the skull, through the stylo-mastoid foramen. This foramen is located internal to, and a little in front of, the base of the mastoid process. Just before the facial nerve emerges from the stylo-mastoid foramen and while still contained within the canal, it gives off a branch, the chorda tympani, which passes forward and upward through a separate canal in the petrous portion, and enters the tympanum through an opening in its posterior wall, near the drum; it runs forward through the tympanic cavity, being covered by mucous membrane, and escapes through the Glaserian fissure, a slit in the anterior part of the floor of the tympanum, into the glenoid cavity.

The stylo-mastoid artery, derived from the posterior auricular, enters the stylo-mastoid foramen to supply the facial nerve and also the mucous membrane of the tympanum.

The Eustachian tube reaches from the tympanum to the pharynx; its outer one-third is bony; its inner two-thirds, cartilaginous. Where these join, the tube is narrowest: the isthmus. The tube opens into the anterior end of the tympanum, near the drum; its inner end opens into the pharynx above the soft palate and just behind the posterior border of the inferior turbinated bone. The walls of the cartilaginous portion of the tube are usually in contact and the tube is thus closed. To ventilate the tympanum, muscular action, which will open the pharyngeal end of the tube, is required. This is accomplished by the muscles of the soft palate: the tensor and the levator palati.

OPERATIONS UPON THE MASTOID, ETC.

Paracentesis of the Drum Membrane.—Incision of the drum membrane for the purpose of evacuating pus from the middle ear. If this operation is done early enough it will prevent most cases of acute middle-ear disease from going on to involvement of the mastoid antrum, etc. By means of direct or reflected light the drum is brought into view and incised. The incision is made with the narrow-bladed knife in the lower posterior quadrant of the drum and should be sufficiently large to permit of free drainage. The incision in this part of the drum is least likely to damage important structures.

Wilde's Incision.—This consists of a simple incision through the soft parts, including the periosteum, down to the bone. It is placed 1 cm. behind and parallel with the auricle, and reaches from the base of the mastoid process to its apex. Usually no vessels are cut and it is not necessary to apply any ligatures. It is often sufficient in very young children.

To Open into and Drain the Antrum.—This operation is indicated in cases of acute mastoid disease. The patient is placed with the head upon the side resting upon a thin sandbag.

Regardless of any condition that may complicate mastoid disease, the first step should always consist in freely opening and draining the mastoid antrum.

An incision is made 1 cm.—$^1/_3$ inch—behind the attachment of the auricle, through the soft parts, including the periosteum, down to the surface of the bone, and reaching from the base of the mastoid to its tip. In this incision we do not meet the posterior auricular artery; this vessel lies just anterior to the line of incision and, as a rule, no vessels that require ligation are divided. With the periosteum elevator the soft parts, including the periosteum, are separated from the surface of the bone, exposing a considerable area of the surface of the mastoid process. The soft parts are retracted with broad, sharp retractors, the ear and anterior edge of the incision being drawn well forward, and search made for the spina supra meatum, the spine of Henle, which is the guide to the location of the mastoid antrum. The antrum is situated one-half to three-quarters of an inch beneath the surface of the bone, and its position corresponds to the little triangular depression which is found just behind the posterior margin of the external auditory meatus, spine of Henle. The surface of bone, which has been thus laid bare, may be soft, discolored, and may further present the orifice of a fistula, or it may be firm and apparently healthy or thickened, sclerosed, and ivory-like. If the first condition exists,—that is, if the bone is softened, carious, etc.,—one may easily gouge it away with a strong, sharp scoop, continuing thus until the antrum is reached. If the surface of bone which is exposed is not softened, carious, it will be necessary to make an opening through the cortex and substance of the bone down into the mastoid antrum. In cutting through the bone into the antrum we commence by using a broad chisel or gouge,—they vary in width from 2 to 8 mm.,—chipping the bone out in the form of a circle at least three-fourths inch in diameter. This excavation is carried deeper into the substance of the bone, in a direction inward and slightly forward and downward. Working parallel with, and close to, the posterior wall of the auditory canal, we must necessarily enter the antrum. As we progress, narrower chisels or gouges may be used and the opening made smaller in diameter. We continue thus, occasionally sounding with the probe, until the antrum is entered, at a depth corresponding to the depth of the auditory canal. The antrum may contain only a few drops of pus. During this part of the operation the field must be kept clear of blood and chips of bone with a stream of salt-water or by sponging. A funnel-shaped excavation, extending through the substance of the mastoid, is thus made, the base of the opening corresponding to the external surface of the bone and its narrow end to the antrum. The base, or external orifice, of this canal should be sufficiently large to allow of convenient work in its deeper part.

After the antrum has been opened the cortex is gouged away down as far as the tip—this may be conveniently done with the rongeur—in order to expose and drain these most dependent cells. The bone is then explored with the probe and search made for sinuses, soft, carious bone, etc. All diseased bone is gouged away with the curette. Fistulæ may lead into the auditory canal or into the cranial cavity. They should be explored, laid open, and scraped with the curette. At times the cells may be followed backward as far as the thin shell of bone that covers the sigmoid sinus, or inward into the jugular process of the occipital bone, or forward into the root of the zygoma.

When the antrum has been opened a bent probe may be introduced and carried forward through the aditus into the tympanum. This should be done in a gentle manner so as not to injure the ossicles. The drum is usually already perforated and fluid, peroxid, introduced into the antrum with the syringe will escape in part through the ear if the opening from the antrum into the tympanic cavity is not blocked by swelling of the mucous membrane, etc. After irrigating, a thin strip of iodoform gauze is packed into the excavation in the mastoid, reaching into the antrum, and the edges of the soft parts drawn together in part with several interrupted sutures.

In order to avoid accidental opening into the sigmoid sinus, the base, the commencement, of the cone-shaped canal which is chiseled through the bone into the antrum, is placed anterior to the location of the sinus; and as we proceed deeper into the substance of the bone we work in a direction forward, downward, and inward, so that there is no danger of injuring the sinus, as it lies behind the most posterior part, base, of this excavation in the bone, and as we proceed deeper into the substance of the bone we get farther away from the sinus. It is of but little consequence if the sinus is exposed, but one should avoid accidentally perforating the dura and wounding it. If the sinus is opened, the hemorrhage which results may be controlled by packing strip gauze into the wound, between the edge of the bone and the sinus. Air may be sucked into the sinus if it is opened, but this is not accompanied by any danger (Schwartz). Accidental opening into the middle fossa of the skull is avoided by commencing the channel in the bone below the level of the upper margin of the external auditory meatus, below the spina supra meatum, and, as we proceed, working in a direction rather downward. The floor of the middle fossa will thus lie above the base of the cone-shaped canal which is made in the bone. Simple exposure of the dura is not of any serious consequence.

If one does not chisel beyond the antrum, there is but little danger of the injuring the external semicircular canal, the facial nerve or the inner wall of the tympanum (labyrinth). The facial

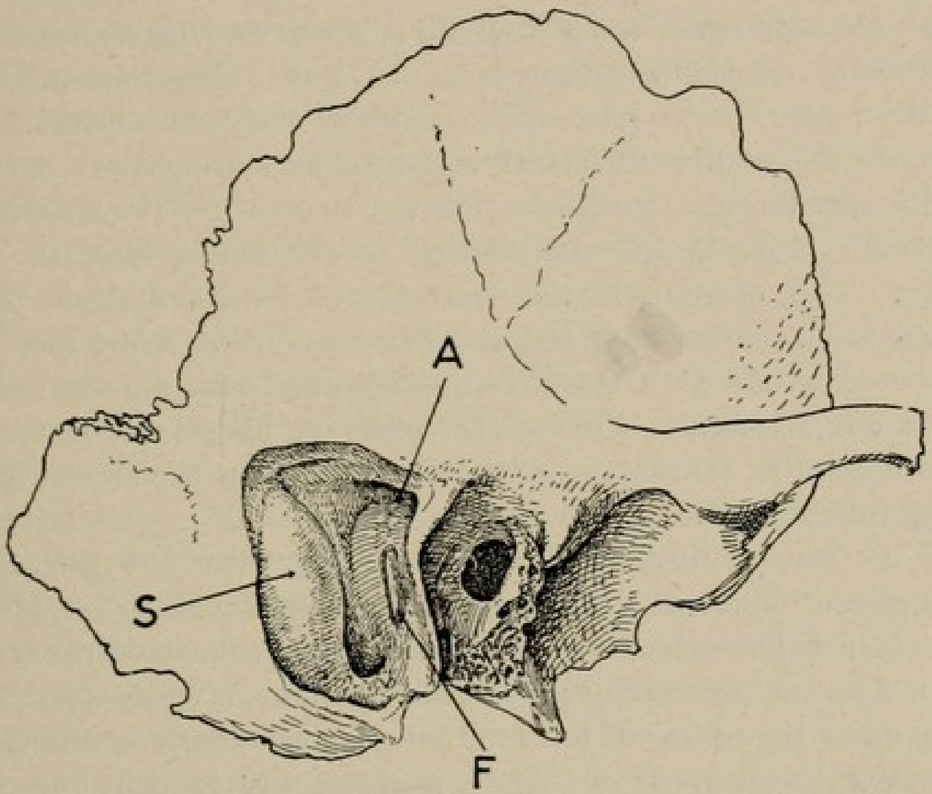

Fig. 72.—Simple Mastoid Operation. As indicated in the illustration, the operation has been extensively carried out. Practically the entire cancellous substance of the mastoid process has been chiseled or gouged away. Behind, *S*, the location of the sigmoid sinus, covered with a thin shell of bone, is seen. Above, *A*, the antrum has been laid freely open. *F* shows the course of the facial nerve which has been purposely uncovered in order to show its position in relation to the operation.

nerve, contained within the Fallopian tube, lies rather deeper than the antrum and anterior to it, in the inner wall of the tympanum. If one penetrates to a depth of 2 cm. or more, there is then danger of getting beyond the antrum, into the tympanic cavity, and injuring the semicircular canal, the facial nerve, or the labyrinth.

In gouging away the cancellous tissue of the mastoid process inward, forward, and downward toward the tip (from the level of the antrum to the tip), there is danger of uncovering the facial nerve (see Fig. 72). Care should be exercised, in this part of the operation, to avoid injuring it.

For Thrombosis of the Sigmoid Sinus.—The sigmoid sinus is encountered about one-half to three-fourths inch posterior to the bony auditory canal (spina supra meatum).

One should always, as a preliminary step, open into the antrum as described above and from here start out to investigate the sinus, etc. After the antrum has been opened an incision is carried backward parallel with the superior curved line of the occipital bone, through the soft parts, for a distance of about two inches, and with the chisel or rongeur the bone is removed in a direction backward until the region of the sinus is reached and the dura exposed. The opening in the skull is sufficiently enlarged by cutting away its margin with the rongeur forceps, so that the sinus is freely exposed and an opening made in the skull which is sufficiently large to work through. This opening in the skull should have a diameter of at least one inch. Oftentimes pus and granulation tissue are met with just as soon as the dura is exposed,—extradural abscess,—and if the sinus is not diseased it will not be necessary to proceed farther, it being sufficient to curette and drain the parts about the sinus without opening into the latter.

If the sinus is thrombosed, it will appear firm and prominent, and in case of doubt an aseptic aspirating needle may be introduced. If pus is not present in the sinus and the needle withdraws fluid blood it does not necessarily prove that the sinus is unaffected. Tenderness along the course of the internal jugular, etc., is an indication for opening the sinus. If in doubt it is always wise to incise the sinus, as this is not accompanied by any special danger.

If it is decided to open the sinus this should be done by making an incision corresponding to its long diameter, with a sharp, narrow-bladed knife. If a clot is found, this should be curetted away first from the jugular end down to the bulb,—if necessary, removing more bone with the rongeur,—until there is a free flow of blood: good, free bleeding tends to wash out any remaining portions of clot. This bleeding may be readily controlled by packing a small strip of gauze into the space between the sinus and the adjoining bone. This flow of blood does not necessarily prove that there is not a clot in the jugular vein beyond the bulb: blood may flow around from the inferior petrosal sinus. This procedure is repeated in the other direction—*i.e.,* toward the torcular—until hemorrhage is established;

this may then be controlled in a similar manner. It may be well, after the hemorrhage has been controlled, to remove the packing and freely irrigate the sinus with normal salt solution.

Before opening the sigmoid sinus the internal jugular vein, the facial vein, etc., may be exposed in the neck and tied; or the internal jugular in its entirety and including all its branches may be resected through an incision made along the anterior border of the sterno-mastoid muscle after first having tied the vessel below, at the clavicle, and, above, near the bulb (avoid the pneumogastric nerve). This procedure is indicated especially if tenderness and induration are present along the course of the internal jugular vein—along the anterior border of the sterno-mastoid muscle. The incision and the method of exposing the internal jugular vein are quite similar to those described for ligation of the common carotid artery. If the internal jugular vein has not been tied, it may be compressed in the neck, during the operation, to prevent the passage of dislodged clots.

Besides the condition described, we may find an opening leading through the dura mater to a collection of pus beneath the dura or within the cerebellum; these purulent collections may also be present without thrombosis of the sinus or without a fistulous opening in the dura. All fistulous openings should be thoroughly explored and treated as the condition indicates.

For Cerebellar Abscess.—The opening in the skull may be made with a trephine or chisel. Usually the antrum and sinus have already been explored, and the opening in this case may be simply extended backward with the rongeur. The center of the opening in the skull for cerebellar abscess should be located two inches behind the external auditory meatus and should be placed below a line drawn from the upper margin of the external auditory meatus to the external occipital protuberance (see Fig. 69). The opening in the bone is thus placed below the superior curved line of the occipital bone, and we enter therefore below the attachment of the tentorium cerebelli and below the course of the lateral sinus. The bone is here very thin, and the opening may be readily enlarged to any necessary extent with the rongeur. A good free opening should be made in the skull. Pus may be found between the dura mater and the bone, extradural abscess, and one may discontinue the operation at this stage, pack and await the result; or there may be a fistulous opening in the dura leading to a deeper, purulent collection. In this case the fistulous opening in the dura is enlarged and the operation continued. If there is no fistulous opening in the dura, the dura is incised around and fairly close to the margins of the opening in the skull, and the flap of dura then reflected, thus exposing the surface of the brain. The brain shows signs of tension, absence of pulsation, and a tendency to bulge. Strip gauze is packed into the subdural space, between the dura mater and pia-arachnoid. The abscess may be quite superficial, its location quite obvious, and may be incised at once. The abscess may be deep-seated, and it may be necessary to search for it with the aspirating needle. A fairly large needle, with a calibre 2 mm. in diameter, is used. If the pus is thin it will escape through the needle without using the syringe. If pus does not appear through the needle the syringe is applied and suction made, at the same time slowly withdrawing the needle. The pus may be so thick that it cannot be withdrawn by aspiration, and it may be necessary to make an incision into the suspected area with the knife before the pus is discovered. If the pus is located with the needle, then, without withdrawing the needle, a thin-bladed artery forceps is introduced down alongside the needle into the abscess cavity and the opening then sufficiently enlarged by spreading the forceps so as to obtain an opening sufficiently large to admit the little finger. It is not advisable to irrigate the abscess cavity, nor should its wall be curetted. The cavity is loosely packed with strip gauze. The opening in the dura is closed except where the drain emerges.

For Extradural Abscess in the Middle Fossa.—There may be an abscess located between the dura mater and the bone.

If the mastoid antrum has already been explored a fistula may be found leading through the roof of the antrum or tympanum into the middle fossa. The incision, which has already been made and through which the mastoid antrum has been opened, is prolonged from the base of the mastoid in a direction upward and forward over the ear, dividing the temporal vessels and the temporal muscle. With the rongeur bone-forceps or chisel, the bone is cut away so that the middle fossa may be entered just above and in front of the external auditory meatus; here we work in between the tegmen tympani and the dura mater, where the abscess is usually located. The pus is evacuated and the abscess cavity packed with strip gauze and drained.

For Temporo-sphenoidal Abscess.—Associated with the extradural abscess we may find an abscess in the temporo-sphenoidal lobe, and there may be a fistula leading through the dura and communicating with such a collection. In this case the fistula should be followed, enlarging the opening in the dura, evacuating and draining the abscess.

A temporo-sphenoidal abscess may be present without an extra-dural abscess. If the mastoid antrum has already been explored, etc., the incision that has already been made for that purpose may be extended upward and forward over the ear, as described in the preceding operation, and sufficient bone gouged out with the rongeur, proceeding from the opening mastoid, to expose the temporo-sphenoidal lobe of the brain.

Independently of the mastoid operation a button of bone may be removed with the trephine from the side of the skull and the opening enlarged with the rongeur. The center of the opening thus made should be one and one-fourth inches above and one inch behind the external auditory meatus (see Fig. 69). The portion of bone removed corresponds to the area indicated by K^2 L N M, Fig. 42. The temporo-sphenoidal lobe may also be exposed by turning down an osteo-tegumentary flap in the temporal region (see "Ligation of the Middle Meningeal Artery").

After the dura has been exposed and incised and the subdural space packed with a strip of gauze, we are ready to open the abscess if it is superficial, or search for it, etc., if it is deep, as described in the operation for "Cerebellar Abscess."

If the osteo-tegumentary flap method of exposure has been used it will be necessary to gouge away a corner of the bone segment to permit the exit of the drain.

THE FACE.

Surgical Anatomy of the Face.—The skin of the face is soft, thin, and intimately united to the underlying muscles and connective tissue, and cannot be pinched up without including these deeper layers. The subcutaneous tissue of the face is widely meshed, and within these meshes there is contained much fat. Those parts of the face where the fat is absent from the subcutaneous layer are loose and flaccid,—for example, under the eyes,—and become marked early in life by wrinkles. These parts also readily become swollen and distended in dropsical conditions. In this layer are contained the muscles of expression and the vessels and nerves.

The facial artery is the chief source of supply to the face. It is a large vessel derived from the external carotid. It pursues a tortuous course, upward and forward, across the side of the face, from the anterior border of the masseter to the angle of the mouth, and then, as the angular, continues upward alongside the nose, anastomosing at the inner canthus with a branch of the ophthalmic. Just below the corner of the mouth the facial gives off a branch, the inferior labial, for the supply of the lower lip; those from either side anastomose. At the corner of the mouth the facial gives off the inferior and superior coronary. These branches pass inward, lying a little beyond the edge of either lip and situated beneath the mucous membrane: between it and the muscular structure of the lip. Those from either side anastomose freely with their fellows.

The facial vein, which accompanies the artery, is not tortuous, and lies superficial to the artery.

The facial nerve supplies the muscles of expression, etc., and the buccinator. It emerges from the parotid gland upon the side of the face at a point corresponding to the lower border of the lobe of the ear, and divides into branches which supply the facial muscles and the platysma (see page 138). The sensory supply to the face and teeth is derived from the fifth nerve.

The Skeleton of the Face.—The upper part consists of the superior maxillary and the adjoining bones with which it articulates and which serve to join it to the skull; it articulates, toward the middle line, with the nasal bones which form the bridge of the nose and laterally with the malar. The malar bone forms the prominent part of the cheek and gives off a process which passes backward and unites with a similar process from the temporal to form the zygomatic arch.

The body of the superior maxillary is pyramidal, its base being directed inward toward the nasal cavity, forming part of its outer wall and presenting the opening into the antrum of Highmore; its apex corresponds to its junction with the malar. The upper surface of the superior maxillary is thin and forms the floor of the orbit. Its anterior or facial surface is very thin in places and easily perforated; it is rather concave, and just below the margin of the orbit presents the opening of the infra-orbital canal. A line drawn from the supra-orbital notch straight downward to a point between the two lower bicuspid teeth, called Holden's line, crosses the infra-orbital foramen one-quarter inch below the inferior margin of the orbit and the mental foramen midway between the upper and lower borders of the inferior maxilla. These foramina give exit to the corresponding branches of the fifth nerve, which it may be desirable to reach in severe neuralgia. A canal descends, as an offshoot from the infraorbital canal, through the anterior wall of the bone; it transmits a nerve-branch which supplies the upper front teeth. The posterior, or zygomatic, surface of the superior maxilla looks backward and outward toward the zygomatic fossa; it gives origin, in part, to the external pterygoid muscle, and is in close relation with the termination of the internal maxillary artery. This surface presents the commencement of the superior dental canal for the transmission of the superior dental nerve to the upper back teeth.

The body of the bone is hollowed out. The space within, known as the antrum of Highmore, communicates with the nasal cavity through an opening into the middle meatus, and is lined with mucous membrane, which is continuous with that of the nose. The walls inclosing the antrum are thin, but strengthened by columns of bone which ascend from the tooth sockets and converge toward the apex, malar process; in this way the bone is strengthened and the shock of blows distributed. The alveolar process is solid and presents the sockets for the teeth. The palate process, projecting inward, joins with its fellow of the opposite side, and together with the horizontal plates of the palate bones forms the hard palate: the floor of the nasal, and the roof of the buccal, cavity.

The periosteum covering the upper jaw is thin and closely attached to the surface of the bone. It is rather more easily separated from the orbital and facial surfaces.

The lower part of the face is composed of the inferior maxillary, which consists of a body and two rami and which is attached to the skull through the temporo-maxillary articulations. The body of the bone is horseshoe-shaped, presenting an upper border, with sockets for the teeth, and a lower rounded border, which may be felt beneath the integument.

To the inner surface of the body of the inferior maxillary are attached the muscles which form the floor of the mouth, and in front, at the symphysis, are attached the muscles which draw the tongue forward and prevent its dropping back into the pharynx.

The ramus is a perpendicular plate of bone with an upper curved border which presents, in front, a thin, pointed process, the coracoid, to which is attached the tendon of the temporal muscle, and, behind, a rather thickened process, the condyle. The upper surface of the condyle is rounded and smooth, for articulation with the glenoid cavity. Below the articular surface there is a rather constricted portion, known as the neck. To the front surface of the neck of the condyle is attached the tendon of the external pterygoid muscle. The lower posterior corner of the ramus is a prominent landmark, and is called the angle of the jaw. The outer surface of the ramus is covered by the masseter and gives attachment to this muscle. The inner surface of the ramus presents, about its middle, the orifice of the inferior dental canal, into which the nerve of the same name passes to supply the teeth of the lower jaw. The anterior margin of this orifice is marked by a small pointed process of bone, to which the long internal lateral ligament is attached. The internal pterygoid muscle is attached to the lower posterior part of the inner surface of the ramus.

Sixteen teeth are inserted in each jaw, eight on a side: two incisors nearest the middle line, and, following these, one canine, two bicuspids, and three molars.

The Mouth.—The mouth is inclosed by the lips and cheeks.

The lips are composed of fatty connective tissue and muscular tissue, and are covered externally by the skin and internally by the mucous membrane. The muscular fibers are found in the subcutaneous connective-tissue layer, coming from all directions and interlacing with each other, and with much fatty tissue interspersed between them. The mucous membrane, lining the inner surface of the lips, is continued over upon the gums. In the middle line, from the lip to the gum, there is a thin, delicate fold of mucous membrane, the frænum, which is well seen when the lip is drawn away from the gum. The vessels to the lips are the labial and the inferior coronary to the lower lip, and the superior coronary to the upper lip. These branches are derived from the facial.

The cheeks are formed of skin, connective tissue and fat, buccinator muscle, and mucous membrane. The buccinator muscle is attached to the outer surface of the upper and lower jaw-bones just beyond the alveolar processes. This muscle is covered, upon its external surface, by a layer of fascia, bucco-pharyngeal, which is continuous behind with that covering the constrictors of the pharynx. The mucous membrane lining the inner surface of the cheeks is continuous with that of the gums. The buccal cavity may be divided into an outer space, the vestibule, and an inner space, the mouth proper. The vestibule is the space between the teeth and the cheeks and lips. When the mouth is closed the mucous membrane lining the cheeks is thrown into the folds, which would be caught between the teeth if not prevented by the contraction of the buccinator to which the mucous membrane is firmly attached.

Opposite the second upper molar tooth is the orifice of Stenson's duct. At times this orifice is marked by a papilla, which may assist in locating it.

The mucous membrane, from the lips and cheeks, is reflected upon the alveolar process of the upper and lower jaw and extends between the teeth. It is intimately united with the periosteum covering the bone, and together with it forms the gums. Behind the last molar tooth the anterior border of the ramus of the jaw may be felt, and upon the outer side of this the masseter muscle may also, when contracted, be distinctly recognized. When the teeth are tightly closed, the vestibule communicates with the cavity of the mouth proper by a small space behind the last molar tooth upon either side.

The cavity of the mouth proper presents a roof and a floor, and is bounded in front and upon the sides by the alveolar processes and the teeth. Behind, the mouth opens into the pharynx. It is separated from the larynx by the epiglottis, and from the posterior nasal space by the soft palate. Where the cavity of the mouth opens into the pharynx it is somewhat narrowed and is called the isthmus of the fauces. The isthmus is bounded above by the free edge of the soft palate; below, by the tongue; and, upon the sides, by the pillars of the fauces.

The roof of the mouth is divided into the hard and soft palate. The hard palate is formed by the junction, in the middle line, of the palatal processes of the superior maxillaries in front, and of the horizontal plates of the palate bones, behind. It is concave, and arched from side to side and from before backward. In front, in the middle line, just behind the incisor teeth, is a foramen, the orifice of the anterior palatine canal, which transmits the anterior palatine vessels. Extending from this foramen, forward and outward, to a point between the lateral incisors and the canine teeth, on either side, may be seen, occasionally, a line which marks the junction of the intermaxillary bone with the palatal processes of the superior maxillaries.

Near the posterior edge of the hard palate, just to the inner side of the last molar tooth, is the orifice of the posterior palatine canal, and passing forward from this is a groove, close to the alveolar process. The posterior palatine vessels descend through the posterior palatine canal and then pass forward, upon the hard palate, lying in the groove just mentioned. Behind the orifice of the posterior palatine canal may be seen the hook-like hamular process: the termination of the internal pterygoid process, around which the tendon of the tensor palati is reflected before it spreads out in the soft palate. The mucous membrane and periosteum, which cover the hard palate, are intimately united with each other and to the surface of the bone.

The soft palate is a curtain-like structure suspended from the posterior border of the hard palate. It is composed of the spread-out aponeuroses of the tensor and levator palati. It marks the boundary line between the mouth and the pharynx. It presents an inferior, or anterior, and a superior, or posterior, surface, each covered with mucous membrane.

The lower, or free, border of the soft palate presents, in the middle line, the uvula and upon either side separates into the anterior and posterior pillars of the fauces. The anterior pillar is continued downward into the side of the base of the tongue at a point just behind the last molar tooth of the lower jaw, and is made up of the palato-glossus muscle. The posterior pillar is continued downward and backward into the side of the pharynx, and is composed of the palato-pharyngeus muscle. Between the two pillars of the fauces there is a triangular space which lodges the tonsil. Just above the soft palate, in the side of the pharynx, is the orifice of the Eustachian tube; it is about on a level with the floor of the nose.

In quiet breathing the soft palate hangs passive; but during the act of swallowing it becomes tense, owing to the contraction of its muscles, and its free border then comes into contact with the posterior wall of the pharynx, thus shutting off the posterior nasal space from the cavity of the mouth.

The floor of the mouth is formed of soft parts: chiefly by the mylo-hyoid muscle. This muscle extends from the mylo-hyoid ridge, upon the inner surface of the body of the inferior maxilla, to the body and greater cornu of the hyoid bone, uniting with its fellow in the middle line. The upper surface of the muscle, which is directed toward the cavity of the mouth, is covered over by the mucous membrane, beneath which are found, on either side, the sublingual gland, Wharton's duct, the gustatory nerve, etc. The external surface of the mylo-hyoid muscle forms part of the floor of the submaxillary triangle, and is in relation with the submaxillary gland.

The Tongue is a muscular organ which projects upward and forward from the floor of the mouth. It is attached by its base and through several muscles to the hyoid bone, and is connected with the epiglottis through the glosso-epiglottidean folds of mucous membrane. The tongue is composed of a mass of muscular and connective tissue interspersed with much fat, and is partly divided into two symmetrical halves by a fibrous septum. The tongue is connected with the hyoid bone by the hyo-glossus muscle on each side; with the styloid process by the stylo-glossus; with the soft palate by the palato-glossus, and through the genio-hyo-glossus with the symphysis of the lower jaw-bone—this muscle serves to draw the tongue forward and prevents its dropping back into the pharynx and obstructing breathing.

When the mouth is closed its cavity is almost completely occupied by the tongue. The anterior part of the upper surface of the tongue is in contact with the hard palate; the posterior part, with the soft palate and the epiglottis. The tongue is covered by mucous membrane, that covering the under surface and sides of the organ being similar to that of the rest of the mouth. That covering its upper surface, dorsum, is rough, marked by numerous glands, and composed of a thick layer of flat epithelium, which gives it rather a grayish color. The dorsum of the tongue is convex and presents in the middle line a raphé, which divides the organ into two symmetrical halves. Behind, near the base, the tongue presents a row of large papillæ, circumvallate papillæ, arranged in a row, V-shaped, with the apex backward. In the middle, corresponding to the apex of the two rows of papillæ, is a deep depression, the *foramen cæcum*. This is the remains of the fœtal thyro-glossal duct, from which cystic tumors and dermoid cysts may develop.

The tongue may be split or fissured at the tip owing to lack of fusion, indicating the two halves of which it is formed. If the tongue is lifted away from the floor of the mouth by its tip, the attachment of its under surface to the floor of the mouth, in the middle line, through a membranous band, the frænum linguæ, is seen. The frænum may be so short as to limit the mobility of the tongue—"tongue-tie"—to such an extent that it seriously interferes with speech, and requires cutting.

The sublingual glands consist each of a number of lobules, and are located in the front part of the mouth, upon either side of the frænum, resting upon the mylo-hyoid muscle and covered over by the mucous membrane. The location of the glands is indicated by a slight swelling in the floor of the mouth, which presents the little pin-point orifices of their excretory ducts.

Upon either side of the frænum there is a little papilla showing the orifice of Wharton's duct. This is the excretory duct of the submaxillary gland. It passes forward, through the floor of the mouth, lying below and to the inner side of the sublingual gland. The duct may become blocked by a calculus and become greatly distended, appearing in the floor of the mouth as a cystic swelling—called a ranula.

Each half of the tongue is supplied by the corresponding lingual artery; this is a large branch which is given off from the external carotid just above the greater cornu of the hyoid bone. It passes forward beneath the hyo-glossus muscle, and ascends beneath this muscle to the under surface of the tongue, where it is continued forward to its tip. The chief vein of the tongue is the ranine, a large branch, which passes backward upon the outer surface of the hyo-glossus muscle and terminates in the internal jugular.

The nerves to the tongue are the hypoglossal, the gustatory, and the glosso-pharyngeal. The hypoglossal descends in the neck as far as the point where the occipital artery is given off from the external carotid; here it passes forward, above and parallel with the greater cornu of the hyoid bone, resting upon the hyo-glossus muscle. The gustatory is one of the branches derived from the third division of the fifth nerve. From its origin it descends in front of the inferior maxillary nerve, lying between the internal pterygoid muscle and the ramus of the jaw; here it communicates with the chorda tympani, from the facial, and passing forward, beneath the body of the jaw and above the submaxillary gland, gives off its branches to the submaxillary ganglion; continued forward, upon the hyo-glossus muscle, it crosses Wharton's duct, and is continued alongside the tongue to its apex, lying directly beneath the mucous membrane. The glosso-pharyngeal is of but little surgical importance. It descends in the neck, in front of the internal jugular vein and the internal carotid artery, curving forward upon the outer side of the stylo-pharyngeus muscle, to be distributed to the base of the tongue, etc.

The Side of the Face.—Passing transversely from behind forward beneath the integument, the zygomatic arch may be felt. This bony arch is formed by the junction of the zygomatic process of the temporal with that of the malar. It is a prominent landmark, and serves to separate the side of the head, the temporal region, from the side of the face, the pterygo-maxillary region.

THE PTERYGO-MAXILLARY REGION corresponds to that part of the side of the face which is situated below the level of the zygoma.

The skin of this region is intimately connected with the underlying subcutaneous connective tissue, which is thick and only loosely attached to the fascia covering the masseter muscle.

The masseter muscle is a strong, thick muscle arising by two portions from the lower border and inner surface of the zygoma. Its fibers pass downward, covering the ramus of the jaw, to the outer surface of which and to the angle of the jaw it is attached. It is covered by an expansion of the cervical fascia, which is attached above to the lower border of the zygoma. The facial artery crosses the lower border of the inferior maxilla just in front of the masseter muscle, grooving the bone in this situation and passing upward and forward across the cheek to the side of the nose. It is accompanied by the facial vein, which joins with a branch from the temporo-maxillary and thus constitutes a big branch, the temporo-facial, which terminates in the internal jugular.

THE PAROTID GLAND.—After the skin and subcutaneous fat have been removed in this region the parotid gland is exposed. The parotid gland is a reddish, glandular mass, situated in front of the ear, and packed into the space or recess between the ramus of the jaw anteriorly and the mastoid process and anterior edge of the sterno-mastoid muscle posteriorly, and the styloid process internally. It reaches from the zygoma above to the angle of the jaw below, and is continued forward upon the side of the face, resting upon the masseter muscle for a variable distance. This portion is called the facial process. The parotid gland is enclosed within a fibrous capsule derived from the cervical fascia. That portion which covers the gland externally is attached, above, to the zygoma; behind, to the anterior border of the sterno-mastoid muscle; below, it is continuous with the cervical fascia, and anteriorly it is continued forward to the masseter, and becomes fused with the fascia that covers that muscle. The duct of Stenson (duct of the parotid gland) is about two inches long and lies about a finger's breadth below the zygoma, passing forward across the masseter, at the anterior border of which it pierces the cheek to enter the mouth opposite the second molar tooth of the upper jaw. Stenson's duct may become occluded by a calculus. Introduction of a probe into Stenson's duct is facilitated by everting the cheek.

The facial nerve, after emerging from the styloid foramen, passes forward and downward into the substance of the parotid gland. It crosses (superficially) the external carotid artery and the temporo-maxillary vein, and divides, in the substance of the parotid gland, into its two terminal branches, temporo-facial and cervico-facial. These terminal branches subdivide further, upon the side of the face and neck, to supply the muscles, etc., of the face and neck. The facial nerve can be rolled under the finger against the bone as it crosses the posterior border of the ramus of the lower jaw, upon a level with the lower border of the lobe of the ear.

The auriculo-temporal nerve emerges upon the face behind the neck of the condyle of the jaw after passing through the upper part of the parotid gland. It ascends across the root of the zygoma, in front of the ear, in company with the temporal artery, to be distributed upon the side of the head (temporal region).

Abscess of the parotid gland is not uncommonly met with. They may be due to direct infection carried along Stenson's duct from the mouth, or they may be metastatic. They are very painful and do not tend to come to the surface on account of the dense fascia that invests the gland. They may burrow deep toward the pharynx or into the deep layers of the neck, or they may discharge through the auditory canal.

In making incisions into the parotid gland it is necessary to avoid Stenson's duct and the facial nerve. The incisions should be made with the knife through the skin and fat in a horizontal line—parallel with the zygoma. The fibrous layer—capsule of the gland—should be penetrated bluntly with the artery forceps. The opening which is thus made is enlarged to a sufficient degree by spreading the blades of the forceps. In incising deep into the parotid gland the facial nerve, external carotid artery, or temporo-maxillary vein may be divided.

Beneath the parotid gland or within its substance the external carotid artery divides into its terminal branches: the internal maxillary and the temporal. The temporal ascends through the substance of the gland and across the root of the zygoma, just in front of the cartilage of the ear, the auriculo-temporal nerve lying posterior to it; and about two inches above the zygoma it divides into the anterior and posterior temporal. These branches, lodged in the subcutaneous connective-tissue layer of the temporal region, divide and supply this part of the scalp, anastomosing anteriorly with branches from the frontal and posteriorly with the occipital, etc. The internal maxillary artery is not exposed until after the removal of the ramus of the jaw, etc. (see later). The temporal artery is accompanied by the temporal vein. The temporal vein does not lie within the substance of the parotid gland, but superficial to it; it receives

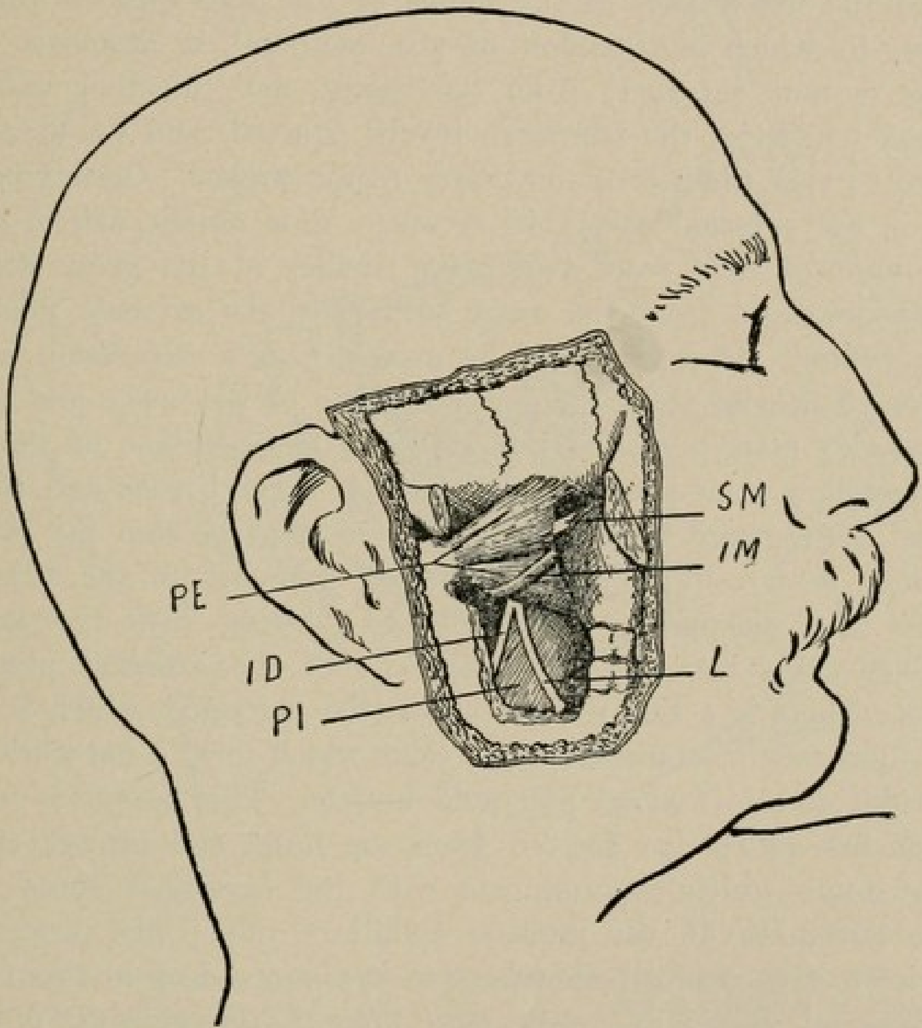

Fig. 73.—Pterygo-maxillary Region. Ramus of the jaw and the zygomatic arch cut away. *ID*, inferior dental nerve; *IM*, internal maxillary artery; *L*, lingual, or gustatory, nerve; *PE*, external pterygoid muscle; *PI*, internal pterygoid muscle; *SM*, superior maxillary (second division of fifth) nerve crossing the spheno-maxillary fossa from behind forward.

many tributaries, and below the angle of the jaw divides into two branches; the posterior joins with the posterior auricular to form the external jugular vein; the anterior joins with the facial to form a large branch, the temporo-facial, which passes obliquely backward across the upper part of the superior carotid triangle, to enter the internal jugular. This branch is often cut in extirpating glands, etc., in this part of the neck, and may give rise to profuse hemorrhage.

The deeper parts of this region are exposed by dividing the zygomatic arch with the chisel or the Gigli saw at its anterior and posterior extremities, and then, after cutting the attachment of the temporal fascia from its upper border, turning the detached segment of the arch, with the attached masseter, downward. There is then exposed the upper part of the ramus of the jaw, with its coracoid process, to which the tendon of the temporal is attached. This process is now cut away from the ramus, and, together with the attached tendon of the temporal, turned upward, and we then have exposed to view the pterygo-maxillary region proper. Occupying this space is the external pterygoid muscle. This muscle arises, by its broad anterior end, from the under surface of the great wing of the sphenoid and from the outer surface of the external pterygoid plate; behind, its narrow end is attached to a depression in the anterior surface of the neck of the condyle of the lower jaw and to the anterior margin of the interarticular fibrocartilage of the temporo-maxillary joint. Curving around its lower border and passing forward and upward upon its outer surface may be seen the internal maxillary artery. This vessel gives off branches to the adjoining muscles and disappears, anteriorly, by passing into the spheno-maxillary fossa between the two heads of the external pterygoid muscle. There is a rich venous plexus, the pterygoid, which is made up of numerous interanastomosing veins which form a net-work upon both sides of the external pterygoid muscle. This plexus is formed of branches which are derived from the nasal and orbital cavities and of some which communicate with the cavernous sinus. The plexus terminates in the internal maxillary vein. The plexus may give rise to free venous hemorrhage in operations deep in this region. The internal maxillary artery pass through the network of veins of the pterygoid plexus. The internal maxillary artery may now be cut away and the external pterygoid muscle cut short at its attachment to the condyle of the jaw and also close to its origin, and in this way the parts which lie beneath the muscle, external pterygoid, are exposed,—the zygomatic and spheno-maxillary fossæ, with their important vascular and nervous structures.

The zygomatic fossa is that space which is limited above by the prominent horizontal ridge called the pterygoid ridge which is found upon the under surface of the great wing of the sphenoid about opposite the zygoma. The floor of the zygomatic fossa is composed of the under surface of the great wing of the sphenoid (base of the skull) from the pterygoid ridge to the base of the pterygoid process, and also of the surface of the external plate of the pterygoid process. It presents the foramen ovale and the foramen spinosum.

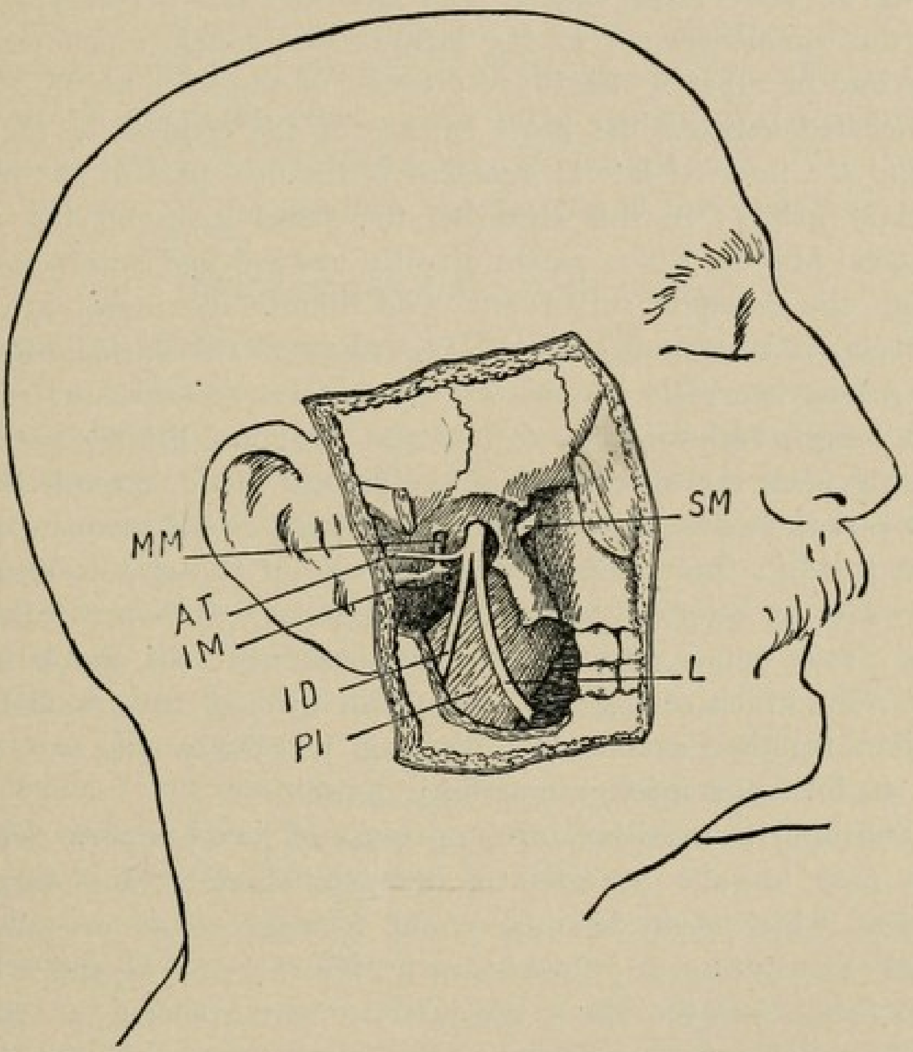

Fig. 74.—Pterygo-maxillary Region. External pterygoid muscle cut away, exposing external pterygoid plate, etc. *AT*, auriculo-temporal nerve; *ID*, inferior dental nerve; *IM*, internal maxillary artery; *L*, lingual, or gustatory, nerve; *MM*, middle meningeal artery; *PI*, internal pterygoid muscle; *SM*, superior maxillary (second division of the fifth) nerve passing across the spheno-maxillary fossa.

The spheno-maxillary fossa is the narrow perpendicular space which is bounded in front by the posterior aspect of the superior maxilla and behind by the front of the pterygoid process. Its inner wall is formed by the vertical plate of the palate bone and constitutes a part of the lateral wall of the nasal cavity. Above, this space is bounded by the orbital process of the palate bone and the body of the sphenoid. The inner wall presents, above, the spheno-palatine foramen, through which it communicates with the nasal cavity and below the upper opening or commencement of the posterior palatine canal. Into the upper part of this fossa, upon its posterior wall, the foramen rotundum opens; above and internal to this is the opening of the Vidian canal. The anterior wall of the space presents the commencement of the infra-orbital canal, which transmits the second or superior maxillary division of the fifth nerve.

Located between the inner surface of the condyle of the lower jaw and the internal lateral ligament is the first part of the internal maxillary artery; in this situation the vessel gives off the middle meningeal branch, which passes directly upward and enters the skull through the foramen spinosum. The middle meningeal artery, at its origin, is surrounded by the two roots of the auriculo-temporal nerve; these two roots join posteriorly to form the auriculo-temporal, which passes backward, as far as the temporal artery, and, after emerging from the upper part of the parotid gland, ascends in front of the ear, to be distributed to the integument of the temporal region.

A little in front and to the inner side of the middle meningeal artery may be observed the inferior maxillary division of the fifth nerve. This trunk consists of a large sensory root and a smaller motor root, which emerge from the skull through the foramen ovale and join together outside this opening, just below the base of the skull, to form the inferior maxillary division.

The inferior maxillary division gives off two temporal branches, which pass upward beneath the temporal muscle, and two large branches, which pass downward and forward. One of these, the lingual or gustatory, is joined below by the chorda tympani, a branch of the facial, and the other, the inferior dental, enters the canal on the inner surface of the ramus of the jaw to supply the lower teeth. Attached to the inner posterior aspect of the inferior maxillary division is the otic ganglion; it is located just below the foramen ovale.

In the upper part of the spheno-maxillary fossa is seen the middle, or superior maxillary, division of the fifth nerve. This nerve leaves the skull through the foramen rotundum, passes forward, across the upper part of the spheno-maxillary fossa and, as the infra-orbital, and accompanied by the terminal branch of the internal maxillary artery, enters the infra-orbital canal, and is finally distributed to the skin of the front of the face, below the orbit. Suspended from the lower border of the middle division, as it passes across the upper part of the spheno-maxillary space, is Meckel's ganglion, with its descending palatine branches, etc.

We may now remove rather more of the ramus of the jaw in order to expose more completely the internal pterygoid muscle. This is seen to arise from the inner surface of the external pterygoid plate, and, passing downward, backward, and outward, is attached to the inner surface of the angle of the jaw. Between this muscle and the inner surface of the ramus of the jaw are the inferior dental nerve, which enters the canal on the inner surface of the ramus, and the lingual, which is joined by the chorda tympani. The internal lateral ligament of the jaw may also be seen in this dissection.

OPERATIONS UPON THE FACE.

Resection of the Upper Jaw.—The chief danger in this operation is from the entrance of blood into the larynx. This may be avoided by previously ligating the external carotid or by a preliminary tracheotomy and the use of a Trendelenburg tampon cannula; or an ordinary tracheotomy tube may be used, in this latter case packing the pharynx, through the mouth, with a gauze pad. The operation may be done without a preliminary tracheotomy by operating with the patient in the Rose position, the head hanging over the end of the table, so that the field of operation is upon a lower level than the larynx. The operation may also be done with the patient in a semirecumbent position, using incomplete morphin-chloroform narcosis, the patient being but partly anæsthetized, and therefore able to cough and keep the larynx clear of blood.

The incision should be so placed as to avoid Stenson's duct.

WEBER'S INCISION.—Reaching from the inner angle of the eye, the incision is carried down alongside of the nose and around the ala to the middle line, terminating by splitting the upper lip. To this is added a second incision reaching from the inner angle of the eye, outward, below the lower margin of the orbit. This second incision should pass along the lower edge of the orbicularis palpebrarum in order to avoid cutting into the substance of this muscle. These incisions penetrate to the bone. Branches of the facial nerve are not cut in making the incision. The flap which is thus marked out is reflected outward, and should be raised subperiosteally if the character of the disease permits. The infra-orbital vessels and nerve are cut when the flap is separated from the anterior surface of the superior maxilla.

Langenbeck's Incision.—A flap, its lower border curved with the convexity downward, is raised. The incision commences at the inner angle of the eye, and passes down alongside of the nose to a point below the level of the ala, as far as the attachment of the upper lip to the alveolar process of the superior maxilla; here it curves outward, corresponding to a line drawn from the ala of the nose to

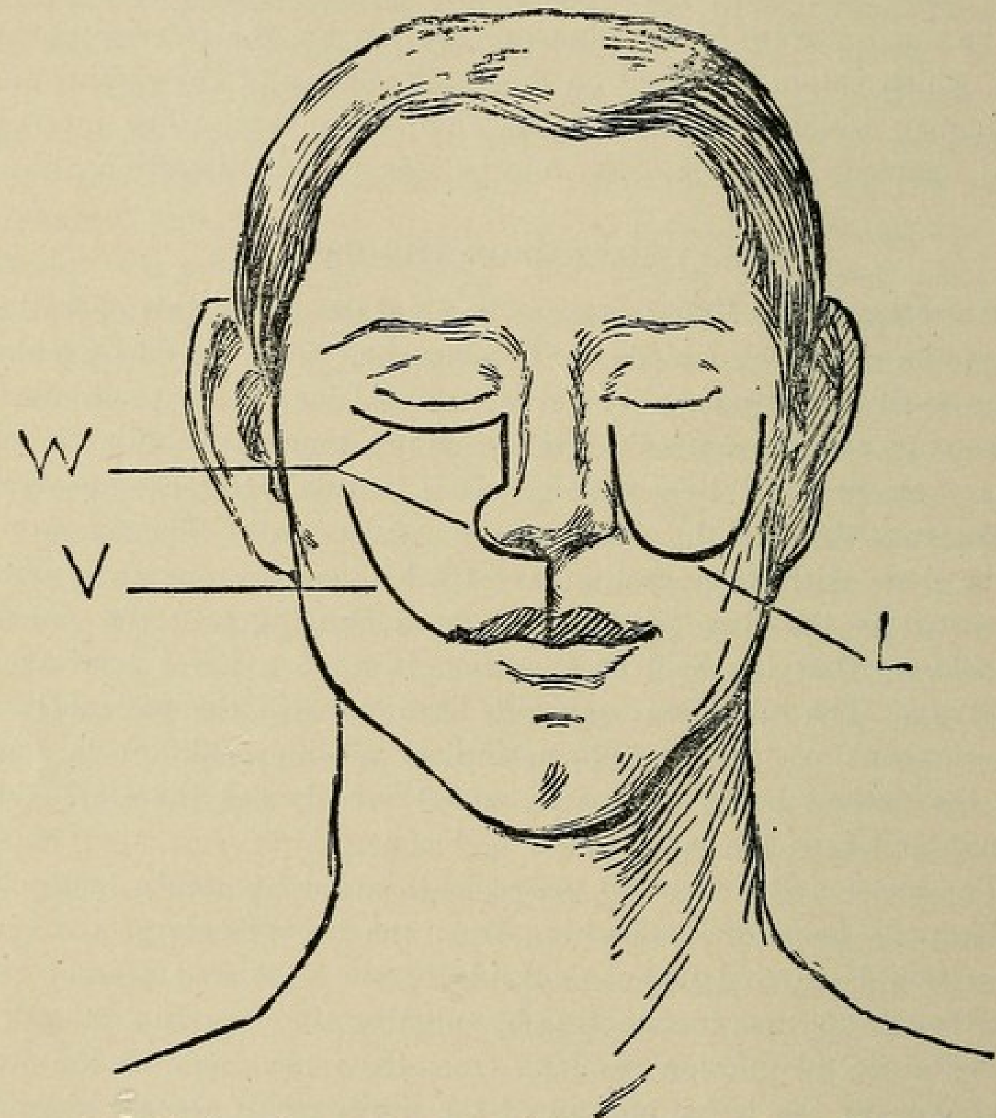

Fig. 75.—Resection of Upper Jaw. *L*, Langenbeck incision; *V*, Velpeau incision; *W*, Weber incision.

the lower border of the lobe of the ear, and is then carried upward to a point over the prominence of the cheek-bone. This incision does not divide the lip, but it will be necessary later to separate the lip from its attachment to the jaw-bone. It divides some branches of the facial nerve, which is a disadvantage. The front surface of the bone is exposed by reflecting the flap upward, subperiosteally, if the conditions permit. In raising the flap from the bone the infra-orbital vessels and nerve are divided.

In making either of these incisions the facial artery is divided and must be clamped and ligated.

After the soft parts have been detached from the bone the cartilage of the nose is separated from the nasal notch, and the soft parts,

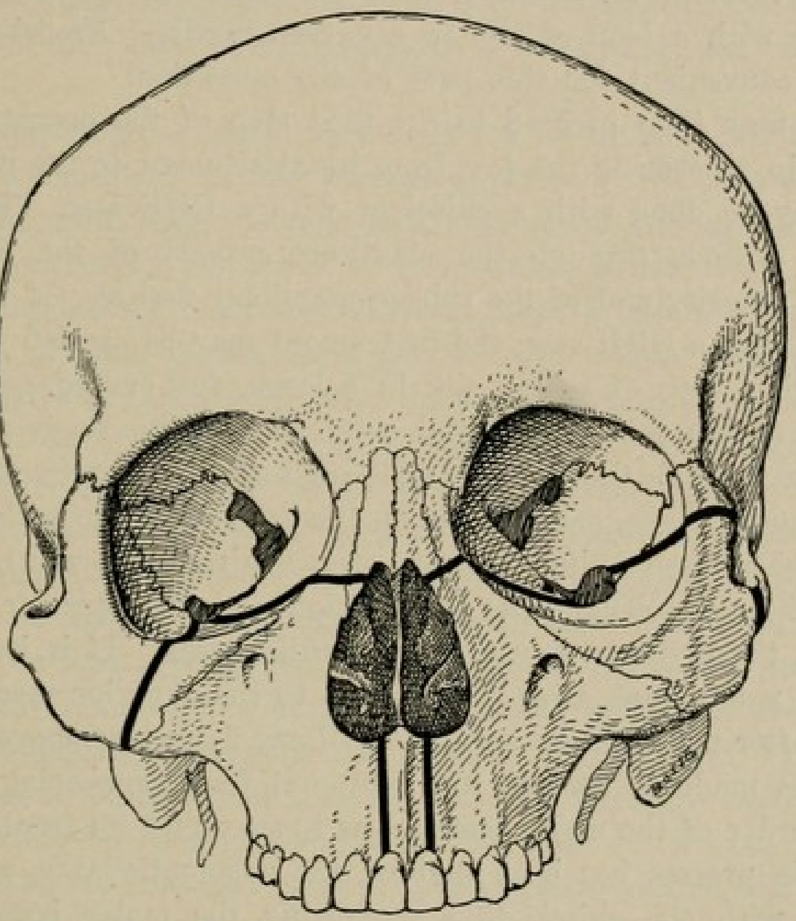

Fig. 76.—Resection of Upper Jaw. When it is desired to leave the major part of the malar bone, the line of section through the bone should be as indicated upon the right side of the skull. If the malar bone is to be removed together with the superior maxillary, the section through the bone should be as is represented upon the left side of the skull, the line of division passing through the frontal process of the malar and the zygoma.

corresponding to the lower margin of the orbit, raised from the bone, and the tarso-orbital fascia cut along the margin of the orbit. The floor of the orbit being thus exposed, the contents of the orbit are raised out of the way with a blunt retractor. We are then ready to cut through the nasal process of the superior maxillary. This division extends from the margin of the nasal notch, across the nasal process, as far as the lacrymal groove or fossa. It is necessary to avoid injury to the lacrymal sac, the upper expanded part of the lacrymal canal, which is lodged in the lacrymal depression upon the lacrymal bone. The division of this process of bone may be accomplished with a chisel, or a hole may be made in the lacrymal bone, which is very thin, just in front of the lacrymal sac, and a Gigli saw introduced through the orbit and around the process, bringing its end out through the nasal notch; the Gigli saw is carried around the bone with a loop of silk in a curved needle. Probably a chisel is more convenient for this part of the operation.

We may then proceed to the next step of the operation, which consists in separating the jaw from its attachment to the malar bone. This may be done with a chisel or with a Gigli saw. The line of division extends through the maxillary process of the malar bone into the anterior end of the spheno-maxillary fissure. If this section is made with a Gigli saw, the instrument may be carried around the bone with a loop of strong silk in a large, full-curved needle. The contents of the orbit being well retracted, the needle is passed into the orbit, through the spheno-maxillary fissure, and then out through the zygomatic fossa, emerging upon the face below the malar process; the suture is then pulled through, drawing the saw, which thus surrounds the malar bone at its conjunction with the superior maxillary, after it; the division may then be readily made. If it is desired to take the malar bone away in addition to the superior maxillary, the needle, after entering the spheno-maxillary fissure, as above described, should be made to traverse the temporal fossa, appearing above the upper border of the malar bone, so as to surround its frontal process; after this process has been divided the zygomatic arch may be cut through with the chisel, thus separating the malar bone from its connection with the temporal bone.

We are then ready to make the division through the hard palate; this is best done as the last step of the operation, after the other connections have been severed on account of the hemorrhage into the mouth. Before dividing the hard palate the muco-periosteal layer, which covers it, is detached. An incision is made in the muco-periosteal covering of the hard palate, commencing anteriorly just behind the incisor teeth; this is carried back along the side of the hard palate, close to the alveolar process, as far as the attachment of the soft palate to the posterior border of the hard palate. With a periosteum elevator, this layer is separated from the surface of the hard palate, as far as the middle line; the soft palate is also separated from the corresponding half of the posterior border of the hard palate. A chisel is then placed in the middle line between the two incisor teeth, and the hard palate divided down the middle for its whole length. It is probably better, in some cases, to accomplish this division with a saw. For this purpose we use a narrow saw, which is introduced into the nasal cavity, after the first incisor tooth of the jaw which is to be excised has been extracted, sawing through the floor of the nasal cavity from above downward and from before backward.

The jaw-bone is now free except for its attachment, behind, to the palate bone and to the pterygoid plate of the sphenoid. The floor of the orbit, which is very thin, may be cut through, just behind its anterior margin, with one or two strokes of the chisel, this line of section reaching from the lacrymal fossa across the floor of the orbit into the spheno-maxillary fissure. One should finally see that the soft parts are separated from the facial surface of the bone, well beyond the last molar tooth; this may be done with a few sweeps of the knife, cutting close to the surface of the bone.

The body of the jaw is seized with a strong bone-forceps, and, with a gradually increasing rocking motion, it is forcibly wrenched from its remaining attachment. Usually all of the palate bone, except its orbital process, comes away with the superior maxilla and there is left remaining a part of the orbital surface of the superior maxilla sufficient to support the contents of the orbit. If part of the pterygoid process comes away with the superior maxillary, the bone will still be held by some of the muscles which arise from this process,—the internal and external pterygoids,—and it will be necessary to divide these with a sweep of the knife before the bone can be removed.

There is left a large bloody space, but, as a rule, there is little or no hemorrhage, owing to the tearing of the blood-vessels in wrenching the bone free. The infra-orbital vessels and nerves may be seen hanging free in the wound. The vessels, which may bleed freely, should be seized at once, clamped, and tied, and the nerve cut short. The other branches of the internal maxillary artery also are exposed,—the descending palatine and spheno-palatine,—and these should also be clamped and tied.

The wound may now be irrigated and tamponed, the ends of the gauze emerging through the nostril. The incision upon the face is closed with interrupted silk sutures, but, before doing this, the edge of the muco-periosteal flap, which was raised from the surface of the hard palate, is stitched with interrupted silk sutures to the inner side of the cheek along the line where this was separated from the alveolar process of the superior maxilla. The ends of these sutures are left rather long and presenting into the mouth, to facilitate their removal later.

During the operation the back of the mouth and the pharynx may be kept clear of blood with gauze pads on long holders.

Total Resection of Both Superior Maxillæ.—This operation is analogous to the preceding.

A curved incision, passing from the angle of the mouth outward and upward to the malar bone on each side, or a double Weber incision, may be used.

The nasal septum, vomer, is divided with bone scissors, and the soft parts as a whole, including the nose, are detached and reflected upward, or if a double Weber incision is used the lateral flaps are separated from the bone and reflected outward.

The attachments of the superior maxillæ are then divided as in the preceding operation, except that it will not be necessary to split or cut through the hard palate, as this is taken away entirely. If possible, the muco-periosteal covering of the hard palate should be stripped off and preserved; this is done by separating it, with an elevator, through a curved incision which penetrates through this layer down to the bone and which is placed just inside the line of the teeth. The soft palate, at its attachment to the posterior border of the hard palate, is also completely separated. Finally, with lion-jaw forceps, the bone is forcibly wrenched free as in the preceding operation.

The soft parts are brought together with silk sutures, first uniting the edges of the muco-periosteal flap, which was raised from the hard palate, to the inner side of the cheeks, corresponding to the line where they were separated from the alveolar process.

To Drain the Antrum of Highmore. Through the Tooth Socket.—Empyema is frequently associated with carious teeth. These or their remaining roots may be extracted and an opening made into the antrum by gouging out the alveolar cavity, which is often found to be carious. This may be done, as a rule, with a sharp spoon or with a narrow chisel. The chisel should be directed upward toward a point corresponding to the middle of the lower margin of the orbit. Such an opening, if made sufficiently large, provides satisfactory drainage from the antrum. A strip of gauze may be introduced to drain the cavity and to prevent the entrance of particles of food. The opening should be made through the alveolus of the first molar tooth.

Through the Anterior Wall.—Drainage may be established by making an opening through the front wall of the antrum. The upper lip is everted and the mucous membrane cut and the soft parts separated from the front surface of the bone with the periosteum elevator. The front wall of the antrum is perforated through the canine fossa just above and to the outer side of the canine tooth. The socket of this tooth is marked by a prominent ridge.

After the periosteum has been stripped off the bone a good-sized opening is made into the antrum with the chisel or with a strong, sharp-pointed perforator or with a drill. The instrument should be directed upward and somewhat backward toward the floor of the orbit, but care should be taken to avoid entering the antrum abruptly with such force as to endanger the floor of the orbit. A drainage tube may be introduced and left in place for several days until the drainage opening is well established.

This operation may well be combined with drainage through the tooth socket as described above. Both operations may be done with the patient in the Rose position or with partial morphin-chloroform anæsthesia.

Through the Lateral Wall of the Nose.—Mikulicz advises making an opening in the lateral wall of the nose just below the middle of the inferior turbinated. This may be done with a sharp-pointed perforator somewhat bent upon itself near the end. The bone is thin, and the operation is readily done except when the nasal cavity is narrow or the inferior turbinated much hypertrophied.

Resection of Half of the Lower Jaw.—The incision commences at the middle of the chin and follows along the lower border of the body of the jaw as far as the angle, whence it is continued upward along the posterior border of the ramus as high as the lower border of the lobe of the ear (one may cut to this point without danger of injuring the facial nerve; see Fig. 138). This incision for its whole extent should reach to the bone. There may be added in front a vertical incision, splitting the lower lip through the middle line, but this is usually unnecessary. The facial vessels are severed in making the incision along the lower border of the body of the jaw-bone, and these must be clamped and tied.

If the glands, etc., in the submaxillary region are diseased, instead of the above-described incision one may be made which commences anteriorly, in the middle line, at the lower border of the jaw, from which point it passes backward and somewhat downward across the submaxillary triangle, deviating from the lower border of the jaw as it passes backward, as far as the anterior border of the sterno-mastoid muscle, whence it is turned upward toward the apex of the mastoid process. This incision passes through the integument and the platysma. The flap which is thus outlined is turned up over the side of the face, and we are then enabled, as a preliminary step, to clear out the submaxillary triangle, and before doing this we can, if desired, easily expose and ligate the external carotid artery. Some surgeons precede the operation with a preliminary tracheotomy, introducing a tampon cannula; or an ordinary tube may be introduced and the pharynx tamponed through the mouth. These measures eliminate the danger of blood being inspired into the trachea.

After having cleaned out the submaxillary triangle, if this has been necessary, the soft parts are separated from the external surface of the body and ramus of the jaw, back as far as the angle, working close to the surface of the bone; the attachment of the masseter is thus separated from the ramus. The separation of the masseter and, in fact, the soft parts from the body of the bone as well, may be accomplished with a periosteum elevator, occasionally snipping with the knife. It is desirable, if the nature of the condition present permits, that is, if the periosteum is not diseased, to make this separation subperiosteally. In the mass of soft parts which is raised from the outer surface of the ramus of the jaw are included, besides the masseter muscle, the parotid gland and Stenson's duct, the facial nerve, and the temporal artery. None of these structures are injured if the operator works close to the surface of the bone. Finally, with a clean cut, the cavity of the mouth is entered, incising the mucous membrane close to the anterior border of the ramus and along the dental margin of the body of the jaw as far as the middle line; in this way the outer surface of the lower jaw, including the teeth, is laid bare. Anteriorly, where the body of the jaw is to be divided, a tooth is extracted and the floor of the mouth, close to the bone, incised, so that the Gigli saw may be carried around the bone. This is done with a loop of strong silk in a large curved needle. This division may also be accomplished with a metacarpal saw. The section through the body of the jaw in front, should, if possible, be made a little external to the middle line, toward the side of the disease, in order to avoid separating the genio-hyoid and genio-hyoglossus muscles from their attachment to the tubercles on the inner aspect of the symphysis mentis. If these muscles are separated from their attachment to the jaw there is a great tendency, both during and after the operation, for the tongue to drop back into the pharynx, closing down the epiglottis and thus greatly interfere with the patient's breathing.

After the bone has been divided anteriorly its free end is seized with a bone-forceps and drawn outward, thus putting the structures attached to its inner surface (floor of the mouth) on the stretch, and they are then divided close to the dental margin (teeth) with a scalpel. When the condition of the periosteum permits, if the periosteum is not diseasd, these parts may be separated from the inner surface of the jaw subperiosteally with the elevator. The body of the bone, still firmly grasped with the bone-forceps and being now freely movable, is dragged forcibly downward and out of the wound so that the operator can reach the coracoid process to which the tendon of the temporal muscle is attached; this is separated with a knife, cutting close to the bone and avoiding the internal maxillary artery, and the bone is then still further luxated. Behind, attached to the inner surface of the ramus of the jaw, at the angle, is the internal pterygoid muscle; this is cut away close to the surface of the bone.

The inferior dental vessels and nerves enter the jaw-bone through the inferior dental canal on the inner surface of the ramus; these structures may be cut or torn, but before being cut they should be grasped with an artery forceps; later the vessels are tied and the forceps removed, liberating the nerve. If the inferior dental should bleed in the sawn surface of the remaining half of the bone this may be stopped by plugging the orifice of the canal with a strand of catgut.

The flap of soft parts is drawn forcibly upward, and the bone, still held with the bone-forceps, dragged downward; so that the outer wall of the capsule of the temporo-maxillary joint may be reached with the point of a sharp knife and incised; the tendon of the external pterygoid, which is attached to the front of the neck of the condyle, is likewise divided. In cutting these structures the knife is kept applied close to the surface of the bone in order to avoid the internal maxillary and the temporal arteries. The bone may now be readily twisted out of its socket.

If it should be necessary to separate the muscles of the tongue from their attachment to the symphysis of the jaw, a thick silk suture should be previously passed through its tip, to be used as a tractor to prevent its being drawn backward into the pharynx and closing the larynx and interfering with respiration. It is probably advisable to introduce such a suture in all cases.

The cut edge of the mucous membrane which was separated from the inner aspect of the jaw-bone is now accurately sutured to the corresponding edge of the mucous membrane which was separated from the outer aspect, except for a short space behind, through which the cavity of the mouth is drained; these sutures should be of silk, knotted on the inside of the mouth, and the ends left sufficiently long to allow of their ready removal later.

The edges of the skin are approximated with interrupted sutures except at the posterior part where the drain emerges.

For the purpose of facilitating drainage, the wound is loosely packed with iodoform gauze, reaching into the cavity of the mouth. This may be removed after a few days, when a sinus is established through which all secretions from the mouth may find exit.

Resection of Half of the Body of the Lower Jaw.—A strong, thick suture is passed through the tongue for use as a tractor, if this becomes necessary. An incision is made along the lower border of the body of the jaw from the middle line in front to the junction of the body and ramus just beyond the last molar, behind; this incision penetrates to the bone. In many cases the facial artery, where it curves over the lower border of the body of the jaw, just in front of the masseter, is divided; but frequently this may be avoided. If the vessel is cut it must be clamped and ligated. There may be added anteriorly a vertical incision which splits the lower lip in the middle line; but, as a rule, this is unnecessary, and should be avoided.

With the elevator or knife, working close to the surface of the bone, the soft parts are separated from the outer surface of the body of the jaw, finally cutting through the mucous membrane close to the teeth and thus entering the mouth and exposing the outer surface of the body of the bone and the teeth.

The floor of the mouth is now perforated, anteriorly, near the middle line, close to the inner surface of the bone, and, after extracting a tooth, the Gigli saw is introduced, being carried around the jaw with a loop of silk in a large curved needle, and the bone is then sawn through; this section should be made to the side of the middle line in order not to disturb the attachment of the muscles of the tongue to the symphysis. If the end of the divided bone bleeds, this may be controlled by plugging the orifice of the canal which contains the nutrient artery. The end of that half of the bone which is to be excised is seized with the bone-forceps and drawn strongly outward, thus putting the soft parts attached to its inner surface (floor of the mouth) upon the stretch. These parts are separated from the inner surface of the bone as far back as the junction of the body with the ramus—beyond the last molar tooth. This may be done bluntly with an elevator, separating subperiosteally, or, if this is contra-indicated on account of the character of the disease, the soft parts, including the mucous membrane, may be simply cut away from the bone with the knife. After having thus stripped the body of the bone of its soft parts, both upon its outer and its inner or buccal surface, the saw is applied just behind the last molar tooth and the bone cut through. This may be done with the Gigli saw or with a narrow metacarpal saw. While the bone is being divided it should be drawn well downward with the bone-forceps.

Hemorrhage from the cut surface of the bone is controlled with a plug of catgut, which is packed into the orifice of the dental canal.

The mucous membrane, which was separated from the outer surface of the segment of bone which has been resected, is sutured to the cut edge of the parts which were separated from the inner surface of the bone. This closes in the cavity of the mouth, and may be done with interrupted silk sutures tied within the mouth, the ends being left long so that they may be readily removed.

The incision in the skin is closed in part, leaving the posterior end open for drainage. It is probably wise, in most cases, to leave a small opening through the mucous membrane also, so that the cavity of the mouth may be drained; in this case the gauze, which is introduced into the posterior portion of the skin incision, is packed into the mouth.

Resection of the Entire Body of the Lower Jaw.—This is analogous to the preceding operation, but special care must be exercised to guard against the tongue dropping back into the pharynx after the attachment of the muscles, which pull it forward, have been separated from the inner surface of the symphysis. This accident may be prevented by passing a ligature through the tip of the tongue by which traction may be made. There is also considerable danger of the tongue dropping back and obstructing the breathing after the operation, and this accident might easily cause the death of the patient; so that the tractor should be allowed to remain in the tongue and fixed outside.

The jaw-bone is divided in the middle line, and then each half is resected separately as described in the preceding operation.

Resection of Part of the Body of the Lower Jaw in Continuity. FROM WITHIN THE MOUTH.—Precautions must be taken to prevent blood entering the larynx during the operation (see "Resection of the Upper Jaw," etc.). A mouth-gag is introduced and an incision is made through the mucous membrane on either side of the teeth, and the soft parts separated from the inner and outer surfaces and from the lower border of the segment of the jaw-bone that is to be excised, with an elevator. A tooth is then extracted and the Gigli saw passed around the bone with a loop of silk in a large curved needle and the bone divided; this procedure is repeated at the other end of the segment of bone which is to be excised. The hemorrhage from the cut ends of the bone is controlled by a plug of catgut packed into the dental canal. The soft parts may be separated from the surface of the bone subperiosteally, as above described, but in most cases this is not permissible on account of the character of the disease. After removal of the segment of bone the edges of the mucous membrane may be brought together, at least in part, by interrupted silk sutures. A small opening may be made externally through the skin for drainage.

If the anterior portion of the body is resected, necessitating the separation of the tongue muscles from the symphysis, proper measures must be taken to guard against the tongue dropping back upon the epiglottis and larynx. The operation done from within the mouth is ordinarily rather disadvantageous, as it is rather difficult to properly drain the wound afterward.

FROM WITHOUT.—An incision is made along the lower border of the body of the bone corresponding to that part of the bone which is to be resected and reaching down to the surface of the bone. Usually it is not necessary to split the lower lip. The soft parts are separated from the outer surface of the body of the bone with the elevator, if permissible subperiosteally, and the mucous membrane then incised close to the teeth, thus opening into the mouth. Corresponding to the points at which the bone is to be divided the teeth are extracted and incisions made in the floor of the mouth close to the bone to allow the passage of the Gigli saw; this is carried around the bone with a loop of silk in a full curved needle and the bone then divided. The segment of bone, which has been thus loosened and to the inner aspect of which the soft parts of the floor of the mouth are still attached, is seized with the bone-forceps, and the soft parts (mucous membrane and muscles of the floor of the mouth) are then separated with the elevator or cut with the knife close to the surface of the bone and near its alveolar margin.

Hemorrhage from the bone may be controlled by plugging its nutrient canal with a piece of catgut.

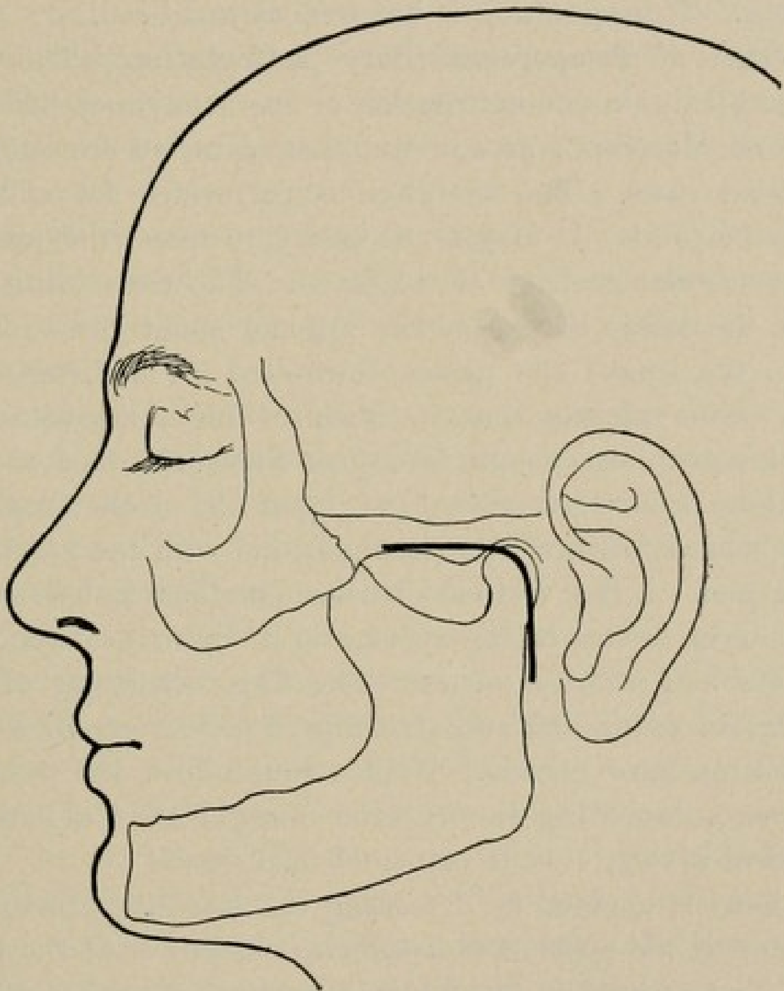

Fig. 77.—Incision for Resection of the Temporo-maxillary Joint.

The mucous membrane, which was separated from the outer surface of the resected segment, is united to that which was separated from the inner surface with several interrupted silk sutures, tied within the mouth, in this way closing in the cavity of the mouth. The external wound is partly closed and drained.

If the part resected corresponds to the anterior portion of the body of the jaw-bone, it is desirable to secure the tongue by passing a silk suture through its tip.

Resection of Part of the Body of the Lower Jaw (Not Through Entire Thickness, Not in Continuity).—Practically as described in the preceding operation, working either from within the mouth or without. The operation consists in resecting the diseased part of the bone and leaving a portion of the body, of greater or less thickness, as a bridge to preserve the continuity of the bone and prevent deformity, and to facilitate the application of an apparatus. The removal of the bone may be effected with a chisel or with the cutting bone-forceps. This operation is but seldom practiced.

Resection of Temporo-maxillary Articulation.—This operation consists, as a rule, in the extirpation of the condyle of the lower jaw. The interarticular cartilage and the glenoid cavity are not interfered with in most cases. The operation is performed for ankylosis and disease of the joint. It may be necessary to resect the joint on both sides. An angular incision is employed. The descending arm commences at the lower border of the zygoma about three-fourths inch anterior to the tragus and passes downward for a distance of about one inch. This incision lies in front of the temporal artery and should not reach low enough to injure Stenson's duct or the facial nerve. These latter structures rest upon the masseter muscle and pass from behind forward below and parallel with the zygoma. From the upper end of the vertical incision another is carried forward along the lower border of the zygomatic arch for a distance of from one and one-half to two inches. The flap, consisting of skin and fat, is reflected downward and strongly retracted, exposing the upper part of the masseter muscle. With a blunt hook the posterior edge of the wound, including the anterior margin of the parotid gland and temporal artery, etc., is retracted backward.

The joint is exposed by detaching the masseter muscle from the lower border of the zygoma to a sufficient extent with the periosteum elevator. The capsule is incised in a vertical direction and also detached with the elevator. The condyle is thus exposed and may be removed by dividing the neck close to the articular surface with the chisel or Gigli saw. The condyle is seized with small bone-forceps and any remaining soft parts cut close to the bone and the condyle thus removed. It is desirable to leave as much of the tendon of the external pterygoid attached to the neck of the bone as possible. It is advisable in most cases, especially of disease, to establish temporary drainage by leaving a thin strip of gauze in the wound. The incision is closed except where the drain emerges.

Division of the Second and Third Branches of the Trifacial Nerve at the Base of the Skull (Krönlein's Modification of Lücke's Operation).—This operation consists in exposing the second and third divisions of the fifth nerve as they emerge from the skull and dividing them or twisting them free from their origin.

An incision marking out a rounded skin-flap, with its convexity downward and its base corresponding to the upper border of the zygomatic arch, is made. It commences anteriorly, one finger's breadth behind the external angular process, and terminates behind, just in front of the tragus (see Fig. 68). This flap, which consists of the skin and subcutaneous fascia, is raised from the deep fascia covering the parotid gland and masseter muscle, and is reflected upward, thus exposing the arch of the zygoma and the lower portion of the temporal fascia, which is attached to the upper border of the arch. The incision does not reach low enough to injure the facial nerve or Stenson's duct. Bleeding points are clamped and ligated as the operation progresses.

The temporal fascia attached to the upper border of the zygomatic arch is incised along this border of the arch, and the arch sawn through: first, posteriorly and then anteriorly. Before making this division of the arch, holes should be drilled for the purpose of wiring the detached segment in position later. In dividing the arch anteriorly it is necessary to get well forward so as to include as much of the length of the arch as possible; the line of division should not be from above directly downward, but from above obliquely downward and forward. This segment of the arch, carrying the attached masseter muscle with it, is reflected downward, exposing the coracoid process of the ramus of the lower jaw and the attached temporal tendon. This process, after making drill-holes for subsequent wiring, is cut away, the line of section extending from the deepest part of the sigmoid notch obliquely downward and forward so as to include practically all that part of the ramus which corresponds to the attachment of the temporal tendon. This segment of bone, carrying the temporal tendon, is reflected upward, and held thus with a retractor. The external pterygoid muscle, and the internal maxillary artery which passes obliquely across its outer surface, may now be recognized. It is well to tie the vessel double and cut it. With the elevator the attachment of the external pterygoid is separated from the under surface of the great wing of the sphenoid and drawn downward. The finger is introduced into the space above the upper border of the muscle and is passed inward close to the under surface of the bone (base of the skull), feeling for the posterior sharp edge of the external pterygoid plate and searching for the foramen ovale, which is directly behind and a little external to the root or base of the pterygoid process, external pterygoid plate. We should recognize the trunk of the inferior maxillary as it emerges from the foramen ovale; directly behind this, the middle meningeal artery, surrounded by the two roots of the auriculo-temporal nerve, is seen passing upward to enter the skull through the foramen spinosum (see Fig. 74). The inferior maxillary division is seized with a hook and drawn forward and cut, and then the stump, grasped with a forceps, is twisted free from its origin at the Gasserian ganglion. Usually the motor root is grasped at the same time and included with it. We then penetrate into the spheno-maxillary fossa, and in the upper part of this cavity, the superior maxillary, or second, division of the fifth nerve, just before it enters the infra-orbital canal, is seized with the hook and drawn out and cut, and then likewise twisted away from the Gasserian ganglion. The Eustachian tube is located close to the inner side of the inferior maxillary nerve, and, therefore, as soon as this trunk of the nerve is accessible, one should not penetrate deeper into the wound for fear of injuring the Eustachian tube and causing infection of the wound.

The coracoid process is reunited to the ramus of the jaw with a wire suture and the segment of the zygomatic arch is likewise replaced and wired. The skin incision is then closed.

Operations upon the Peripheral Branches of the Trifacial Nerve.—The supraorbital, infraorbital, inferior dental and lingual branches are sometimes attacked for the relief of pain.

The supra-orbital and infra-orbital branches may be exposed through an incision above or below the orbit.

The inferior dental may be reached through an incision in the side of the mouth, reaching from behind the upper to behind the lower last molar tooth. The finger is inserted, through the incision, between the internal pterygoid muscle and ramus of the jaw and the spine that marks the orifice of the inferior dental canal is recognized. The nerve is secured with a blunt hook just before it enters the canal, and is drawn out of the wound and may then be stretched, divided, etc., or it may be exposed by trephining the external surface of the ramus of the jaw midway between its anterior and posterior borders and upon a level with the crown of the last molar tooth. The nerve is thus exposed just before it enters the canal.

The lingual (gustatory) nerve may be divided for relief of pain in inoperable cancer of the tongue. The nerve is exposed through an incision in the floor of the mouth close to the side of the tongue and opposite to the last molar tooth. The nerve is hooked out of the incision and a portion of its length resected. The nerve may also be exposed by trephining the ramus of the jaw as described above for exposure of the inferior dental. It is found just a little anterior to

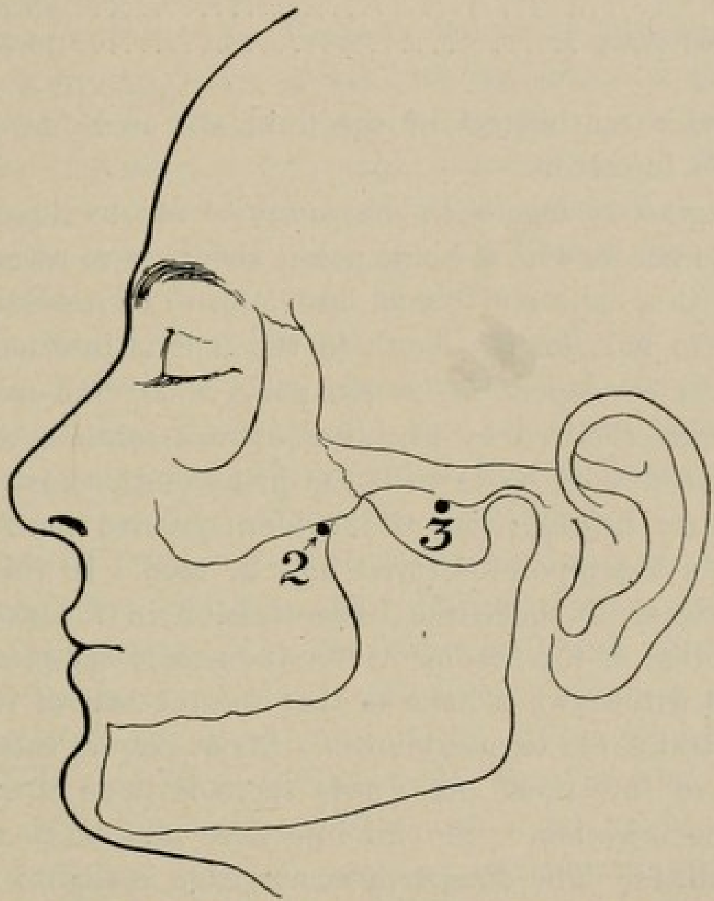

Fig. 78.—Points of Injection of the Superior and Inferior Maxillary Branches. 2, point where the needle is introduced to reach the second division; 3, point for the third division.

the inferior dental and may be picked up and a piece resected in this situation.

Injection of the Trunks and Peripheral Branches of the Trifacial Nerve.—Alcohol is injected into the three divisions and terminal branches of the fifth nerve for neuralgia—tic douloureaux. Relief is obtained for a period varying from a few months to a number of years.

For pain corresponding to the distribution of the second and third, superior and inferior maxillary, divisions the injection is made down into or around the trunks as they emerge from their foramina in the base of the skull; the superior as it emerges from the foramen rotundum and the inferior as it emerges from the foramen ovale. The first division, the ophthalmic, is injected through the orbital cavity, but this is very hazardous.

The fluid injected is composed as follows:—

Cocain hydrochloride	½ per cent.
Alcohol	85 per cent.
Distilled water	15 per cent.

Two cubic centimetres of the fluid are used for each division of the nerve injected.

An all-glass syringe with a capacity of two to three cubic centimetres and a needle with a blunt point, about six to seven centimetres long, and with a calibre of 1 mm., are used. The needle is marked in centimetres to indicate the depth to which it is inserted.

The skin corresponding to the point where the needle is to be inserted is anæsthetized by injecting a weak solution of cocain and a small incision then made with the point of the knife in order to permit of easy introduction of the blunt-pointed needle. A blunt needle with a sharp-pointed stylet may be used. In this case it will not be necessary to make the little incision in the skin to permit the introduction of the needle. After the needle has pierced the skin the stylet is withdrawn a little so that for the rest of its course the needle penetrates the tissues bluntly. Strict asepsis should eliminate the danger of infection. As a rule there is little or no complaint following the injection. Several injections may be necessary before relief is obtained. The danger of hemorrhage is slight; usually more or less ecchymosis of the skin is seen after the injection.

Superior Maxillary Division.—A line is carried perpendicularly downward continuous with the posterior border of the frontal process of the malar bone; one-half centimetre behind the point where this line strikes the inferior border of the zygoma and very close to this (lower) border of the zygoma, the needle is introduced. The needle is pushed inward and slightly upward and backward to a depth of five centimetres. The point of the needle enters the upper part of the spheno-maxillary fossa and touches or is very close to the nerve as it crosses the spheno-maxillary fossa before it enters the infraorbital canal (see Fig. 74). The needle as it is pushed in may strike the coronoid process of the inferior maxilla at a depth of one and one-half to two centimetres. This may be avoided by withdrawing the needle a little and directing it a trifle more anteriorly. At a depth of three and one-half to four centimetres the needle may strike the anterior border of the pterygoid process. The needle is withdrawn a trifle and its direction changed a little more anteriorly, when it will pass into the spheno-maxillary fossa. In changing the direction of the needle toward the front when it strikes an obstruction in its course, care should be taken to do this cautiously and only to a slight degree. There is danger of pushing the needle through the spheno-maxillary fissure into the orbit. A sudden sharp pain corresponding to the area supplied by the nerve results if the needle touches the nerve. Two cubic centimetres of the alcoholic solution is injected at this depth. As a rule the fluid is not injected actually into the nerve-trunk, but into the tissues immediately adjacent and reaches the nerve-trunk by diffusion.

INFERIOR MAXILLARY DIVISION.—The needle is introduced at a point two and one-half centimetres in front of the anterior edge of the external auditory meatus and just below the lower border of the zygoma, and is pushed inward and a little backward and upward to a depth of four centimetres and the fluid injected.

OPHTHALMIC DIVISION.—The needle is inserted, according to Patrick, through the orbital cavity. It passes along the outer wall of the orbit, hugging close to the outer wall and passing between this wall and the lacrymal gland. At a depth of three and one-half to four centimetres the injection is made. It would seem to be an extra hazardous procedure to inject the first division. The first division is not so frequently affected and relief might be obtained by the less dangerous plan of injecting the supraorbital branch as it emerges from its foramen.

The end branches of the fifth nerve may be injected as they emerge upon the face at the supraorbital, infraorbital, and mental foramina.

CONGENITAL DEFORMITIES OF THE FACE.

The Development of the Face.—About the twelfth day the arrangement of the head end of the embryo is quite simple. A cross-section shows it to consist of two tubes, one being situated in front of the other. The anterior is the blind, head end of the alimentary tube,—the future pharynx. The posterior is the enlarged neural tube which is later developed into the brain. The anterior wall of this upper, head end of the alimentary tube is called the "oral plate," and marks the location of the future mouth and face. A sagittal section will also show this relationship, and further that the neural tube not only lies behind the alimentary tube, but also arches forward above the upper end of the latter like a hood, overriding it anteriorly. This upper part of the neural tube, which projects forward over the end of the alimentary tube, is called the vesicle of the fore-brain.

In the third week there may be seen, upon either side of the head end of the embryo, four transverse plates or ribs of tissue which

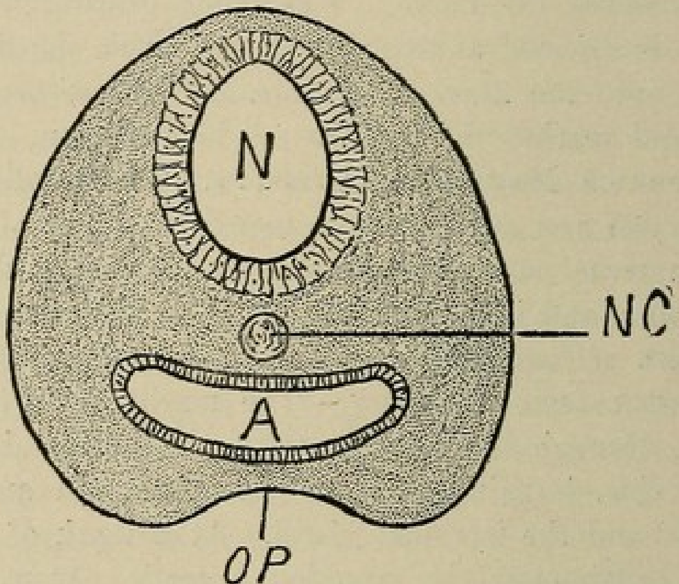

Fig. 79.—Transverse Section of the Head End of an Embryo Twelve Days Old. *A*, alimentary tube; *N*, neural tube; *NC*, notochord; *OP*, oral plate.

are separated from one another by deep fissures, or clefts. The thickened plates are called visceral arches, and the intervening spaces, or fissures, visceral clefts. Within the alimentary tube, upon its inner aspect, there may be seen corresponding arches and clefts. These arches are simply thickenings or ribs in the lateral walls of the head end (*"schlund,"* pharynx) of the alimentary tube. Each mass consists of mesoblast, covered upon its outer surface by the epidermic layer, which covers the whole exterior of the body, and upon its inner surface by the endodermic layer, which lines the whole inner surface of the alimentary tube. Between the arches, at the bottom of any two opposed clefts, the wall of tissue is extremely thin; consists practically of the outer (epidermic) and the inner (endodermic) layers. The uppermost of these visceral arches, that concerned in the formation of the face, is the thickest. It extends forward, and in front, where it is narrower, unites in the middle line with its fellow of the opposite side, to form the mandibular arch, which represents the future lower jaw. The second arch is less prominent than the first, and as it passes forward is directed somewhat upward. This second arch does not reach as far as the middle line. The third and fourth arches are still less prominent and still shorter. These lower three arches do not join with their fellows across the middle line in front, but are continued into the plate of tissue which forms the front wall of the *(schlund)* pharynx. From above downward these arches

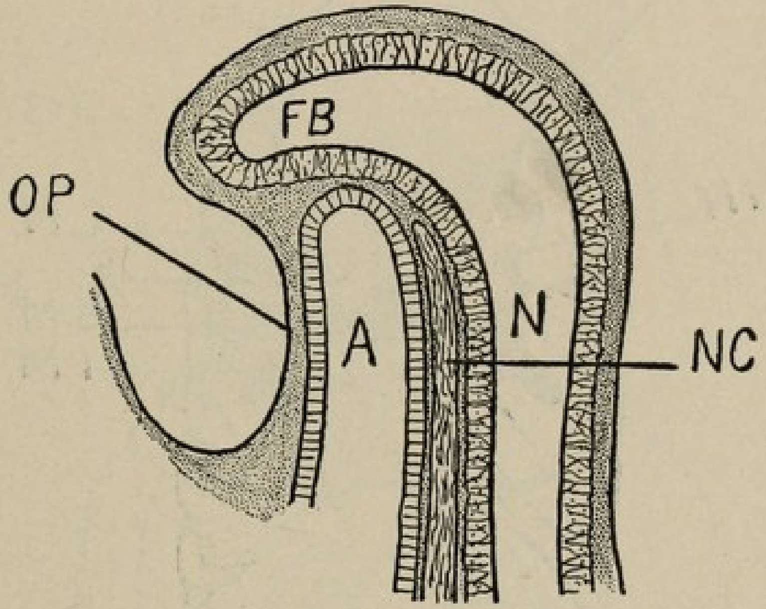

Fig. 80.—Sagittal Section of the Head End of an Embryo Twelve Days Old. *A*, alimentary tube; *FB*, vesicle of the forebrain overriding the end of the alimentary tube; *N*, neural tube; *NC*, notochord; *OP*, oral plate (site of future mouth), which ruptures during the fourth week.

overlap and partially conceal each other; so that the third and fourth, especially the fourth, are almost entirely concealed by the first and second. The uppermost arch appears earliest. The appearance of these arches is the first indication that marks the commencement of the formation of the face.

Owing to the progressive growth of the visceral arches, which causes a thickening of the parts that immediately adjoin the area already mentioned as the oral plate, and on account of the presence of the prominent overhanging forebrain vesicle (neural tube) above, the oral plate becomes relatively depressed, and we have thus, in its stead, a distinct fossa, which is called the oral pit. The oral pit is bounded above by the overhanging forebrain vesicle and below and upon the sides by the first visceral arches. These are the parts which immediately surround the oral pit and which are finally developed into the face; the oral pit represents the future oral and nasal cavities.

The second, third, and fourth visceral arches are not concerned in the formation of the face.

The next change noticed in the parts about the oral pit is the appearance of a thick, rounded mass or process upon the upper back

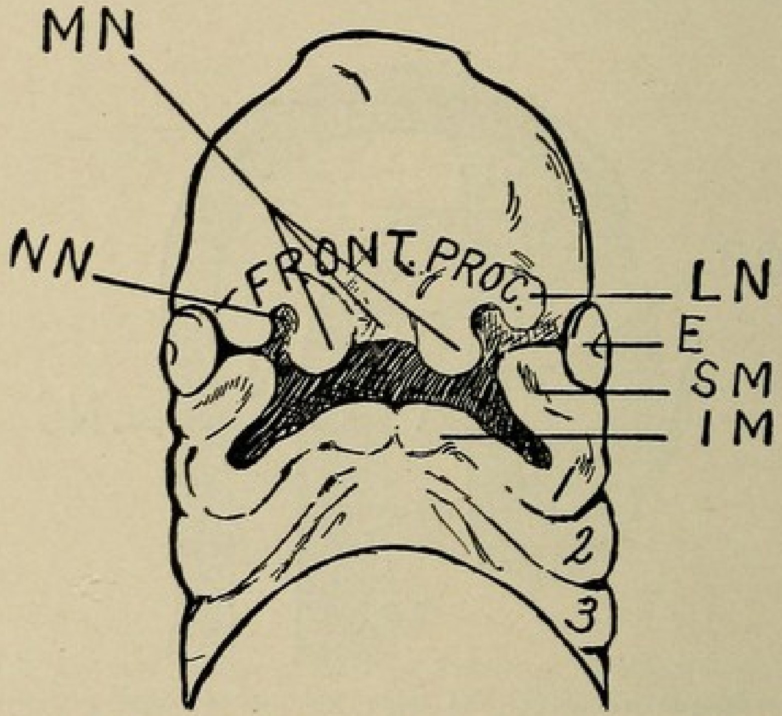

Fig. 81.—Face of Embryo, Fifth Week. Front view. *E*, eye; *IM*, inferior maxillary process (first visceral arch) joins in middle line with its fellow of the opposite side to form the mandibular arch (future lower jaw); *LN*, lateral nasal process (outer extremity of the frontal process); *MN*, middle nasal process (middle portion of frontal process); *NN*, nasal notch (future nostril); *SM*, superior maxillary process (upper back part of the first visceral arch); 1, 2, 3, first, second, and third visceral arches.

part of the first visceral arch of either side; this is called the superior maxillary process. Above, corresponding to the upper margin of the oral pit, there appears a single broad process, which is developed by the forward and downward growth of the anterior wall of the vesicle of the forebrain; this is called the frontal process or frontal plate, and is really a prolongation of the front wall of the vesicle of the forebrain; it grows downward and plays a very important rôle in the development of the face. At this stage the oral pit is a five-sided, deep fossa, bounded above by the frontal process or frontal plate, below by the mandibular arch (inferior maxillary processes), and upon each side by the superior maxillary process.

The eyes are located one upon either side of the head, and are bounded below by the upper back part of the superior maxillary process and internally by the outer border of the frontal process.

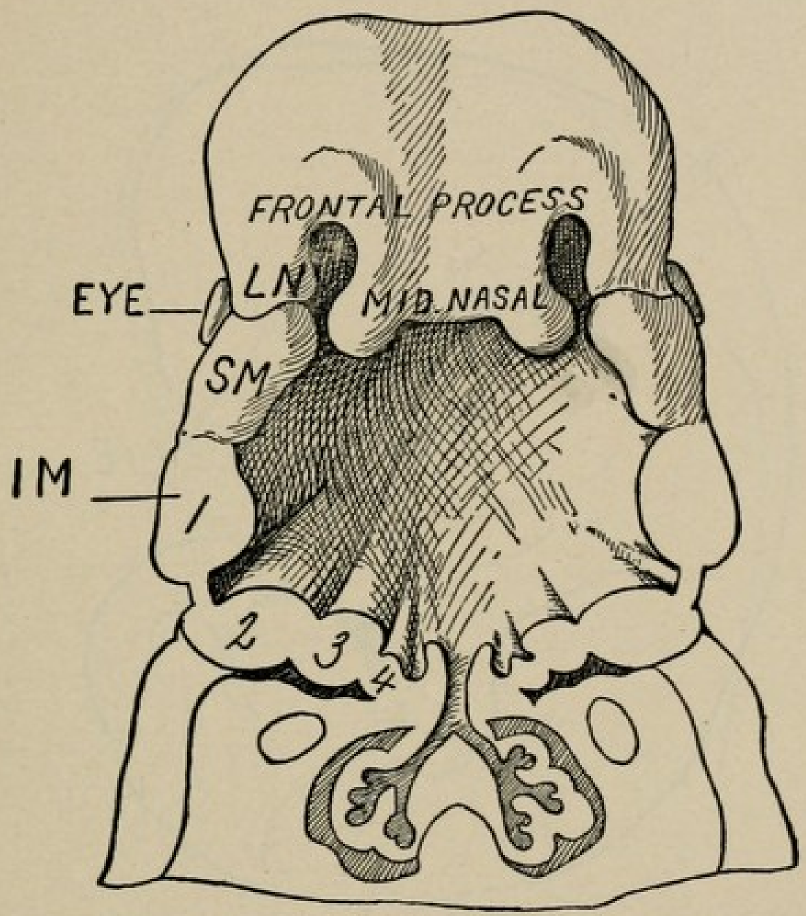

Fig. 82.—Face of Embryo, Fifth Week. Front view. The anterior portion of the visceral arches has been cut away to show the interior of the mouth cavity (pharynx), the wall of which shows the visceral arches with intervening clefts corresponding to those upon the outside. *IM*, cut surface of inferior maxillary process; *LN*, lateral nasal process; *SM*, superior maxillary process; 1, 2, 3, 4, cut surface of the first, second, third, and fourth visceral arches, showing the corresponding clefts between them. Between *LN* and middle nasal process is the nasal notch (future nostril).

The frontal process, frontal plate, is broad, and consists of a middle portion, the middle nasal process, and two lateral portions,—the lateral nasal processes.

The middle nasal process is quite broad, and its lower free border is deeply notched in the middle. The lateral nasal process, one on either end of the frontal process, is separated from the middle nasal process by a deep notch, the olfactory groove; the floor of each olfactory groove is intimately related with the base of the cerebral vesicle,—organ of smell.

During the fourth week the plate of tissue which forms the floor of the oral pit becomes very thin, consisting only of the epidermic and endodermic layers. It is called the "rachenhaut of Remak," or the pharyngeal membrane, and during this week ruptures and so

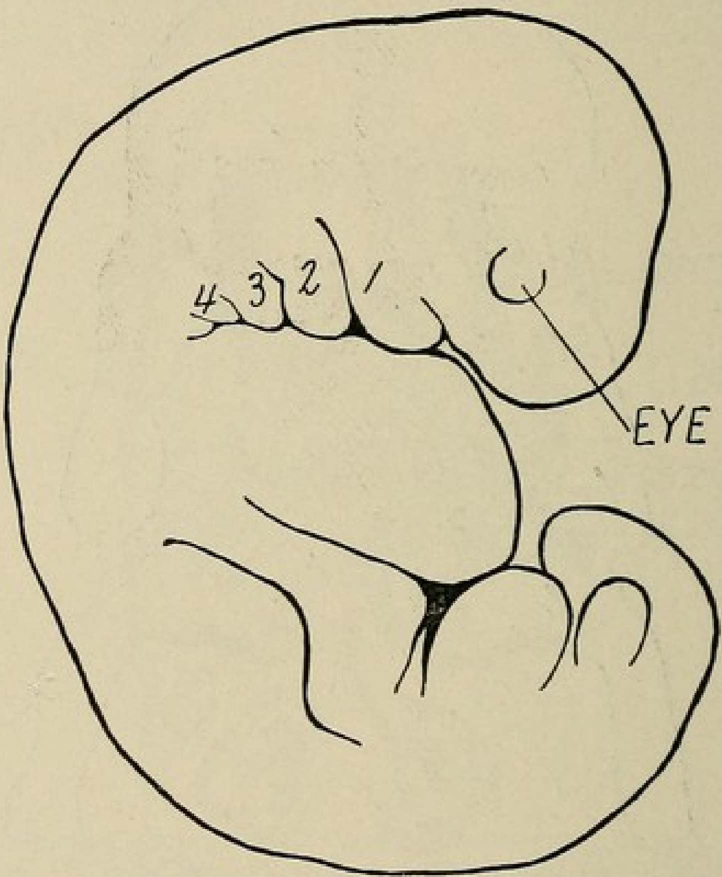

Fig. 83.—Embryo about Fourth Week, seen from Side. 1, 2, 3, 4, visceral arches with clefts between them.

establishes a communication from without with the alimentary tube,—pharynx.

Somewhat later, about the fifth week, we find that the various processes have approached each other, and the appearance begins to suggest the ultimate conformation of the face. The superior maxillary processes are nearer the middle line, the whole frontal process is longer, and its separation into a middle and two lateral portions is still more pronounced on account of the increased depth of the olfactory grooves. The eyes are fairly well bounded, but are still located upon the side of the head.

About the seventh week we note that the superior maxillary process, in part, has become fused with the lateral nasal process of the frontal plate; this line of fusion corresponds to the position of the tear-duct. If union does not occur along this line, we have a so-called orbito-nasal or oblique facial cleft. The eye is entirely surrounded and is placed more to the front of the face. The middle portion of the frontal plate, the middle nasal process, is still notched

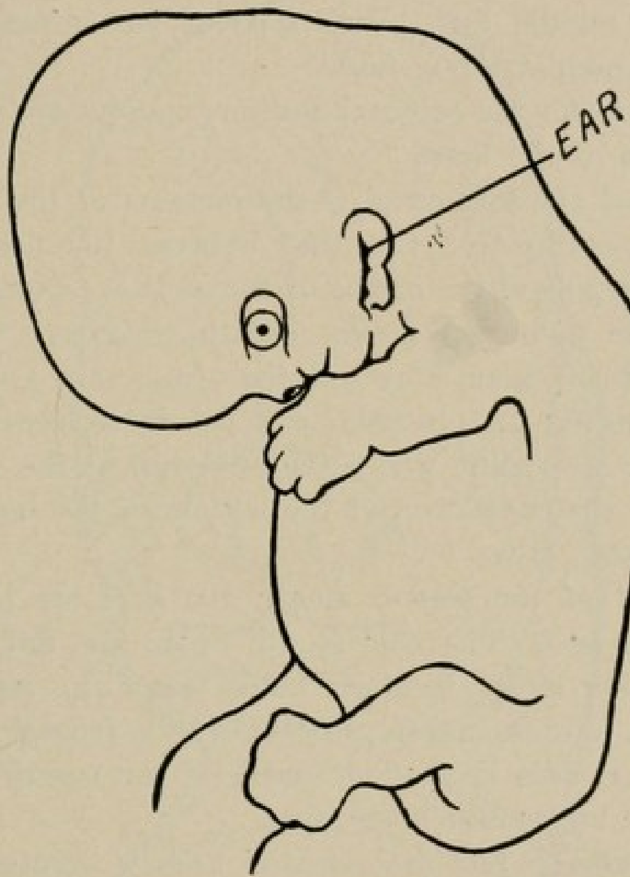

Fig. 84.—Embryo about Eighth Week. Development of face well advanced.

in the center and broad; the extremities of this middle nasal process have become fused with the lowest and most internal part of the superior maxillary process, and by this union the upper lip is formed and at the same time the olfactory grooves are bounded below, and are thus converted into round openings: the nostrils. If the superior maxillary process and middle portion of the frontal plate, middle nasal process, fail to unite, we have, as a result, a cleft in the lip,—harelip; this may or may not reach into the opening of the nostril: *i.e.*, may be complete or incomplete according to the extent to which the parts have failed to unite.

The lower edge of the superior maxillary process becomes partially united with the upper border of the mandibular process, the inferior maxillary process, which has also become thickened, and in this way the size of the mouth is much diminished. If this union falls short of normal we have a characteristic deformity: macrostoma or transverse facial cleft. The face, as a whole, is, therefore, at this period closed in, but the nostrils are still far apart, the nose broad, and perfectly flat and directly forward, and the upper lip is still notched in the middle line. This type of face often persists, and we then have a peculiar "pug face."

The openings for the external auditory meatus are seen low down upon either side of the head.

The external auditory canal is the remains of the posterior part of the first visceral cleft: *i.e.,* that between the first and second arches. The margins of the orifice of the auditory canal later become nodulated; these nodules coalesce, and in this way the auricle is formed. The Eustachian tube and the tympanum are the remains of the corresponding first internal cleft (from pharynx). The ear-drum represents the point where the epiderm, at the bottom of the outer cleft, and the endoderm, at the bottom of the inner cleft, have coalesced with each other.

At the end of the second month the eyes are located toward the front of the face. The nose is still broad and flat, although the nostrils are rather closer together. The upper lip, representing the middle portion, middle nasal process, of the frontal plate, is still notched in the middle line. The cavity of the mouth is fairly well closed in by the upper and lower lips.

To recapitulate: The first visceral arch is eventually developed into the inferior maxillary bone and the adjoining soft parts, including the lower lip and the floor of the mouth, and assists in the formation of the tongue. The superior maxillary process of the first visceral arch is developed into the superior maxillary bone and the adjoining soft parts, including the hard and soft palate. The frontal plate, its lateral portion, the lateral nasal process, forms the side of the nose, including the nasal bone; its middle portion, the middle nasal process, forms the bridge of integument between the nostrils, reaching from the tip of the nose to the upper lip, and the cartilaginous and bony portions of the nasal septum (vomer and perpendicular plate of the ethmoid); also the middle portion of the upper lip and intermaxillary bone.

The intermaxillary bone was first described by the poet Goethe. It is a small, wedge-shaped, bony process which is attached to the anterior end of the vomer and fits into a corresponding triangular space in the anterior part of the hard palate, and carries the four incisor teeth. The line of union between this bone and the palatal processes of the superior maxillary may often be plainly seen in the

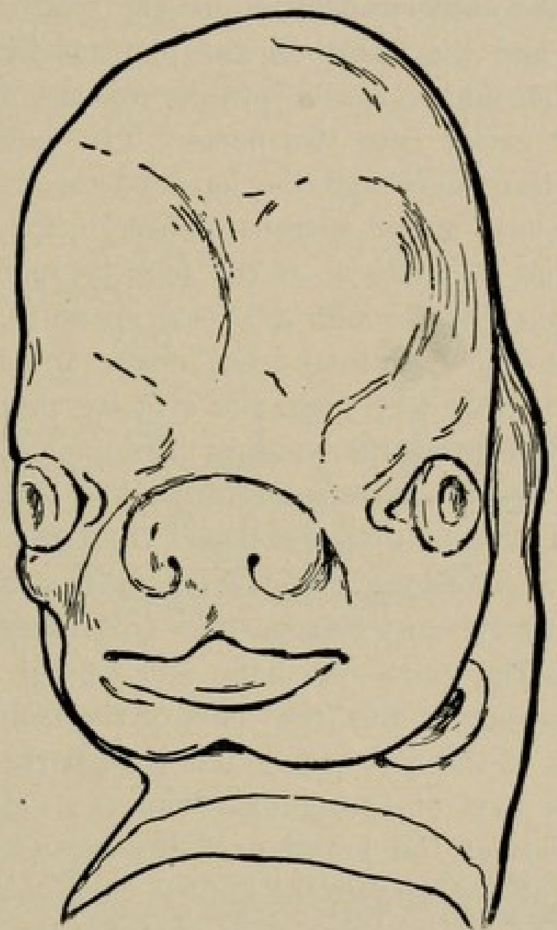

Fig. 85.—Face of Embryo about Eighth Week. The various processes that go to make up the face have coalesced, but the embryonal type of the face is still well marked. Eyes located upon the side of face. Ears low down. Nose flat and projecting forward, with nostrils far apart. Upper lip still notched in the middle.

adult upper jaw-bone. The anterior palatine canal marks the junction of these parts. A non-united, abnormally placed intermaxillary bone often complicates harelip.

Formation of the Palate.—The superior maxillary process of either side gives off, upon its inner aspect, a shelf-like process: the palate process. These processes gradually grow toward the middle line and unite with each other, and thus form the hard and soft palate, the union taking place from before backward, the uvula being the last part to unite. Union between the palatal processes is complete at about the eleventh week. With the formation of the hard and soft palate, the nasal cavity is separated from the oral, or mouth, cavity. Failure of union between the palatal processes gives rise to the various degrees of cleft palate. In front, where the two halves of the hard palate join with the intermaxillary bone, there are a suture line and the anterior palatine canal.

The vomer and the perpendicular plate of the ethmoid are developed from the middle nasal process of the frontal plate, and divide the nasal cavity into two parts. The junction between the lower border of the vomer and the hard palate occurs after the two palatal processes have united with each other in the middle line. The nasal cavity opens in front upon the face through the nostrils and behind into the pharynx through the posterior nares.

The Teeth.—The margins of the upper and lower jaw become prominent, and in this way form the alveolar processes; the epithelium covering these processes becomes invaginated,—dips down into the substance of the processes,—and from this the teeth are formed.

The floor of the mouth is developed from the first visceral arch.

The Tongue.—The tongue is developed, its anterior portion from the first arch and its posterior portion from the second and third arches. The anterior part—the body and tip—is developed from a tubercle which appears in the front part of the mouth at the junction of the two halves of the first arch. The back part, the root, is developed in the back part of the mouth from the wall of the pharynx, from two tubercles at the junction of the second and third arches. These two parts of the tongue, the anterior and the posterior, become joined, the line of union being indicated by the V-shaped row of papillæ upon the dorsum of the adult tongue. At the apex of the V there is a dimple, the foramen cæcum, which indicates the point of junction of the parts of which the tongue is formed. As the tongue is developed, it increases rapidly in size, occupying the mouth cavity and projecting up into the future nasal cavity. As the palatal processes grow inward to meet each other in the middle line, however, the tongue is gradually forced down into the mouth cavity proper, where it belongs. The thyro-glossal duct, which leads from the thyroid gland into the foramen cæcum, may persist in the form of an open duct or as a cystic enlargement in the base of the tongue, floor of the mouth.

Deformities of the Face.—These consist of abnormal clefts and atresias, which may be partial or complete.

Clefts are due to entire or partial absence of normal union between the original embryonal processes by whose coalescence the face is formed. Atresias are caused, on the other hand, by excessive union, beyond the normal, between these processes, and as a result we get a partial or complete closure of the facial orifices: mouth, nostrils, and eyes. Still further, the union between the processes may occur to its normal extent, but the lines of union may remain permanently marked by cicatricial seams or irregular tags and nodules.

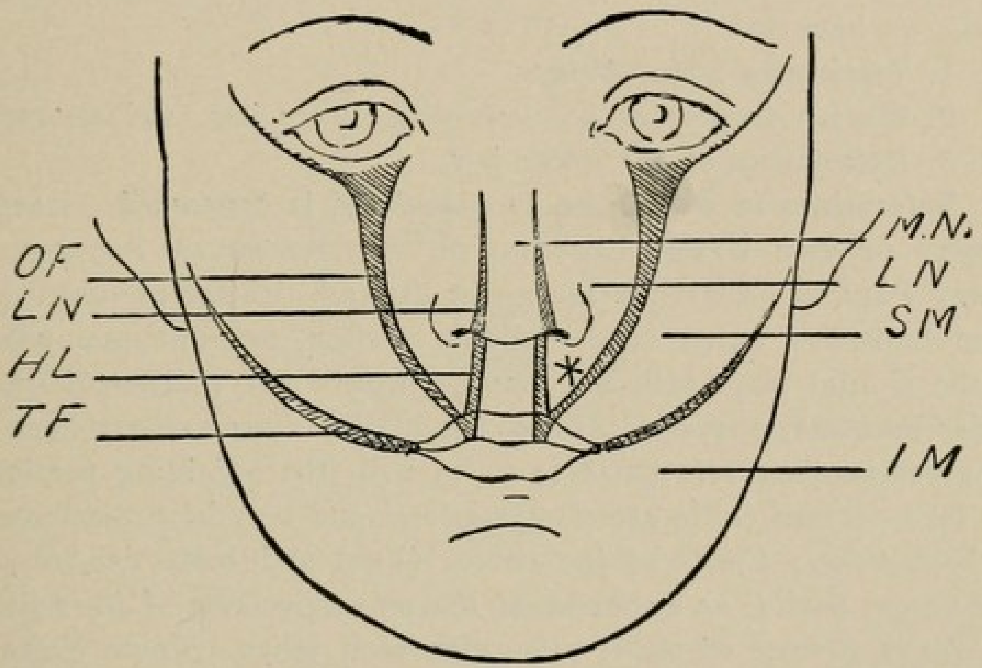

Fig. 86.—Diagram of Congenital Facial Clefts. Shaded portions indicate the location of the different congenital fissures. *HL*, harelip; *IM*, inferior maxillary process; *LN*, *, lateral nasal process of frontal plate; *LN*, lateral nasal cleft; *MN*, middle nasal process of frontal plate; *OF*, oblique facial cleft; *SM*, superior maxillary process; *TF*, transverse facial cleft; *, lower part of lateral nasal process which takes part in the formation of the upper lip, but not of its red border; the free red margin of the lip is formed by the union of the lower part of the middle nasal process (*MN*) and the lower part of the superior maxillary process (*SM*).

The failure of the embryonal processes properly to coalesce, with the resulting clefts, is really due to the incomplete development of the processes themselves; they are deficient: *i.e.*, too small to meet each other, and hence the clefts. The clefts vary in degree from narrow, incomplete fissures to widely gaping spaces. The margins of the clefts may be smooth or they may be irregular and marked by nodular processes, tags, etc.

The congenital deformities of the face may be divided into two general groups:—

(A) Those in which the frontal plate or process is concerned. Under this heading we have:—

1. Lateral clefts of the upper lip and the alveolar process; clefts of the palate may also be conveniently included in this group.

2. Median clefts or notches of the upper lip and deformities of the nose.

3. Notching of the wing of the nose.

4. Oblique facial fissures, etc.

(B) Those in which the first visceral arch is involved. In this group we have:—

1. Transverse facial fissures.

2. Median fissures of the lower lip, lower jaw, and tongue.

3. Deformities of the lower jaw.

Deformities in which the Frontal Plate is Concerned. Lateral Clefts of the Upper Lip and of the Alveolar Process and Cleft Palate.—Clefts of the upper lip and alveolar process depend upon imperfect union of the middle portion, middle nasal process, of the frontal plate with the corresponding lower portion of the superior maxillary processes: to failure of the intermaxillary bone and its accompanying soft parts to unite with the adjoining portion of the face. These clefts are always lateral and may be present on one or both sides. Clefts of the palate (hard and soft) depend upon non-union, partial or complete, of the palatal process of the superior maxillary process of either side with each other. These clefts are median when the processes of both sides are at fault. If the palatal process of one side only is involved, the fissure will be present upon the corresponding side of the middle line, the palatal process of the other side being joined with the lower border of the vomer, thus shutting off the nasal cavity, on that side, from the mouth.

If union has failed, on both sides, between the middle process of the frontal plate, the middle nasal process, and the corresponding part of the superior maxillary process of either side (double harelip and fissure of the alveolar process) and between the palatal processes of the superior maxillary processes of either side (cleft of the hard and soft palate), we have the most extreme variety of this group of deformities. There are found all degrees of this variety of deformity from this exaggerated form down to a mere notching of the upper lip (incomplete harelip) or bifurcation of the uvula.

Harelip.—This condition may be incomplete or complete.

Incomplete harelip consists in a vertical notch in the free margin of the upper lip. It is located to one side of the middle line between the middle segment and the lateral segment of the lip. It varies in depth from a barely noticeable notch to a deep fissure which may extend almost through the entire lip, leaving but a narrow bridge of integument separating the angle of the notch from the nostril.

In complete harelip the fissure extends all the way through the upper lip into the nostril. It may be associated with cleft of the alveolar process and with cleft palate. The nose is unusually broad and flattened, the wing of the nose, on the side corresponding to the cleft, being carried outward away from the middle line. These deformities may involve one or both sides. If double, those of the two sides may differ from each other; the fissure on one side may be complete, that of the other side incomplete, or those of both sides may be complete. They may be associated with cleft of the alveolar process and with cleft palate, the intermaxillary bone often being small and misplaced forward. The entire middle segment of the lip may be absent, together with the intermaxillary bone and the vomer. In this case the upper lip shows a broad, median space, which opens into the nasal cavity.

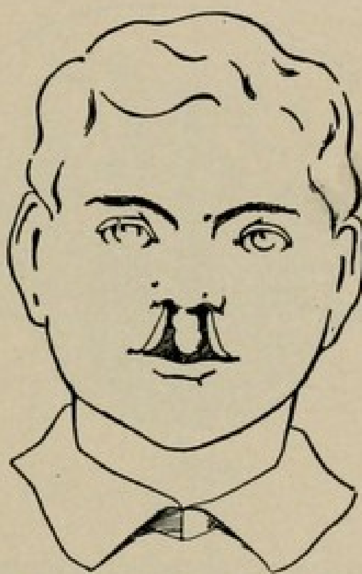

Fig. 87.—Double Complete Harelip.

Cleft of the Alveolar Process.—With harelip, as already mentioned, there may also be present a cleft of the alveolar process, and this may vary from a narrow, incomplete fissure to a broad, open space; it may be unilateral or double, and is usually associated with cleft palate. If there is no cleft of the hard palate, the cleft of the alveolar process terminates at the anterior palatine foramen: the meeting point of the palatal process of either side and the intermaxillary bone. If the cleft in the alveolar process involves both sides, the intermaxillary bone, which is continuous with the front of the vomer, may be placed forward in advance of the rest of the alveolar process, especially if cleft palate is also present; so that it and the corresponding portion of the upper lip seem to be suspended

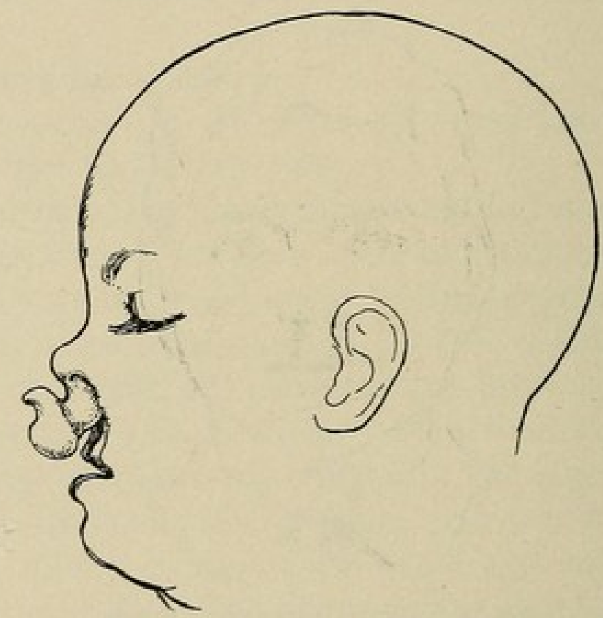

Fig. 88.—Harelip with Advanced Intermaxillary Portion.

from the point of the nose. In this case the lower tegumentary part of the septum of the nose is absent, the soft parts which represent the middle part of the lip being continued directly with the tip of the nose. This advancement of the intermaxillary bone is due to the unrestricted forward growth of the vomer, which is not inhibited as is normally the case when it is joined to the palatal processes. If the cleft is confined to one side of the alveolar process and the hard palate, the intermaxillary bone, as it is carried forward by the growth of the vomer, is apt to become markedly twisted upon its long axis, so that its anterior surface, instead of being directed forward, looks almost directly toward the normal side of the face, presenting its prominent sharp lateral edge anteriorly. The intermaxillary segment may be entirely absent, as already mentioned.

Cleft Palate.—The presence of a longitudinal fissure which may involve the hard or soft palate or both. It is caused by a failure of the palatal processes of the superior maxillary processes to meet in the middle line and coalesce. In these cases the base of the skull may be unusually broad and the pterygoid processes unusually far apart.

Cleft of the Hard Palate.—This may be unilateral or double. If one-sided, the palatal process of the normal side is seen to be united with the lower border of the vomer, shutting off that side of the nasal cavity from the mouth, while upon the affected side the palatal process is deficient and falls short of meeting its fellow of

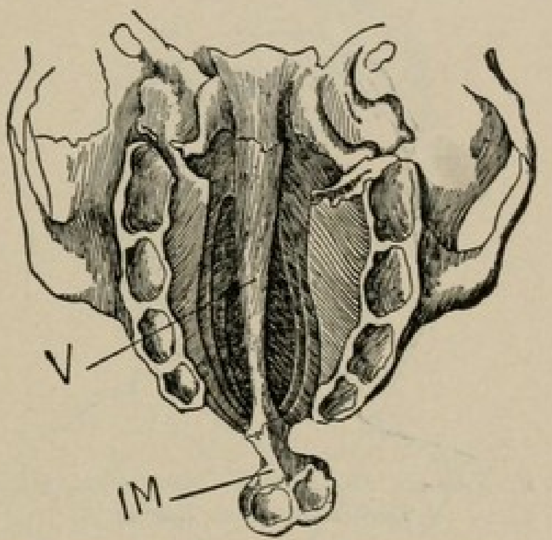

Fig. 89.—Double Cleft Palate with Advanced Intermaxillary Portion (*IM*) Carrying the Sockets of Two Incisor Teeth. *V*, vomer (septum of the nose).

the opposite side, and there is thus left an opening which leads into the corresponding half of the nasal cavity. In double cleft palate both palatal processes are deficient, and the lower free edge of the vomer may be seen between the separated edges of the cleft. Usually the lower border of the vomer does not reach low enough to present itself in the fissure between the edges of the cleft, and the cleft thus has the appearance of a median cleft when it is, in reality, a bilateral, or double, cleft.

At times we may find the palatal processes of either side properly united with each other, but the vomer fails to grow down sufficiently far to articulate with them, and there is thus left a space below the lower border of the vomer through which the two sides of the nasal cavity communicate with each other. The vomer does not play any part in the formation of the hard palate.

Cleft of the hard palate ends anteriorly, either at the anterior palatine foramen, which marks the point of junction between the intermaxillary bone and the palatal processes of the superior maxillaries, or else it is combined with a single or double cleft of the alveolar process and harelip. It usually ends, posteriorly, in cleft of the soft palate.

In cleft palate, especially if double, the forward growth of the vomer is unrestricted on account of its not being joined to the palatal processes, and by this forward growth the intermaxillary bone and its corresponding soft parts may be carried forward beyond the line of the alveolar processes, the intermaxillary bone often being bent

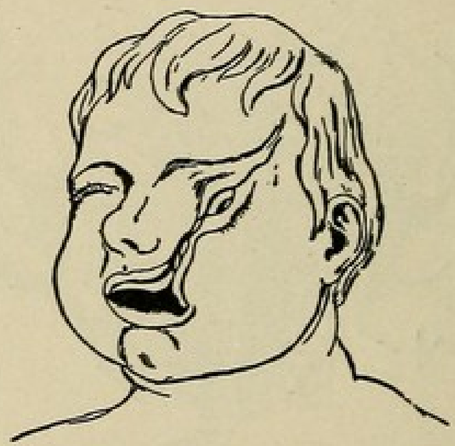

Fig. 90.—Oblique Facial Cleft Extending into the Temporo-frontal Region.

upward or twisted upon its long axis (see Fig. 89). This advancement of these parts adds very much to the difficulty of correcting the deformity.

Cleft of the Soft Palate.—The fissure extends from the tip of the uvula for a varying distance into the soft palate. It may be simply a bifurcation of the uvula, but, as a rule, it extends all the way through the soft palate as far as the posterior border of the hard palate or for some distance into the hard palate. It may be combined with a lateral or double cleft of the hard palate. As is the case with cleft of the hard palate, there is not only a simple lack of union between the two halves of the palate, but an actual deficiency of tissue which prevents the parts from meeting and coalescing in the middle line, and this fact is important in considering the operative treatment of this condition.

With the exaggerated forms of cleft palate there is frequently associated imperfect development of the middle nasal process of the frontal plate or it may be entirely absent: the intermaxillary bone may be absent, with or without absence of the vomer. If the intermaxillary bone, etc., are absent, we have a median cleft of the upper lip, or, better, a double harelip with absence of its middle segment; and this condition is usually associated with a broad cleft in the hard and soft palate, and the nose may be soft and flattened, on account of the absence of the nasal septum, etc. This condition is apt to be accompanied with defective cerebral development.

Median Clefts and Notches of the Upper Lip.—These deformities depend upon exaggeration and persistence of the embryonal

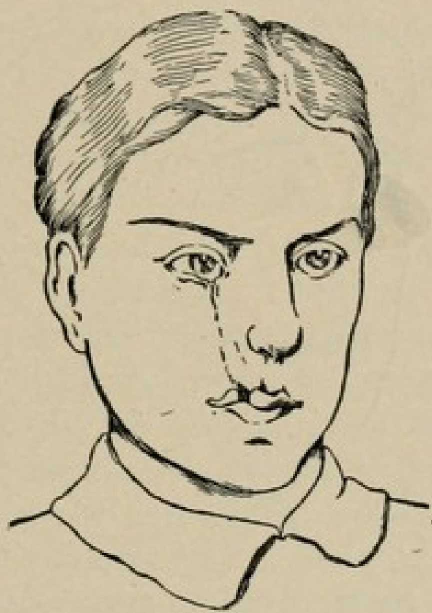

Fig. 91.—Incomplete Oblique Facial Cleft. The edge of the upper lip is notched and a cicatricial line extends across the cheek to the lower eyelid, which is everted.

notch of the middle portion, the middle nasal process, of the frontal plate and failure of the nostrils to approach each other. These defects are much less frequent than the preceding. There may be simply a notch or fissure in the middle of the upper lip reaching part way through, or this may be combined with a grooving or furrow upon the point and dorsum of the nose and a wide separation between the nostrils. This condition may be so pronounced that the nose appears to consist of two halves completely separated from each other and each containing one nostril. Instead of this extreme degree of deformity the nose may be simply flattened, the bridge depressed, the nostrils far apart and looking directly forward: "dog nose." The fissure in the upper lip instead of simply notching the lip may extend completely through the whole lip and into the intermaxillary bone. This variety of deformity may also be represented by a fistula of the tip or dorsum of the nose.

Lateral Nasal Clefts.—These occur with or without harelip and cleft palate; the notch or fissure involves the wing of the nose. If they extend upward for a considerable distance through the side of the nose, they terminate above, not in the inner canthus, but to the inner side of the inner corner of the eye; they represent the embryonal notch between the middle and lateral nasal processes of

Fig. 92.—Transverse Facial Cleft.

the frontal plate. Fissures of the side of the nose, that resemble these, but terminate above in the inner canthus of the eye, are varieties of oblique facial clefts.

Oblique Facial Clefts.—Failure of normal union between the lateral process of the frontal plate and the superior maxillary process of the first visceral arch. They correspond to the embryonal orbitonasal line of coalescence. These deformities may be very extensive or slight: one-sided or double. They commence below at the edge of the upper lip, and, after splitting this at the usual harelip site, extend upward through the cheek, alongside of the wing of the nose, not into the nostril like harelip, and terminate above, at the lower margin of the eye (lower lid) or inner canthus. They may extend beyond the orbit, from its outer corner, upward and outward into the fronto-temporal region of the skull. They vary from a narrow fissure or incomplete notch to a wide, gaping fissure, between the edges of which is the eyeball. This class of deformity is frequently represented in its simplest form by a notch or coloboma of the lower or upper eyelid. Instead of a fissure, this deformity may be represented by a cicatrical, nodulated seam, indicating the orbito-nasal junction.

Deformities in which the First Visceral Arch is Concerned. Transverse Facial Clefts, etc.—These are due to a failure of the inferior maxillary process of the first visceral arch and its superior maxillary process to coalesce to the normal extent. This deformity may be unilateral or double. The cleft extends from the corner of the mouth outward through the cheek and exposes the teeth: macrostoma. If the reverse of this process occurs, we may have a mouth so small as to require surgical interference: microstoma.

Median Clefts of the Lower Lip, Lower Jaw, and Tongue.—These conditions are very rare. They are due to failure of the two halves of the first visceral arch (mandibular processes) to unite with each other in the middle line. They vary from a slight notching of the lower lip, in the middle line, to a complete separation through the lower lip, the lower jaw at the symphysis, and the tongue. The tongue, by itself, may be split or absent or bound down to the floor of the mouth or adherent to the side of the cheek, etc.

The lower jaw may be imperfectly developed, rudimentary, etc. It may be split in the middle line or there may be absence of the condyles, etc. As the formation of the face advances the jaw is gradually protruded forward, and, if arrested, we have, as a result, the receding chin, etc.

OPERATIONS FOR HARELIP AND CLEFT PALATE, ETC.

Operations for Harelip.—In speaking of harelip—if single—the flap corresponding to the angle of the mouth is called the lateral flap, or segment, and the other, the middle; if the harelip is double, one speaks of the middle segment and two lateral segments, the right and the left.

Early operation, within a few days or weeks after birth, is desirable. If the child has been nursing it may continue to nurse after the operation. If the baby is bottle-fed it will be necessary to feed it with a dropper for several days after the operation. At the time of the operation the child should be free from intestinal and bronchial trouble.

For very young children, a few days to a few weeks old, little or no anæsthetic is necessary. A few drops of chloroform occasionally upon the Schimmelbusch mask will suffice. For older children more complete anæsthesia is desirable, using ether, drop by drop, upon the mask with an occasional few drops of chloroform.

The child is wrapped in a blanket in such a way that the arms and legs are confined and then held upright in the arms of a nurse who sits opposite the operator. The child's head is steadied by an assistant, who thrusts the head a little forward to prevent the blood entering the mouth during the operation. It may be more convenient in some cases, especially older children, to place the child flat upon the back with the shoulders raised high upon a sandbag and the head hanging low in the Rose position.

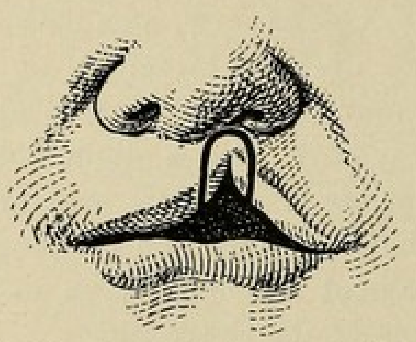

Fig. 93.—Simple Paring of the Edges of the Notch for Incomplete Hare-lip.

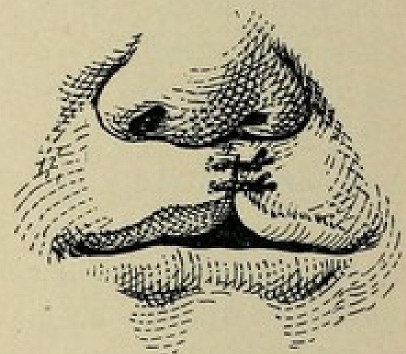

Fig. 94. — Imperfect Result After Simple Paring and Suture, Showing the Notch Still Present.

The instruments that are required consist of a sharp, narrow-bladed knife with a sharp point, several tenacula, mouse-tooth forceps, and narrow-bladed, sharp-edged scissors. The steps of the operation consist in freshening the edges of the cleft and suturing. In freshening the edges one should cut with a view to providing broad, raw surfaces for apposition; they should be cut somewhat obliquely, and more taken away from the skin than from the mucous surface. During this step of the operation the hemorrhage may be controlled by an assistant, who compresses either segment of the lip between the finger and thumb. With the mouse-tooth forceps the edge of the defect is seized and transfixed with a knife, and the incision made with care and deliberation. In order to bring the raw surfaces into apposition it may be necessary to liberate the flaps by cutting them free from their attachment to the deeper adjoining parts: from the alveolar process and the anterior surface of the superior maxilla.

After the edges of the defect have been pared, the flaps cut, etc., the corresponding edges of the flaps are brought into very accurate apposition with a sufficient number of silk sutures. A number of these sutures are of rather heavy silk. These are introduced with a fairly large straight needle, penetrating deep into the substance of the lip, down to, but not through, the mucous membrane and

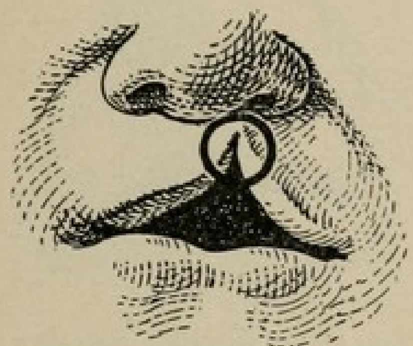

Fig. 95.—Von Graefe Method of Paring an Incomplete Harelip so as to Increase the Length of the Raw Apposed Edges.

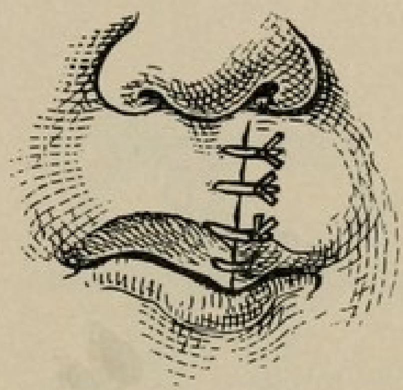

Fig. 96.—Result After Suturing.

should take a good hold. Between these sutures the skin and the mucous membrane on the inside of the lip are brought accurately together, edge to edge, with a number of superficial sutures of finer silk. No dressings whatever are applied.

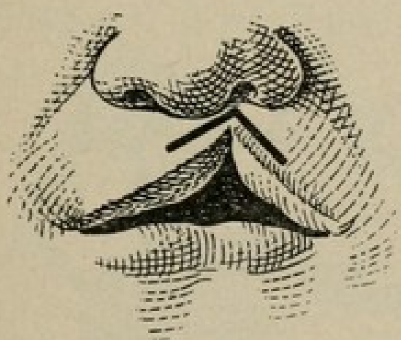

Fig. 97.—Nélaton Operation for Incomplete Harelip. Line of incision.

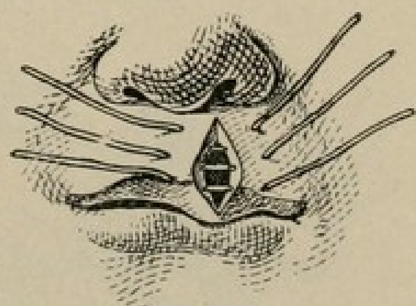

Fig. 98.—Incision Converted into a Perpendicular, Ready for Suture.

Operations for Incomplete Harelip. Simple Freshening of the Opposing Edges and Suture.—This plan would not answer even for incomplete harelip, since a notch would remain which would increase with time as the scar contracts, especially if the cleft is deep.

Von Graefe proposed a very simple method to increase the length of the apposed edges of the freshened surfaces. This method will answer, however, only for the very incomplete defects, and not for wide or complete splits. It consists in paring the edges of the notch by making a circular incision, which arches over the corner of the notch.

NÉLATON METHOD.—Without removing any tissue, an incision is made through the substance of the lip, around the corner of the notch and parallel with its edges, and after converting this incision

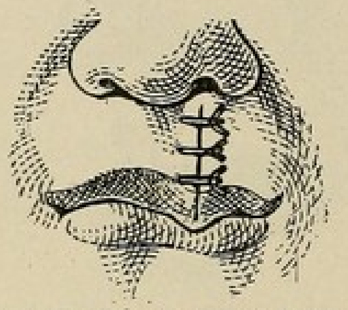

Fig. 99.—Result After Suture.

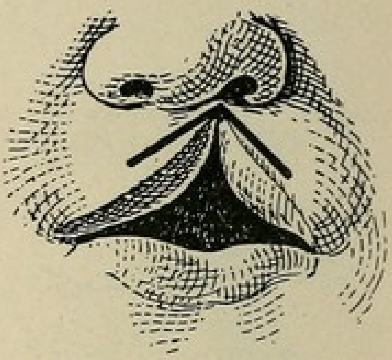

Fig. 100.—Malgaigne Operation for Incomplete Harelip. Paring and formation of flaps.

into a vertical one its edges are united with several interrupted stitches.

MALGAIGNE proposed to close the defect, especially where the defect is considerable, by making use of flaps in addition to freshening the edges. In his operation the tissue is removed from the

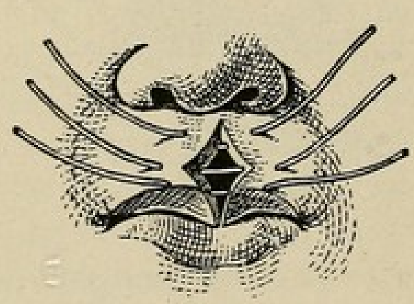

Fig. 101.—Flaps Turned Down, Ready for Suture.

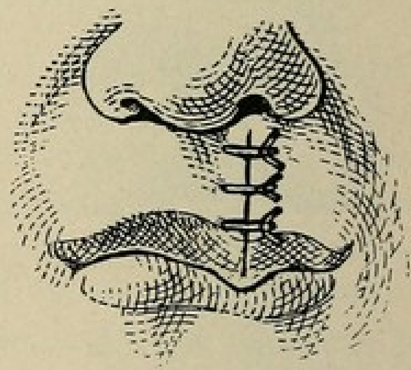

Fig. 102.—Result After Parts have been Sutured.

angle of the notch only, the second part of the operation consisting in the formation of two flaps by simply cutting into the substance of the lip along either side of the defect, commencing near the angle and cutting toward the red border of the lip. The base of the flap should be no thicker than the red of the lip; otherwise it is very difficult to turn it down. The tongues of tissue thus marked out are turned down and sutured together, with the result that the cleft is not only filled in, but a little tongue of tissue is left projecting beyond the free line of the lip to allow for future retraction.

The objection to this operation is that, on account of the considerable torsion to which the flaps are subjected, their nourishment is uncertain and they may become gangrenous, especially in very young and poorly nourished children.

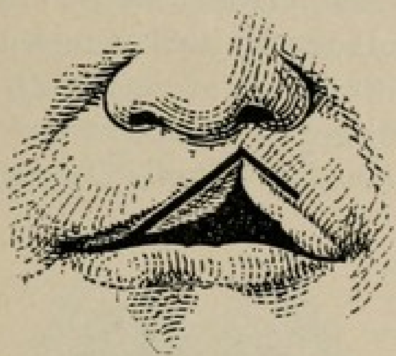

Fig. 103.—Mirault Operation for Incomplete Harelip. Paring and formation of one flap.

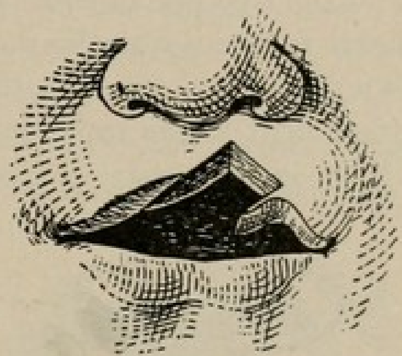

Fig. 104.—Parts Ready for Suture.

Mirault's operation is an improvement on Malgaigne's. Only one flap is made, and that is taken from the edge of the lateral segment. The flap which is thus formed is sutured to the freshened edge of the middle segment. This single flap is not likely to become gangrenous as is the Malgaigne, because it is not necessary to turn

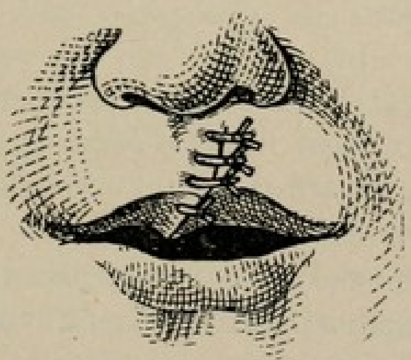

Fig. 105.—Result After Suture.

it down so far, and, secondly, because its base may be made sufficiently broad to include the coronary vessels. In forming the flap a single cut is made into the substance of the lip proper, striking well above the red margin so that the base of the flap corresponds to the lower third of the breadth of the lip. This is a very satisfactory operation.

Operations for Complete Harelip.—Cases in which the split extends through the entire width of the lip into the nostril.

In these cases it is not only necessary to freshen and prepare the edges for suture, but in addition it will be necessary to separate the flaps from their bony attachments, alveolar processes, etc., in order that the raw surfaces may be brought together and sutured without tension. The entire width of the lip from the nasal opening down to the free border must be sutured and an effort made to correct the nasal deformity at the same time. It usually suffices to separate the outer or lateral segment, that nearer the corner of the mouth, from its attachment to the superior maxillary bone. Only in extreme cases does it become necessary to detach the other flap as well. To separate

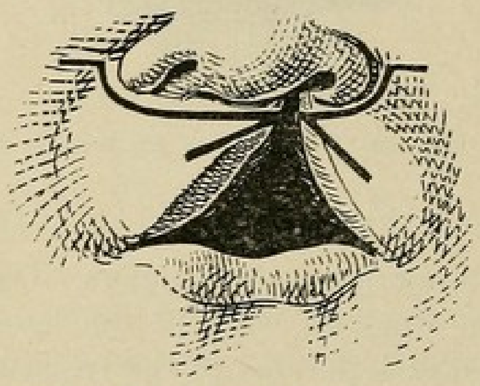

Fig. 106.—*Wellenschnitt* for Complete Harelip. Incision carried around the alæ of the nose in order to liberate the segments. Formation of flaps by incision into each segment.

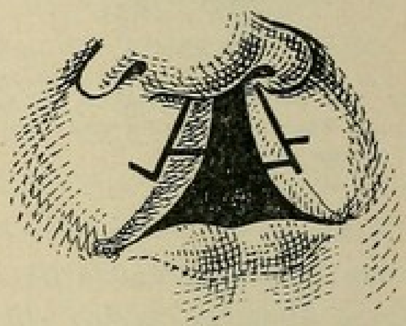

Fig. 107.—Hagedorn Operation for Single Complete Harelip. Lines of incision.

the flap from the underlying bone its edge is seized with a mouse-tooth forceps, and drawn inward toward the middle line, and forward, away from its attachment to the bone. In this way the fold of the mucous membrane which attaches the lip to the gum is put upon the stretch, and may be incised with the knife, cutting toward the bone (superior maxillary). Further separation may be accomplished with the periosteum elevator. The separation is carried sufficiently far and deep to thoroughly liberate the lateral flap and the corresponding side of the nose and to allow of the parts being readily apposed without tension. Hemorrhage from this step of the operation may be considerable, especially if it is necessary to cut deep, but this is readily controlled by a few minutes' pressure with the fingers and a gauze pad. Any spurting vessels that are to be seen should be clamped and ligated with fine catgut.

Occasionally, in order to free the flap sufficiently it may be necessary to make an incision around the wing of the nose; this, however, is but seldom necessary (Dieffenbach's *Wellenschnitt*). The Mirault or the Hagedorn operation is usually done for this condition of complete harelip. The Mirault is quite analogous to that described for incomplete harelip. The entire vermilion edge is pared away from the inner segment of the lip and a flap consisting of the vermilion margin of the lateral segment cut and turned down. The results from this method of operating are very satisfactory.

HAGEDORN's operation consists in paring away the edges of each flap, first from the margin of the lateral flap,—that nearer the angle of the mouth,—and then from the margin of the other flap. A

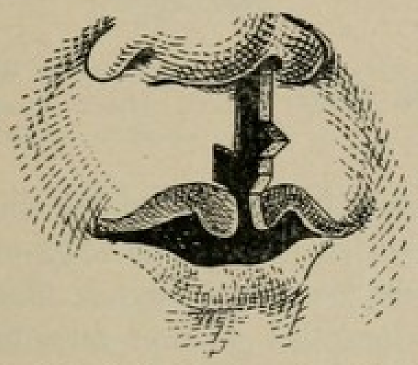

Fig. 108.—Parts Freshened and Ready for Suture.

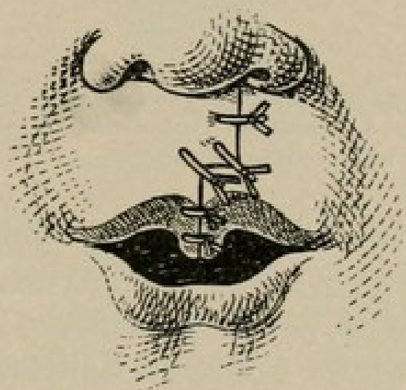

Fig. 109.—Result After Suture.

horizontal incision is then made into the substance of the lateral flap and an oblique one into the median flap. With a scissors, the long strips of vermilion border which have been pared away from the edges of the flaps are snipped off. When the parts are sutured there is left a little process hanging from the edge of the lip: this retracts in time. Before suturing the flaps they must be thoroughly separated from their bony attachments.

Operation for Single, Complete Harelip Associated with Cleft of the Alveolar Process and Advancement of the Intermaxillary Bone.—In these cases the intermaxillary bone, besides being misplaced, may be rotated upon its long axis in such a way that it presents, anteriorly, a prominent, sharp edge, which would greatly interfere with the healing process. Under these circumstances it becomes necessary to place the bone in its natural position. It is forcibly twisted upon its long axis and pushed back into place so that its sharp lateral edge will not project under the suture line in the lip. It may be necessary to divide the process from its attachment to the alveolus with the bone-forceps or the chisel and force it into position by rotating it partly upon its long axis. After the intermaxillary bone has been forced back into position the defect in the lip may be closed by any of the methods described above.

Operation for Double Harelip without a Prominent Advanced Intermaxillary Bone.—The middle segment is always found to be too

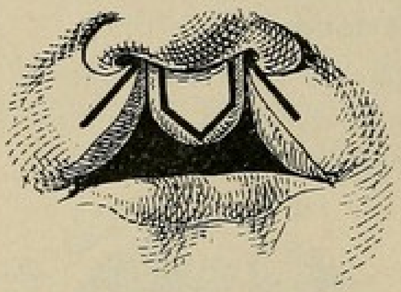

Fig. 110.—Double Mirault Operation for a Double Complete Harelip. Paring of edges of defects.

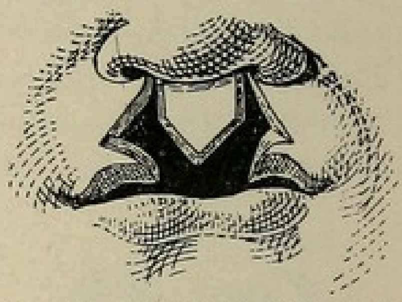

Fig. 111.—Flaps Turned Down Ready for Suture.

short to take part in the formation of the free border of the lip, but it may be used to form the middle portion of the lip. From the whole of the middle segment the mucous membrane edge is trimmed away, and a Mirault flap then made from the edge of each lateral segment. If the nose is flattened and the alæ spread out, this de-

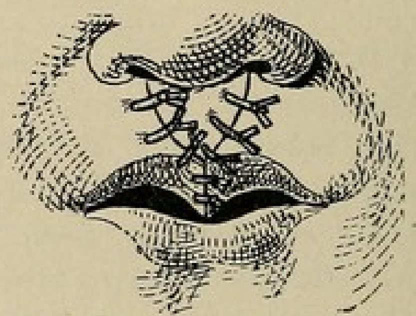

Fig. 112.—Result After Suture.

formity may be corrected by separating the lateral segments of the lips and the sides of the nose from their deep attachments—from the superior maxillary bone. The fold of mucous membrane that attaches the lateral segment to the alveolar process, etc., is snipped with the knife and the segment of the lip and the side of the nose are then freely separated with the periosteum elevator. The lateral segments of the lip must be very loose. Instead of the Mirault, a double Hagedorn may be done for this condition.

Operation for Double Harelip with Prominent Advanced Intermaxillary Bone.—The middle segment may be placed very far forward upon or near the point of the nose. This condition may be remedied by resecting the bony part of the prominent intermaxillary portion, leaving the soft parts to assist in making the lip. This should be avoided, however, if possible, as there results a very unsightly deformity; the lip is flat and has a sucked-in appearance

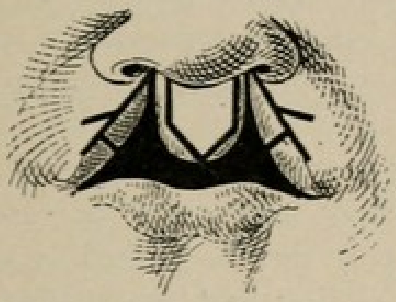

Fig. 113.—Hagedorn Operation for Complete Double Harelip. Paring and formation of flaps.

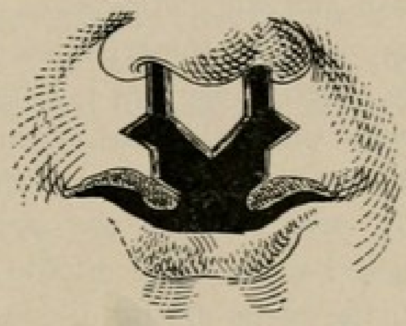

Fig. 114.—Parts Ready for Suture.

and lacks the support of the corresponding bony part, and besides the four incisor teeth are lost. The most satisfactory plan is to forcibly separate and replace the intermaxillary portion. In many cases, especially very young children, this can be accomplished by forcible pressure with the fingers. Usually, however, it will be necessary to

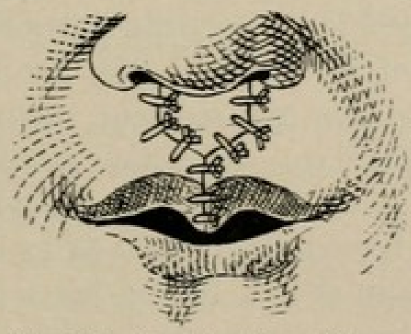

Fig. 115.—Result After Suture.

separate the intermaxillary portion from its attachment to the septum of the nose. It may be seized with the bone-forceps and broken away from the vomer, or the line of fracture may extend upward and backward through the vomer proper. The segment is then forced back into proper position and the edges of the flaps freshened and sutured. Blandin recommends the resection of a triangular-shaped portion from the nasal septum posterior to the intermaxillary segment. The base of the triangular piece of bone which is thus resected corresponds in width to the space that intervenes between the middle segment and the intermaxillary notch, its apex running upward into the septum of the nose. This resection may be very conveniently made with a pair of strong bone scissors. The apex of the resected triangular piece should be directed upward and forward, toward the bridge of the nose, in order to avoid cutting the anterior palatine vessels. The intermaxillary segment may then be readily forced back into proper position and the cleft closed. If the anterior naso-palatine artery is cut in removing the triangular piece of bone, the hemorrhage will be severe. Bardeleben has modified the above procedure in that he first separates the periosteum, upon either side of the septum, behind the middle segment, and then, with the ordinary strong, straight scissors, simply cuts through the septum without attempting to resect a triangular piece. The middle segment may then be pushed back into place, the edges of the divided septum sliding past one another and overlapping.

It will be necessary to liberate the lateral segments of the lip sufficiently from the alveolar processes of the superior maxillary in order to bring them together and suture them. In addition to detaching the flaps with the periosteum elevator it may be necessary to make an incision upon either side of the nose, around the alæ (Wellenschnitt of Dieffenbach) before they are sufficiently loose. This incision should be avoided, however, if possible.

If the projecting middle segment has not been replaced early, during the first year of the patient's life, the problem becomes much more difficult because later the segment becomes too large and the corresponding intermaxillary space too small to accommodate it. Many surgeons make it a rule to excise the advanced intermaxillary bone entirely. This is undesirable and is to be avoided if possible, as the support of the lip is lost, the lip has a flat, sucked-in appearance, and the four incisor teeth are lost; but, of course, a dental bridge and artificial teeth can be fitted to substitute for these. If the intermaxillary bone is replaced it usually becomes firmly united to the adjacent bony parts in the course of four or five months. It may, however, remain rudimentary and wabbly, and the incisor teeth may be crooked and imperfect. If a considerable part of the septum of the nose has been removed, in order to place the intermaxillary portion in its normal position, the point of the nose will be drawn down so close to the front of the face as to give it a peculiar flattened, "bird-like" appearance. This condition improves as the child grows.

Operation for Cleft Palate.—The cleft may be limited to the soft or hard palate or may extend through both.

The operation upon the soft palate is called staphylorrhaphy; that upon the hard palate, uranoplasty. Cleft palate is frequently combined with harelip. This latter condition may be remedied during the first few weeks of life, leaving the cleft in the palate until later, until the child is about one year old. The cleft in the palate diminishes in size as the child grows if the harelip has been cured. Eighteen months to two years is the age usually selected for closing the cleft in the palate. The child should be well nourished, weighing twenty-five to thirty pounds, free from bronchial and intestinal dis-

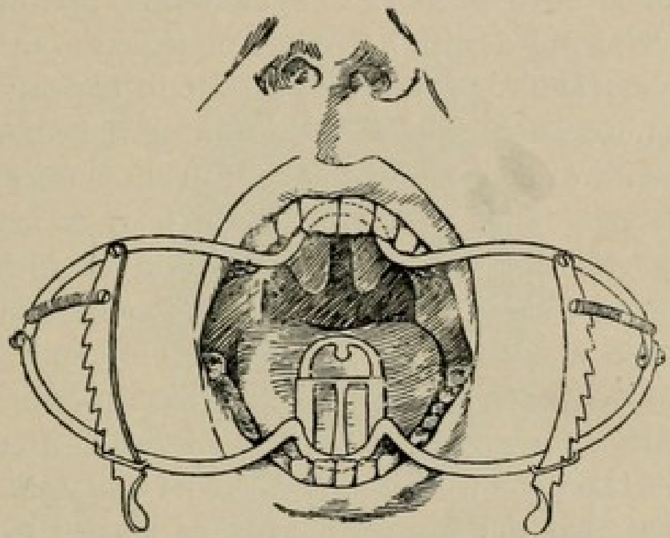

Fig. 116.—Whitehead Gag and Tongue Depressor in Place. For operations upon the hard and soft palate.

turbance. Summer is the preferable time for operation. Cleft limited to the soft palate may be operated upon earlier,—before one year. The operation for closure of a complete cleft may be done in two sittings: closure of the hard palate first and the soft palate subsequently at a second sitting. As a rule, however, it is preferable to close the entire cleft at one sitting.

The operation is best done with the child lying upon the back, the shoulders raised high upon a sandbag, and the head hanging low in the Rose position. The child should be completely anæsthetized (chloroform with ether) administered by vapor method through a bent tube introduced into the mouth or Lumbard's nasal tubes may be used. The mouth and nasal passages are thoroughly cleansed with saline solution before commencing the operation. The jaws are held wide open with a Whitehead gag. In some cases it will be found more convenient to remove the tongue depressor of the gag. At times it is difficult to adjust the tongue depressor, which may press the tongue back upon the glottis and interfere with breathing. In all cases a strong silk suture is passed through the tongue so that it may, at all times, be readily pulled forward. Bleeding during the course of the operation is controlled by pressure with hot wipes on long sponge-holders, and the operation should be interrupted at short intervals for this purpose. Usually the hemorrhage is simply an oozing from the cut edges. By carefully minimizing the loss of blood we are enabled, with safety, to operate upon quite young children—less than one year old. The throat is kept clear of blood with small wipes on long, slender holders. For the first few days after the operation the child is fed with a dropper or it may continue to nurse.

STAPHYLORRHAPHY.—Closure of a split in the soft palate. The first step of the operation consists in freshening the edges of the cleft. The free extremity of one side of the split uvula is seized with a long mouse-tooth forceps, and, while the uvula is thus held taut, it is transfixed, near its tip, with a narrow-bladed, sharp-pointed knife, and with a sawing motion a thin strip is cut away from its margin; the edge is pared along the entire extent of the split from the tip of the uvula to the posterior border of the hard palate. The margin of the other half of the soft palate is then freshened in a like manner. Care should be taken to freshen the angle of the split. The strips should be so cut that the freshened margins present a beveled edge, more tissue being taken away from the buccal than from the nasal aspect of the soft palate, so as to give us broader surfaces for suture. After the edges have been freshened, an attempt should be made to appose the raw edges in order to estimate what degree of tension, if any, exists. It is absolutely necessary that there be no tension whatever. In order to overcome tension of the soft palate it may be necessary to make an incision in the soft palate upon either side. These incisions are made with a narrow-bladed knife, which is introduced just to the inner side of the hamular process. This process, which is located behind and internal to the last molar tooth, is very readily felt. These incisions pass through the entire thickness of soft palate, from behind forward, and divide the tendons of the levator and tensor palati close to the hamular process, where they spread out into the soft palate. As a rule it will not be necessary to make these lateral incisions, especially if care has been taken to thoroughly detach the soft palate from the posterior border of the hard palate and also from the adjoining portion of the pterygoid process, which corresponds to the most external portion of the posterior border of the hard palate. If this separation is thorough, the two halves of the soft palate hang perfectly loose and may be readily approximated without tension and the liberating incisions can be dispensed with. Even when the cleft is limited to the soft palate, it may be advantageous to raise a muco-periosteal flap, the same as

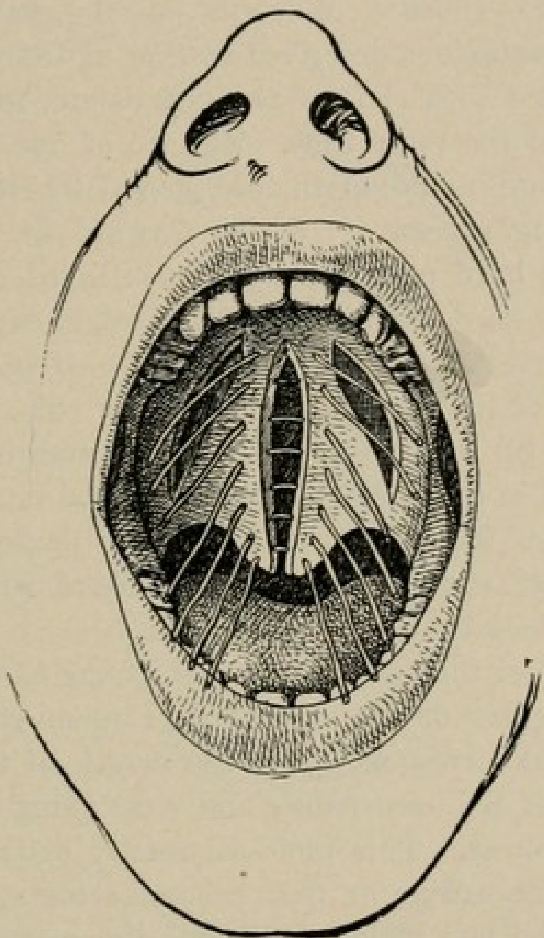

Fig. 117.—Repair of Cleft Palate. Muco-periosteal flaps raised and edges of cleft in hard and soft palate pared. Sutures all introduced and ready for tying.

when closing clefts of the hard palate; so that, working underneath this flap, close to the surface of the bone, we may be able to completely separate the soft palate from the posterior border of the hard palate. This step of the operation is accomplished with a periosteum elevator bent near the end to almost a right angle.

To unite the freshened edges of the soft palate a small, short, surgeon's needle with a moderate curve may be used. The needle is carried in a long needle-holder, and as it pierces the tissues its end may be seized with an artery forceps for the purpose of withdrawing it. A combination needle and holder in one piece is preferred by many surgeons. The stitches, which are of silk, are introduced from before backward and are not tied until they have all been introduced. From four to five sutures are required, and they should be placed about one-fourth inch apart. The edges of the soft palate should be accurately apposed without tension and free from hemorrhage.

URANOPLASTY.—Closure of clefts of the hard palate. The operation of Langenbeck as described by him in 1862. This condition is usually associated with cleft of the soft palate, in which case both should be closed at the same time. The tip of one side of the uvula is seized with a long, mouse-tooth forceps and transfixed as described above. The paring process is carried forward as far as the posterior border of the hard palate and then continued along the margin of the cleft in the hard palate, close to its edge, cutting through the muco-periosteal covering down to the surface of the bone, as far as the anterior limit of the cleft. Upon the other side, beginning, again, behind, near the tip of the soft palate, the margin of the cleft in the soft palate and in the hard palate is freshened in a similar manner. During this step of the operation one should pause occasionally for a few minutes and apply steady, firm pressure with a hot pad in order to control the bleeding.

The next step of the operation is the raising of a muco-periosteal flap from the surface of the hard palate upon either side of the cleft. An incision, corresponding to the length of the cleft, is made upon the surface of the hard palate and close along the inner margin of the alveolar process. This incision usually extends from a point anteriorly, near the canine or first premolar tooth, to a point posteriorly, beyond the last molar tooth into the commencement of the soft palate. If the incision is carried thus into the soft palate and the flap is sufficiently liberated from the posterior margin of the hard palate, as described below, the lateral liberating incisions in the soft palate may usually be dispensed with. In making this incision we should remember the point where the posterior palatine artery emerges from the canal in the back part of the palate and place the incision fairly close to the alveolar process so that this vessel may be left in the flap to nourish it and also in order that we may avoid the hemorrhage that would follow its division. Many surgeons claim that it is a matter of indifference whether this vessel is cut or not, as the flap is nourished just the same in either case and that the resulting hemorrhage is readily controlled by pressure; nevertheless one should try to avoid dividing it. Into this incision a sharp periosteum elevator is introduced,—it may be narrow and rather bent near the end,—and with this the muco-periosteal layer is lifted away from the surface of the bone and thus made very freely movable so that it can be brought over to meet the edges of the flap on the opposite side. Care should be exercised to separate the

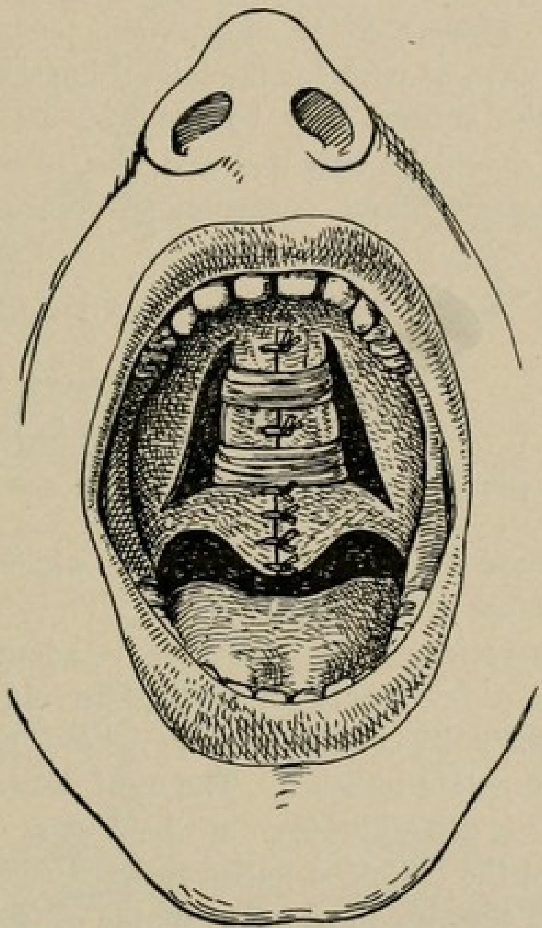

Fig. 118.—Strips of Gauze Passed Around the Flaps.

soft palate thoroughly and completely from the whole posterior border of the hard palate. This is accomplished by working close to the surface of the bone with a periosteum elevator bent upon itself. The mucous membrane upon the nasal aspect of the soft palate is cut away from its attachment to the hard palate by slipping the narrow-bladed knife or the scissors, curved on the flat, under the flaps and cutting from side to side along the edge of the hard palate. If the detachment of the soft palate has been thorough the two halves will hang very loose, so that they may readily be brought together without tension. Under these circumstances there will be no necessity for making the lateral liberating incisions in the soft palate.

The apposed edges of the cleft are now sutured together, commencing in front, behind the incisor teeth, and working backward, completing the operation by uniting the edges of the soft palate. As already mentioned, the sutures are not tied until after they have all been placed. Several strips of plain gauze are passed around the flaps and tied and then twisted so that the knots present upward into the nasal cavity. These serve to support and hold the flaps together, stop oozing, and serve as pack for the lateral incisions.

Ordinarily the sutures may be removed after ten days. The mouth and nose should be irrigated and washed out frequently both during and subsequent to the operation. The original defect of the

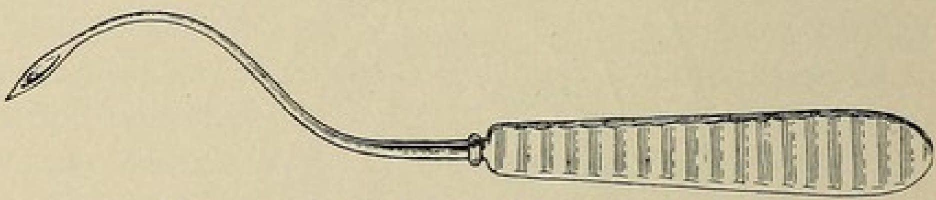

Fig. 119.—Brophy's Needle for Passing Sutures.

hard palate is closed ultimately by the bone which is produced from the periosteal surface of the flaps.

Brophy's Operation.—This operation is adapted to very young children,—within a few weeks of birth. In older children,—over three months,—difficulty would be experienced in forcing the two halves of the hard palate together. The most desirable time is within a few weeks after birth. The jaws are held open with a gag, Whitehead or Lane, and the tongue is pulled forward with a ligature, which is passed through the tip. The edges of the cleft in the hard palate are pared, a thin strip of the bone margin being pared away, as well as the mucous membrane. The edges of the cleft in the soft palate are then pared. The next step of the operation consists in forcing the two halves of the superior maxilla together in the middle line. A loop of strong silk is threaded on a heavy Brophy needle. The cheek is raised and the needle introduced through the body of the maxilla at a point above the level of the palatal process and just behind the malar process. As the loop of silk appears in the cleft it is seized with a forceps and the needle withdrawn. At a corresponding point on the other side of the superior maxilla the needle carrying another strong silk suture is again introduced, and this suture also seized as it appears in the cleft in the hard palate. The nasal septum is perforated with the needle if it interferes with the passage of either one or the other of the sutures. The end of the first suture is caught in the loop of the second. The second suture is then withdrawn and pulls the end of the first with it, with the result that the heavy silk suture

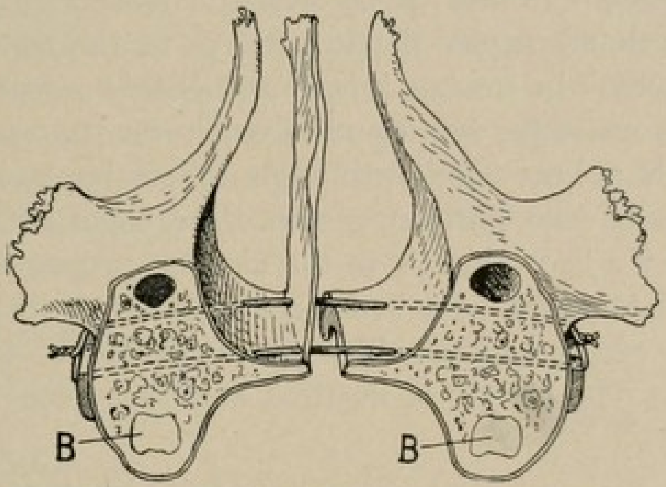

Fig. 120.—Brophy's Operation. Two sutures of silver wire passed across the cleft in the palate, through the bodies of the superior maxillaries and just above the level of the alveolar processes. *B*, germs of the first temporary molar teeth.

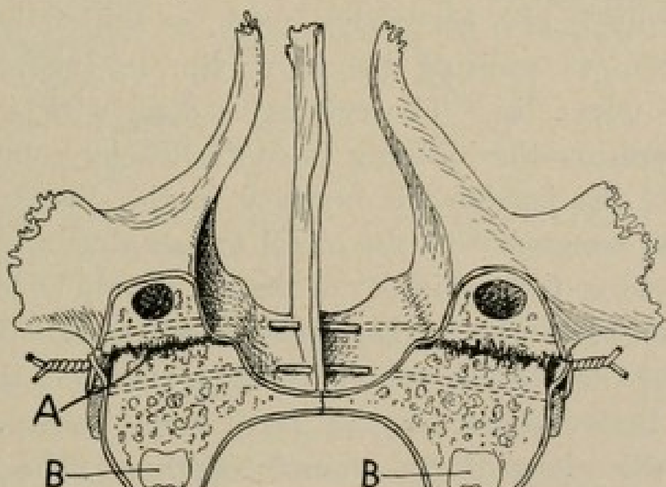

Fig. 121.—Brophy's Operation. The sutures drawn tight, and cleft closed. *A*, line of fracture between the body of the superior maxilla and the alveolar process; *B*, germs of the first temporary molar teeth.

passes through the body of the maxilla from side to side, above the level of the palatal processes and across the cleft in the hard palate. A second heavy silk suture is introduced in a similar manner, anteriorly, through the body of the superior maxilla. The silk sutures are used to draw two heavy silver-wire sutures through the bone, from side to side, across the cleft. The silver-wire sutures are carried through the holes made in two lead plates, which are applied against the sides of the jaw-bone and shaped to conform to the buccal surface of the bones. As the wire sutures are twisted tight the two halves of the maxilla are pressed close together and the cleft in the hard palate thus closed. It may be necessary to make considerable pressure with the thumbs upon the two halves of the superior maxilla before one succeeds in forcing them together. In some cases it will be necessary to incise the mucous membrane over the bone and divide the bones with a heavy knife through the malar processes before they can be forced into close apposition. The bones are bent or fractured through the body just above the alveolar processes. The edges of the soft palate which have been freshened are united with a sufficient number of silk sutures. The plates are allowed to remain two to four weeks. The harelip is repaired at a subsequent *séance*.

OPERATIONS UPON THE LIPS.

Excision of the Whole Lower Lip.—This operation is done for malignant disease. At times the angle of the mouth is involved and the upper lip is also encroached upon, so that it becomes necessary, in addition to excising the lower lip, to excise a triangular portion of the upper lip. The cutting is done with a scissors, and during the operation the bleeding is controlled by compression with the fingers. If the jaw-bone is involved in the disease the diseased portion may be resected with the chisel or saw, but a bridge of bone sufficient to preserve the continuity of the jaw should be left if possible.

Restoration of the Lower Lip After Excision of a Wedge-shaped Portion.—After the whole lower lip has been removed, the triangular-shaped defect that remains may, in many cases, be remedied by simply drawing the edges of the wound together. The edges of the wound may be united with several sutures of rather heavier silk which go through the entire thickness of the lip down to, but not including, the mucous membrane, and these may be placed so as to control the hemorrhage at the same time. There are then applied additional sutures of finer silk that bring the edges of the wound accurately together. As a result, we have a small, rounded, puckered opening, representing the mouth, which is formed entirely from the upper lip, but this regains an appearance very much like normal, after six to eight months.

Formation of the Lower Lip After Complete Excision. DIEFFENBACH-JAESCHE METHOD.—To remedy a triangular defect in the lower lip. In estimating the area of the flaps required one should allow one-third for shrinkage.

From each corner of the mouth an incision is carried outward and somewhat upward into the cheek for a sufficient distance to close the defect in the lip, allowing one-third for shrinkage. From the end of each of these incisions a second curved incision is then carried downward and inward toward the chin so as to terminate near the lower border of the jaw and under the angle of the mouth. Stenson's duct should be avoided in making these flaps. This second

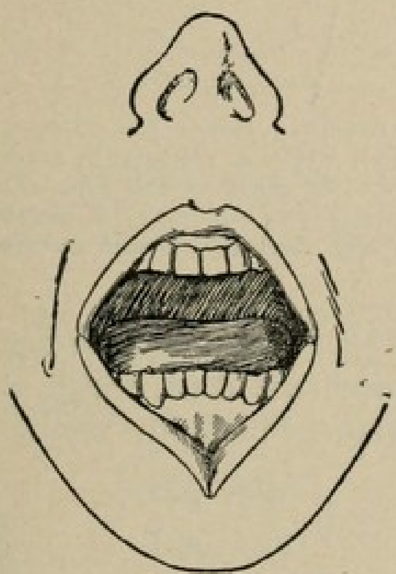

Fig. 122.—Excision of Entire Lower Lip, with Resulting Triangular Defect.

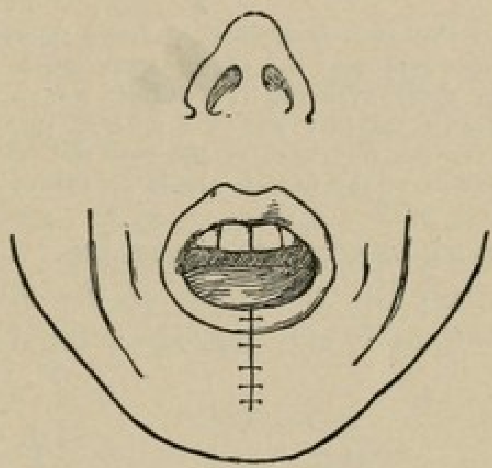

Fig. 123.—Triangular Defect in Lower Lip Closed by Suture.

incision, being curved, makes the flaps more movable. The mucous membrane, corresponding to that part of the incision that reaches outward from the corner of the mouth, should be cut upon a higher level than the skin in order thus to obtain a mucous membrane flap which is sutured over the edge of the flap to the edge of the skin to form the free border of the new lower lip. For the rest of its extent the incision goes through the skin and mucous membrane upon the same level. The two flaps are now separated from the lower jaw, avoiding, as far as possible, cutting the fold of mucous membrane that is reflected from the inner surface of the lips to the gums. If the flaps are not sufficiently movable to bring them together, the incisions may be prolonged downward beyond the lower border of the jaw into the neck and the flaps loosened still farther from the lower jaw. The edges of the flaps are then united with interrupted silk sutures which include the whole thickness of the lip down to, but not including, the mucous membrane. A second set of intermediate silk sutures brings the edges of the skin and mucous mem-

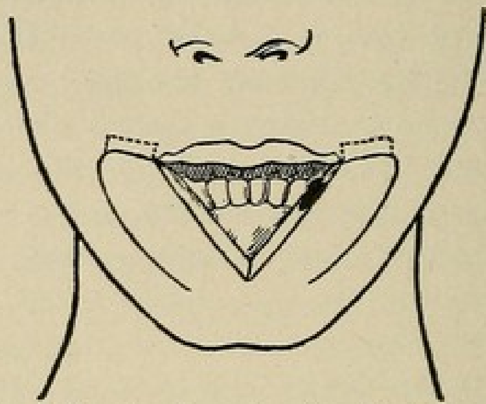

Fig. 124.—Dieffenbach-Jaesche Operation for Restoring Lower Lip. Dotted lines represent the edges of the mucous membrane, which is cut long in order to cover over the free margin of the new lip. The edges of the flaps are drawn together and the mucous membrane, which was cut long, is sewed over the free edge of the new lip. The defect upon each side caused by the sliding of the flaps is closed by suture.

brane into accurate apposition. Corresponding to the free border of the new lip, the edges of the mucous membrane flaps, which were intentionally cut long, are sutured to the skin. Finally the semilunar

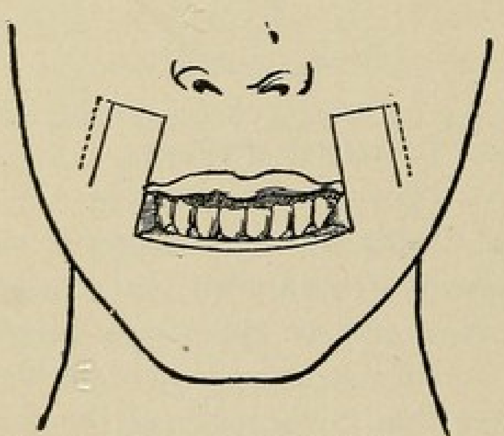

Fig. 125.—Bruns Method of Restoring the Lower Lip. Dotted lines indicate that the mucous membrane is cut longer than the skin in order to provide a mucous membrane border to the new lip.

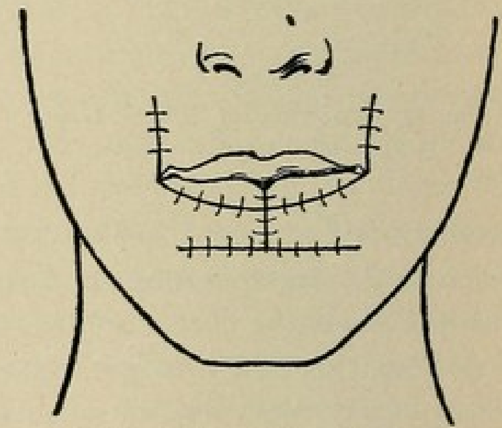

Fig. 126.—Flaps Turned Down and Joined to Form New Lip. Mucous membrane is suturd over the free margin of the new lip. The defect upon each side of the cheek is closed by suture.

defects upon either side are closed with sutures. In the male the scar is hidden by the beard.

Bruns Method.—For a quadrangular defect of the lower lip. A square-cornered flap is taken from either side of the face, including the whole thickness of the cheek, and these are turned down into the defect through an angle of ninety degrees. These flaps have a good blood-supply. Avoid Stenson's duct. The apposed edges of the flaps are united and the mucous membrane sutured to the edge

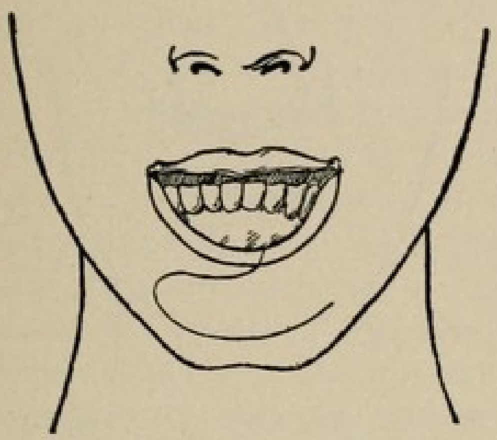

Fig. 127.—Langenbeck Method of Restoring the Lower Lip. An oval flap is taken from the region of the chin.

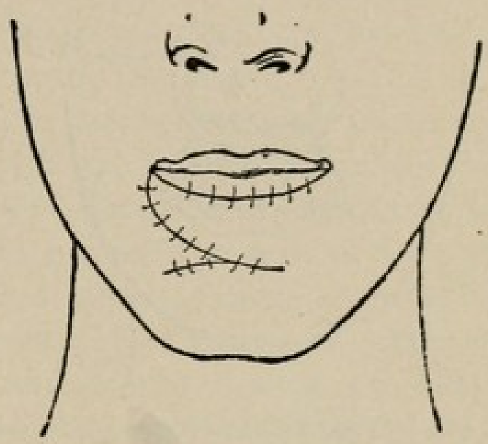

Fig. 128.—Oval Flap is Raised and Sutured into Place and the Defect thus Closed.

of the skin to form the free margin of the new lip. The lateral defect on either side is then closed. The scars that result are upon the cheek.

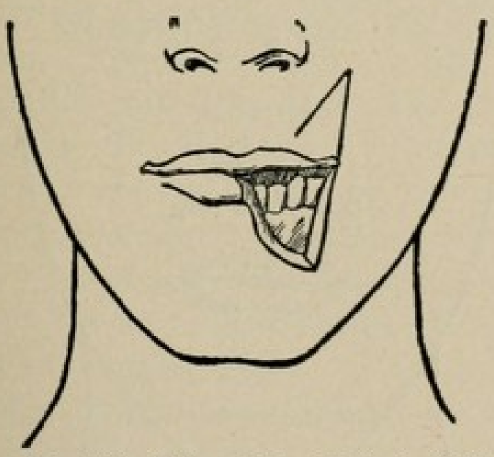

Fig. 129.—Estlaender's Method of Restoring the Lower Lip After Partial Excision. A triangular flap is taken from the upper lip and cheek.

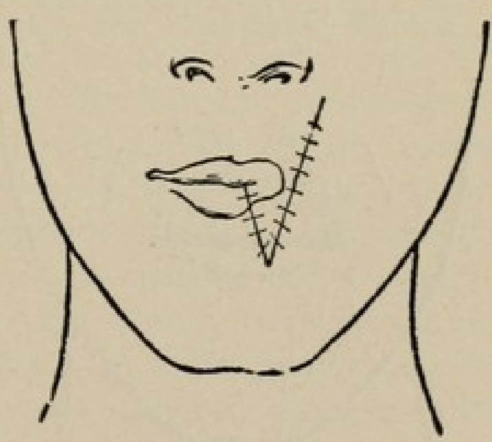

Fig. 130.—The Triangular Flap is Turned down and Sutured in Place, thus Closing the Defect.

Langenbeck's Method.—Formation of the lower lip for oval defect. A long, rounded flap is taken from the region of the chin with its base directed upward and outward. Between the upper border of the flap which is thus marked out and the lower margin of the defect there is a triangular tongue of tissue. This tongue of tissue is partly loosened from its attachment to the underlying tissues. The long flap is raised from the underlying parts and shoved upward, filling in the defect in the lip, and the triangular tongue of tissue is brought under it. These flaps are fixed in their new position with

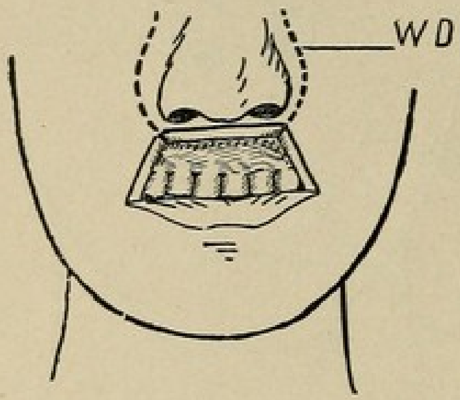

Fig. 131.—Dieffenbach *Wellenschnitt* for Restoration of the Upper Lip. An incision (*WD*) is carried around each side of the nose, extending through the cheek.

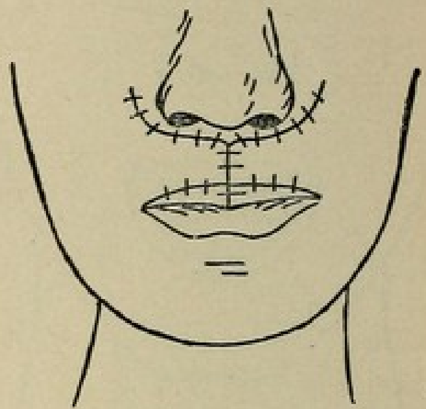

Fig. 132.—The Flaps are Liberated from the Upper Jaw-bone and are Drawn Down into Place and Sutured. The raw space upon either side of the nose is closed with suture.

sutures. The whole defect may be closed over if the flaps are sufficiently detached. The great disadvantage of this method is that the new lip, upon its free edge and posterior surface, is not covered by mucous membrane, and shrinks and contracts as it cicatrizes.

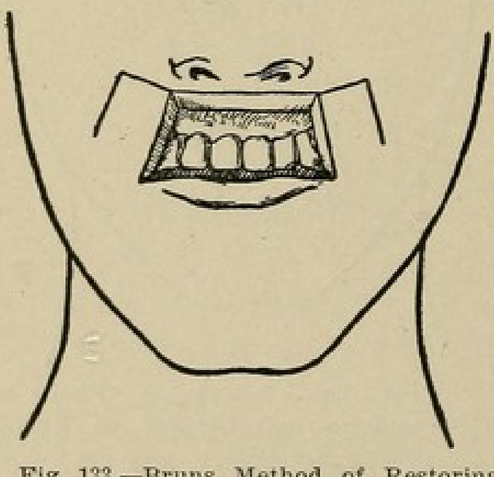

Fig. 133.—Bruns Method of Restoring Upper Lip. A square flap taken from either cheek.

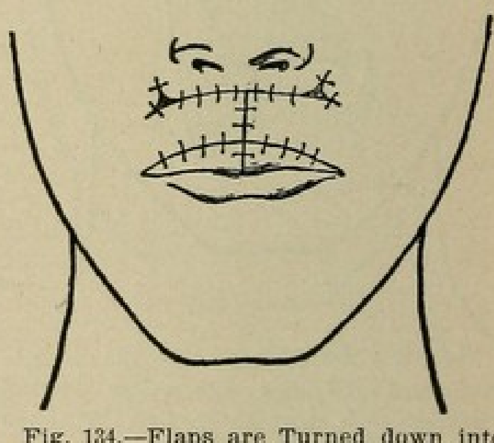

Fig. 134.—Flaps are Turned down into Place and Sutured. Defect in either cheek is closed with sutures.

Estlaender's Method.—As large a defect as that left after excision of three-fourths of the lower lip may be covered by this method. An incision is made reaching from the corner of the mouth upward, through the whole thickness of the cheek, to the level of the infra-orbital foramen and then downward, past the wing of the nose, toward the philtrum, to a point close to the carmine border of the upper lip. If the coronary branch of the facial artery is not divided, the flap will be well nourished. The flap is then turned down into the defect in the lower lip through an angle of one hundred and seventy degrees. One may feel the pulsating coronary artery before cutting the flap and should positively avoid severing it.

The resulting deformity is bad, the mouth one-sided, the corner of the mouth corresponding to the philtrum. In order to correct this feature a subsequent operation might be done, extending the corner of the mouth outward, but it would be necessary to wait at least six weeks, in order to insure a good blood-supply, before undertaking this second operation, otherwise there would be danger of gangrene. Without doubt this deformity will, in time, correct itself to a considerable degree, so that the secondary operation may not be necessary.

Restoration of the Upper Lip.—Restoration of the upper lip is not often required, as this part is but rarely the seat of disease that calls for its excision.

Estlaender's Method may be used to close a wedge-shaped defect in the upper lip, the flap being taken from the lower lip.

Dieffenbach's Wellenschnitt.—A curved incision is made through the whole thickness of the cheek around the corner of the nose. The flaps which are thus marked out are separated from the maxillæ and then drawn toward the middle line and turned down, so that the raw edges of the original defect become the free border of the new lip. The two flaps are then united and the edges of the mucous membrane and skin sutured together along the free margin of the new lip. The mucous membrane corresponding to this margin may be cut a little longer than the skin, in order to facilitate the union of these edges. After uniting the flaps in the middle line the edges of the defect around the side of the nose may be brought together with sutures.

Small, wedge-shaped defects may be closed by simple suture, if necessary, combining this with detachment of the cheek by Dieffenbach's *Wellenschnitt*.

Bruns Method may also be used to restore the upper lip after its complete excision.

PART III.

NECK AND TONGUE.

SURGICAL ANATOMY OF THE NECK.

THE neck is the constricted part of the body that joins the head to the trunk. The spinal column passes through the posterior part of the neck, inclosing within its canal the spinal cord. The anterior part of the neck is made up of important organs and of channels that pass between the head and the trunk.

The Deep Cervical Fascia.—This is an aponeurotic layer that serves to bind the structures that comprise the neck into a compact, cylindrical mass. This fascia offers a strong barrier to the extension of superficial suppurative processes into the deeper parts of the neck, and at the same time hinders, to a considerable degree, the spontaneous evacuation, externally, of pus which is located deep in the neck.

Anteriorly, between the edges of the sterno-mastoid muscle, the deep cervical fascia covers the depressor muscles of the hyoid bone—the sterno-hyoid, sterno-thyroid, and omo-hyoid. Upon the side of the neck it is found beneath the sterno-mastoid, and may be traced from the posterior border of this muscle backward across the posterior triangle of the neck and beneath the trapezius muscle, where it serves to bind the long muscles of the neck to the vertebral column.

Above, the deep cervical fascia is attached to the lower border of the jaw and to the back of the skull, and, below, to the upper border of the sternum, the clavicle, the spine of the scapula, and the spinous process of the seventh cervical vertebra: vertebra prominens. In the middle line of the neck, behind, the deep cervical fascia is blended with the ligamentum nuchæ, which is prolonged deep into the neck to be attached to the tips of the spinous processes of the cervical vertebræ. The deep cervical fascia is firmly attached to the body and horns of the hyoid bone.

Anteriorly, between the edges of the sterno-mastoid muscles, the deep cervical fascia covers the depressor muscles of the hyoid bone, and consists of two layers, the anterior of which is attached to the

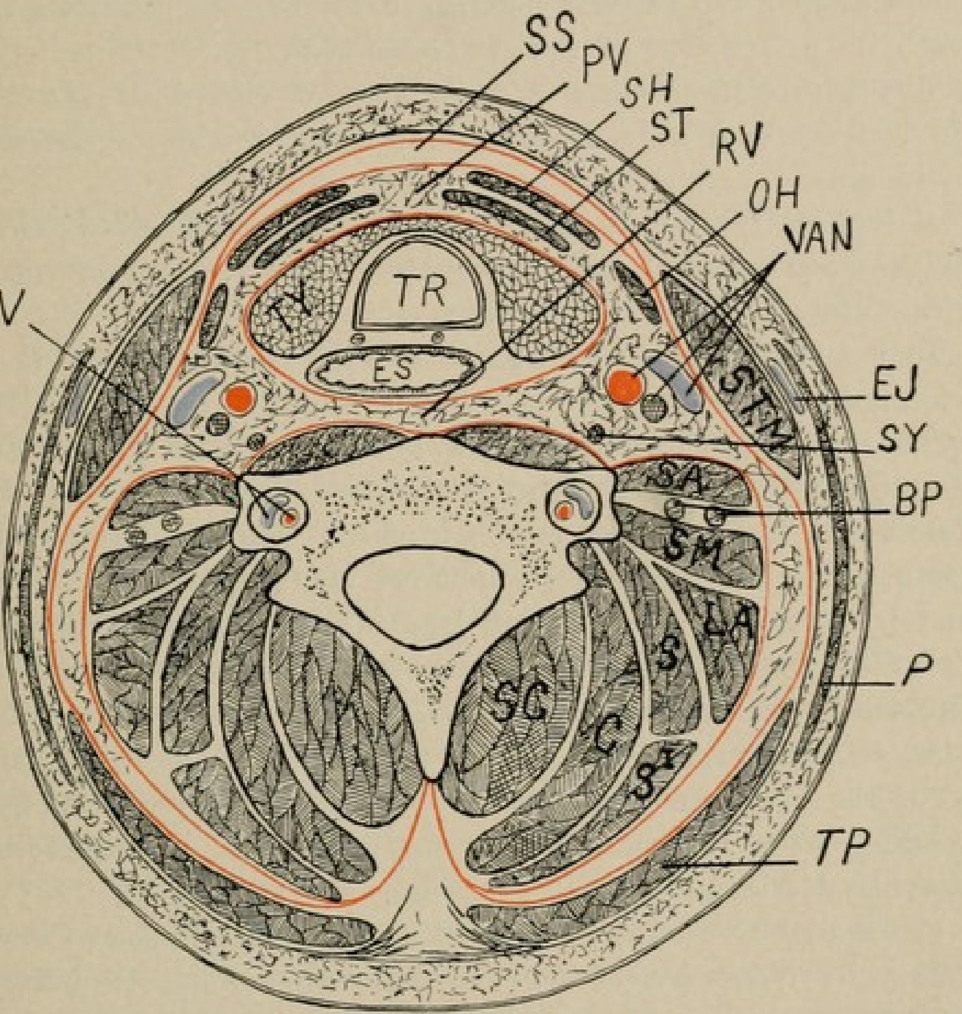

Fig. 135.—Section through the Neck, Level of Sixth Cervical Vertebra, to Show Arrangement of the Deep Cervical Fascia (Indicated in Red). *BP*, trunks of brachial plexus; *C*, complexus muscle; *EJ*, external jugular vein; *ES*, œsophagus; *LA*, levator anguli scapulæ muscle; *OH*, omo-hyoid muscle; *P*, platysma muscle; *PV*, prævisceral space; *RV*, retrovisceral space; *S*, *S*[1], splenius capitis et colli muscle; *SA*, scalenus anticus muscle; *SC*, semispinalis colli muscle; *SH*, sterno-hyoid muscle; *SM*, scalenus medius muscle; *SS*, suprasternal space; *ST*, sterno-thyroid muscle; *ST.M.*, sterno-mastoid muscle; *SY*, sympathetic nerve; *TP*, trapezius muscle; *TR*, trachea; *TY*, thyroid gland; *V*, vertebral artery and vein; *VAN*, internal jugular vein, carotid artery, and pneumogastric nerve inclosed in a mass of loose connective tissue.

anterior and the posterior to the posterior margin of the upper border of the sternum. Between the two layers there is a space known as the suprasternal space, which contains some fat, lymphatic tissue, and a venous branch, the anterior jugular, that enters the external jugular beneath the attachment of the sterno-mastoid.

The suprasternal space extends upward almost as far as the hyoid bone and laterally as far as the anterior edge of the sterno-mastoid muscle.

A suppurative process in this space is pretty effectively shut off from the deep parts of the neck by the posterior layer of the deep cervical fascia.

In the front part of the neck, below the level of the hyoid bone, the pharynx and œsophagus and the larynx and trachea are bound together in a single bundle by a layer of fascia that completely envelops them; the thyroid gland is also included within this sheath of fascia and is fixed by it to the trachea. Another layer of fascia forms a sheath for the muscles that are contiguous to the vertebral column: anteriorly, the recti and longus colli; laterally, the scaleni, cords of the brachial plexus, and the levator anguli scapulæ; posteriorly, the splenius, complexus, etc.

Above the hyoid bone the deep cervical fascia reaches from the body of the jaw-bone to the hyoid bone. The submaxillary gland, surrounded by a mass of loose connective tissue, is lodged in the submaxillary triangle, beneath the deep cervical fascia.

CONNECTIVE-TISSUE SPACES BENEATH THE DEEP CERVICAL FASCIA. *Prævisceral Space.*—This space corresponds to a mass of loose connective tissue that is situated in front of the trachea and thyroid gland and beneath the deep cervical fascia and depressor muscles of the hyoid bone.

If an opening is made in the deep fascia and a probe introduced into this space, it may be readily forced down into the mediastinum, and a collection of pus in this space may readily gravitate along the same route into the mediastinum with fatal results.

Retrovisceral Space.—This is the recess between the pharynx and œsophagus in front and the vertebral column behind; it reaches from the base of the skull down into the chest. Pus in this space may readily find its way down along this path into the chest.

Vascular Space.—Upon either side of the pharynx and œsophagus and the larynx and trachea the carotid artery and its adjoining structures are found. These structures, beside the carotid artery, consist of the internal jugular vein and pneumogastric nerve, sympathetic nerve, and loop formed by the descendens and communicans noni. These structures are not provided with a distinct sheath, but are lodged in a mass of loose connective tissue, which may be traced all the way down into the thoracic cavity.

Suppuration may be spread along the course of these structures,—for example, the internal jugular vein,—and thus invade the chest cavity.

The Back of the Neck.—This region of the neck corresponds to the cervical portion of the trapezius muscle. It is limited above by the occipital protuberance and superior curved line of the occipital bone, below by the vertebra prominens, and upon the sides by the edges of the trapezius muscle.

The skin of this region is intimately united with the subcutaneous connective tissue, which is very dense and is marked by hair-follicles and sebaceous glands. Inflammatory processes which attack the structures of the skin in this region show but little tendency to spread and are excessively painful (carbuncles).

This region presents two longitudinal, rounded swellings—one on either side of the middle line—which correspond to the trapezius muscle. Between these, in the middle line, is a depression marked by the spinous processes of the cervical vertebræ. The spinous processes of the cervical vertebræ are short and not distinctly felt, except the lower ones; that of the seventh, the vertebra prominens, is especially prominent. They are joined together by a dense, ligamentous band,—the ligamentum nuchæ,—which is continued upward as far as the external occipital protuberance. The cervical portion of the vertebral canal is roomy and contains the spinal cord. This part of the vertebral column lies at a considerable depth from the surface, and is well protected by the overlying muscles.

The Side of the Neck.—This region is quadrilateral; bounded above by the lower border of the jaw-bone and an imaginary line drawn from the angle of the jaw to the mastoid process; below, by the clavicle; in front, by the middle line of the neck; and, behind, by the anterior border of the trapezius. It is divided into two triangles—an anterior and a posterior—by the sterno-mastoid muscle.

The sterno-mastoid muscle is a most important surgical landmark. It is attached above to the mastoid process and the adjacent part of the occipital bone; below, to the inner end of the clavicle and the upper end of the sternum. This muscle not only divides the side of the neck into an anterior and a posterior triangle, but, being a broad muscle itself, covers important structures not seen in either of the triangles; therefore in addition to the triangles one might well describe a sterno-mastoid region.

The side of the neck is covered by the skin, beneath which the subcutaneous fat and superficial fascia are found, and, beneath these, there is a broad, thin, muscular layer: the platysma. This muscle, which is spread out in a thin sheet, extends from the lower border of the inferior maxilla downward and backward, being continued downward beyond the clavicle, where it is blended with the subcutaneous tissue of the upper part of the chest. The platysma is intimately united with the skin, and together with it is freely movable upon the parts which lie beneath it and with which it and the skin are united by loose connective tissue. It will be observed that the platysma does not cover the anterior portion of the neck in the laryngeal and tracheal regions.

Beneath the superficial fascia and the platysma—*i.e.*, between these and the deep cervical fascia—are found the external and anterior jugular veins together with some nervous branches which are derived from the cervical plexus and from the facial.

The External Jugular Vein, during efforts of straining and in conditions of obstructed venous return, may become distended and sufficiently prominent to be recognized beneath the skin. This vessel is formed above, behind the angle of the jaw, by the junction of the posterior auricular vein and the posterior branch of the temporo-maxillary vein; it passes straight down the side of the neck, crossing the sterno-mastoid muscle from its anterior to its posterior border, and, below, pierces the deep cervical fascia, just above the clavicle and behind the attachment of the sterno-mastoid to this bone, to empty into the subclavian. After it pierces the deep cervical fascia and before it terminates in the subclavian, which it does just external to the tendon of the scalenus anticus, it receives the suprascapular, transverse cervical, and anterior jugular veins.

The Anterior Jugular Vein.—This is formed in the hyoid region by the junction of several veins from the upper anterior part of the neck, and passes downward, anterior to the edge of the sterno-mastoid muscle, between the superficial fascia and platysma and the deep cervical fascia; in the lower part of the neck it pierces the anterior layer of the deep cervical fascia in front of the sterno-mastoid and then passes backward, beneath this muscle, through the

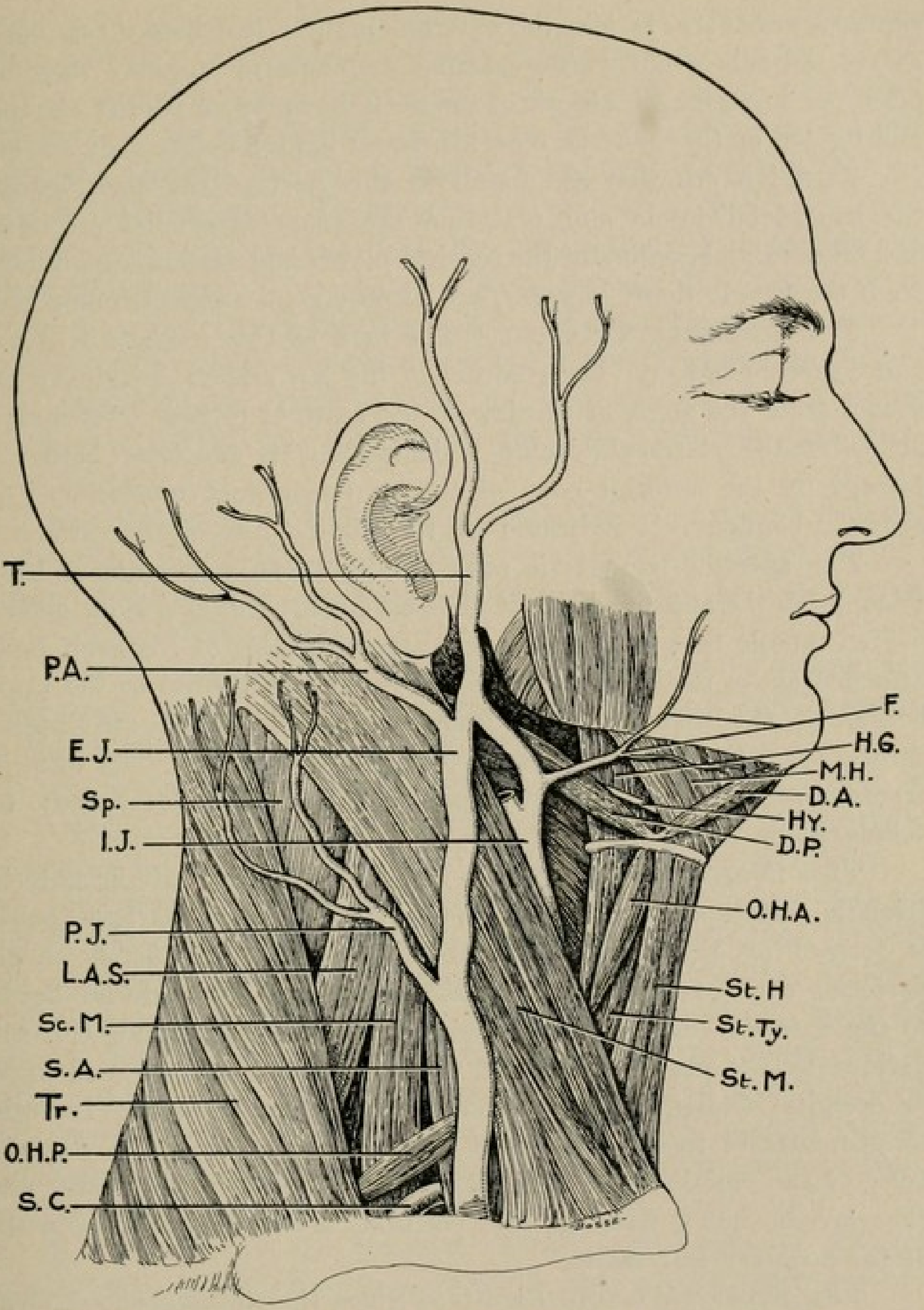

Fig. 136.—Side of the Neck to Show Triangles. *D.A.*, anterior belly of the digastric; *D.P.*, posterior belly of the digastric; *E.J.*, external jugular vein; *F.*, facial vein; *H.G.*, hyo-glossus muscle; *H.Y.*, hypoglossal nerve; *I.J.*, internal jugular vein; *L.A.S.*, levator anguli scapulæ muscle; *M.H.*, mylo-hyoid muscle; *O.H.A.*, omo-hyoid muscle, anterior belly; *O.H.P.*, omo-hyoid muscle, posterior belly; *P.A.*, posterior auricular vein; *P.J.*, posterior jugular vein; *S.A.*, scalenus anticus muscle; *S.C.*, subclavian artery; *Sc.M.*, scalenus medius muscle; *Sp.*, splenius muscle; *St.H.*, sterno-hyoid muscle; *St.M.*, sterno-mastoid muscle; *St.Ty.*, sterno-thyroid muscle; *T.*, temporal vein; *Tr.*, trapezius muscle.

suprasternal space, to join the external jugular just before this vessel enters the subclavian. The external and anterior jugular veins are often cut in making incisions in the neck, but may be readily clamped and ligated or they may be recognized and ligated before they are cut.

The Nerves that are found in this part of the neck beneath the superficial fascia and platysma are some superficial ascending and descending branches of the cervical plexus and descending branches from the facial; these, however, are of no special surgical importance.

The Anterior Triangle.—The base of this triangle is above, and corresponds to the lower border of the jaw and an imaginary line drawn from the angle of the jaw to the mastoid process. Its apex is below at the sterno-clavicular articulation; its posterior border is formed by the anterior edge of the sterno-mastoid muscle, and its anterior boundary is indicated by the middle line of the neck.

The anterior triangle is subdivided into an upper and a lower triangle by the anterior belly of the omo-hyoid; this is a thin, double-bellied muscle that swings obliquely across the side of the neck, being attached above to the hyoid bone and below and behind to the upper border of the scapula. The lower triangle is called the inferior carotid, and the upper, the superior carotid triangle. The anterior triangle presents, in its upper part, a third triangular space: the submaxillary triangle.

The Posterior Triangle.—This is the reverse of the anterior triangle. Its apex is above at the mastoid process; its base, below, is formed by the clavicle; its anterior border corresponds to the posterior edge of the sterno-mastoid muscle and its posterior border to the anterior edge of the trapezius. The posterior triangle is subdivided by the posterior belly of the omo-hyoid into two: an upper or occipital triangle, and a lower or subclavian triangle. In order to demonstrate these triangles it is necessary to draw the posterior belly of the omo-hyoid a little upward, as it usually lies pretty near the clavicle, being fixed in this position, to the first rib, by a slip of the deep cervical fascia.

The Sterno-Mastoid Region.—Since the sterno-mastoid, as already mentioned, is not a line, but a muscle of considerable breadth and covers structures of importance, one might describe, besides the triangular spaces lying in front of, and behind, the sterno-mastoid muscle, a "sterno-mastoid" region, and we will proceed to do this at once and thus dispose of it and then consider the triangles more in detail. The sterno-mastoid region is covered by the skin and fat (superficial fascia) and to a considerable extent by the platysma. After removing these layers we come down upon the surface of the muscle covered by the deep portion of the superficial cervical fascia. The fibers of the muscle have an oblique direction from above downward and forward, and it is crossed from above downward by the external jugular vein. To examine the structures that lie beneath the sterno-mastoid, we may divide the muscle through its middle and reflect either end. Then, after cutting through the deep cervical fascia, there are exposed the deep muscles which lie beneath the sterno-mastoid and which are connected with the vertebral column, the longus colli, scaleni, levator anguli scapulæ, etc., the cervical plexus of nerves, the carotid vessels, internal jugular vein, etc., and numerous lymphatic glands.

The Inferior Carotid Triangle.—This triangle is bounded in front by the middle line of the neck, above and behind by the anterior belly of the omo-hyoid, below and behind by the anterior border of the sterno-mastoid.

This triangle contains the larynx, trachea, thyroid gland, and œsophagus. These structures are partly covered over and concealed by the sterno-hyoid, sterno-thyroid, and thyro-hyoid[1] muscles.

The œsophagus, which projects well beyond the left border of the trachea, is more accessible in the left triangle than in the right. Ascending in the recess between the trachea and the œsophagus is the recurrent laryngeal nerve; this nerve enters the larynx between the thyroid and cricoid cartilages, behind the articulation of these two cartilages. Lying to the outer side of these structures (larynx, trachea, and œsophagus) are the common carotid artery, with the internal jugular vein upon its outer side, and the pneumogastric nerve between them, but on a plane posterior. The middle thyroid vein passes outward across this space to enter the internal jugular vein, passing across the front of the common carotid artery to reach its destination.

In this triangle the common carotid artery and the internal jugular vein lie beneath the anterior border of the sterno-mastoid muscle, which is the guide to them and which must be drawn outward (backward) in order to expose them. Lying still deeper in this part of the neck, beneath the carotid artery and the internal jugular vein, are the inferior thyroid artery, which passes inward and upward behind these vessels to reach the lower part of the thyroid gland,

[1] The thyro-hyoid is really the continuation of the sterno-thyroid.

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and the vertebral artery, which enters the foramen in the root of the transverse process of the sixth cervical vertebra. The sympathetic nerve is also found deep in this space behind the carotid vessels, resting upon the muscles which cover the front of the vertebral column, and in this situation it presents its middle cervical ganglion.

The Superior Carotid Triangle.—This space is bounded behind by the anterior border of the sterno-mastoid, above and in front by the posterior belly of the digastric and the stylo-hyoid, and below and in front by the anterior belly of the omo-hyoid. The floor of this space is formed by the constrictor muscles of the pharynx and the thyro-hyoid and a part of the hyo-glossus muscles. It contains the upper part of the common carotid artery and its bifurcation into the internal and external carotids, which division occurs upon a level with the upper border of the thyroid cartilage. The internal jugular vein lies in close contact with the outer side of the common carotid artery and its continuation, the internal carotid; and the pneumogastric nerve still holds its place between the artery and vein, but on a plane posterior to both.

The vessels in this triangle are superficial, not being covered by the anterior edge of the sterno-mastoid, but lying anterior to it. The edge of the muscle is here also the guide to the vessels. A chain of lymphatic nodes is located along the front border of the sterno-mastoid muscle, and some of them are in very close proximity to the internal jugular vein.

In this triangle, the external carotid, as it ascends to a point behind the angle of the jaw, describes a slight curve with the convexity forward, and lies rather beneath the posterior belly of the digastric and stylo-hyoid and upon a plane anterior to the internal carotid, giving off several important branches: among them the superior thyroid, which passes to the upper part of the thyroid gland; the lingual, which passes forward beneath the hyo-glossus muscle to supply the tongue; and the facial, which passes upward and outward over the lower border of the jaw. The occipital and the posterior auricular are derived from the posterior aspect of the external carotid artery and ascend in a direction upward and backward.

The hypoglossal nerve arches forward across the external carotid artery upon a level with the origin of the occipital artery.

In this space the facial vein is joined by a large branch from the temporo-maxillary, and then passes downward and outward across the external carotid and internal carotid arteries to enter the internal jugular vein. This vein is often cut during extirpation of glands in this triangle and gives rise to a copious hemorrhage, which is readily controlled by pressure with the finger in the wound and artery forceps. It may often be recognized and tied double before it is cut.

THE SUBMAXILLARY TRIANGLE.—The submaxillary triangle is bounded above by the lower border of the jaw and an imaginary line drawn from the angle of the jaw to the tip of the mastoid process, below and in front by the anterior belly of the digastric muscle, and below and behind by the posterior belly of the digastric and the stylo-hyoid muscle. The apex of the triangle corresponds to the attachment of these muscles to the hyoid bone. When the coverings of this triangle—consisting of the skin, subcutaneous fat, platysma, and deep fascia—are reflected, we find it fairly well occupied by the submaxillary gland, which rests in a bed of loose connective tissue, and various lymph-nodes. The back part of this triangle is crossed by the facial artery, which passes upward and forward over the upper border of the submaxillary gland to reach the lower border of the jaw, over which it curves on to the side of the face, grooving the bone just in front of the attachment of the masseter muscle. The facial vein, which lies superficial to the facial artery, after receiving the submental vein, also crosses the posterior part of the submaxillary triangle, passing downward and backward across (superficial to) the posterior belly of the digastric and stylo-hyoid muscles and, after uniting with a large branch from the temporo-maxillary vein in the upper part of the superior carotid triangle, enters the internal jugular.

After the submaxillary gland has been raised out of its bed, its duct, Wharton's, may be seen passing forward beneath the posterior edge of the mylo-hyoid muscle to open anteriorly in the floor of the mouth. The gland may be isolated and cut away from its duct, and then the floor of the triangle is exposed to view. The floor of the triangle is formed, for the most part, by the mylo-hyoid muscle, whose fibers have an oblique direction, and the hyo-glossus, which lies upon a deeper plane than the mylo-hyoid and forms the posterior part of the floor of the triangle; the fibers of the hyo-glossus muscle run straight up and down from the hyoid bone to the under surface of the tongue. The lingual artery lies beneath the hyo-glossus muscle. The submental branch of the facial artery passes forward parallel with and close to the inner surface of the body of the jaw, resting upon the mylo-hyoid muscle. The hypoglossal nerve may be seen passing forward, entering the submaxillary triangle from beneath the posterior belly of the digastric muscle. In the triangle this nerve rests upon the hyo-glossus muscle, disappearing anteriorly beneath the posterior border of the mylo-hyoid muscle. Accompanying the hypoglossal nerve is the lingual vein, which passes backward and enters the facial.

The hypoglossal nerve forms the base of a second smaller triangle, which corresponds to the apex of the submaxillary triangle and which is called the lingual triangle.

The Lingual Triangle.—The base of the lingual triangle, which is above, is formed by the hypoglossal nerve; its borders, anterior and posterior, by the respective bellies of the digastric. The apex of the triangle is located below where this muscle is attached to the hyoid bone. The floor of the triangle is formed by the fibers of the hyo-glossus muscle. Directly beneath this muscle, in the space marked out as the lingual triangle, the lingual artery is located, and in this situation it is very readily found and ligated. The hyo-glossus muscle is picked up with mouse-tooth forceps and snipped through, when the lingual artery comes into plain view and may be easily surrounded with a ligature in a carrier. The lingual artery is ligated preliminary to extirpation of the tongue.

The Occipital Triangle.—This space is bounded in front by the posterior border of the sterno-mastoid, behind by the anterior border of the trapezius, and below by the posterior belly of the omohyoid. This triangle is of but little surgical importance. It is covered by the skin, superficial fascia (fat), by the platysma in part, and by the deep cervical fascia. Beneath the deep cervical fascia there is a mass of loose fat. Lying upon the deep fascia (superficial to it) is the posterior jugular vein, which, below, at the posterior border of the sterno-mastoid muscle, joins the external jugular. A chain of lymphatic nodes, which lie along the posterior border of the sterno-mastoid in this triangle, are frequently diseased and require removal. The space is crossed by the superficial descending branches of the cervical plexus. The spinal accessory nerve emerges from the posterior border of the sterno-mastoid, at the junction of its upper and middle thirds, and passes obliquely downward and backward across this space, beneath the deep cervical fascia, and disappears under the anterior border of the trapezius muscle, which it supplies. The floor of this space is formed, from above downward, by the splenius, the levator anguli scapulæ, and the middle and posterior scaleni.

THE SUBCLAVIAN TRIANGLE.—This triangle corresponds to the lower part of the posterior triangle. It is covered by the skin, fat, and superficial fascia, the platysma, and deep cervical fascia, and is crossed by the superficial descending branches of the cervical plexus. In the front part of this space, just behind the posterior border of the sterno-mastoid muscle, the external jugular vein pierces the deep cervical fascia. After the integument, etc., including the deep cervical fascia, have been incised, the boundaries of the subclavian triangle may be sought for. These are, below, the clavicle; in front, the posterior border of the sterno-mastoid muscle; and, above, the posterior belly of the omo-hyoid; this latter muscle lies low in the neck, close to the clavicle, and in order to demonstrate the triangle it may be necessary to draw it somewhat upward.

Crossing the space from without inward, just above the clavicle, are the transversalis colli and suprascapular veins; these form a plexus beneath the deep cervical fascia and terminate in the external jugular; the external jugular vein enters the subclavian just external to the tendon of the scalenus anticus. The external jugular vein, after piercing the deep cervical fascia and immediately before it terminates in the subclavian, also, as a rule, receives the anterior jugular vein. This latter drains the front of the neck, originating above in the hyoid and suprahyoid regions. In the subclavian triangle there is also found (beneath the deep cervical fascia) a mass of lymphatic nodes, fat, and loose connective tissue which communicates with the lymphatics of the breast and axilla and which may become involved in disease of the breast. The floor of the subclavian triangle is formed by the scalenus anticus and scalenus medius muscles. In order to expose the scalenus anticus muscle, the sterno-mastoid, which conceals it, must be drawn forward (inward). When the scalenus anticus is thus exposed the phrenic nerve may be seen passing obliquely downward and inward across its anterior surface, descending into the chest across the front of the first part of the subclavian artery. Beneath the venous plexus above mentioned, and lying close upon the muscles that form the floor of the triangle, are the transversalis colli and suprascapular arteries: branches from the first part of the subclavian. Emerging from between the scalenus anticus and the scalenus medius and passing obliquely downward and outward are the three cords of the brachial plexus. They disappear beneath the clavicle into the axillary space. The third part of the subclavian artery is found below the cords of the brachial plexus, deep in the subclavian triangle, below the level of the clavicle, resting in the groove upon the upper surface of the first rib, external to the attachment of the tendon of the scalenus anticus. The tendon of the scalenus anticus is the guide to the artery, and is readily recognized in the inner or forward part of the subclavian triangle as a tense cord and may be followed downward with the finger as far as its attachment to the first rib. The subclavian vein lies some distance away from the artery in front of, and internal to it, the artery and vein being separated from each other by the tendon of the scalenus anticus.

As the subclavian artery emerges from the chest it arches outward and forward to reach the first rib. That portion of the subclavian which lies behind the tendon of the scalenus anticus is the second part of the artery; the part which lies to the inner side of this tendon is the first part; and that which lies external to the tendon of the scalenus anticus, resting upon the upper surface of the first rib, is the third part of the artery: the part that is usually ligated. The second and first parts of the subclavian artery, the parts behind and internal to the tendon of the scalenus anticus, are in direct relation with the dome of the pleura and the apex of the lung, which projects upward into the root of the neck, beneath the scaleni muscles, for a distance of 3 to 3½ cm. above the level of the clavicle. In tying the third part of the subclavian artery one should not mistake for it one of the cords of the brachial plexus, which lie above. The artery is deep, and rests directly upon the first rib. The subclavian vein is pretty well separated from the artery, lying in front of, and internal to, it and upon a rather lower level than the artery. By drawing the shoulder down we depress the clavicle, and may thus make the artery more accessible.

The Front of the Neck.—This part of the neck may be divided into the suprahyoid region, the part above the hyoid bone, and the infrahyoid region, the part below the hyoid bone. The infrahyoid region presents for consideration the larynx, trachea, and thyroid gland, and the œsophagus, which lies behind these.

THE HYOID BONE.—This is a horseshoe- or U- shaped bone, with a body and two lateral horns, which are prolonged backward, one on either side, and two lesser horns, directed upward.

In the natural position of the head the hyoid bone is on a level with the lower border of the inferior maxillary bone, and is not distinctly recognized until the head is thrown back. It is not stationary, but may be said to be about opposite the fourth cervical ver-

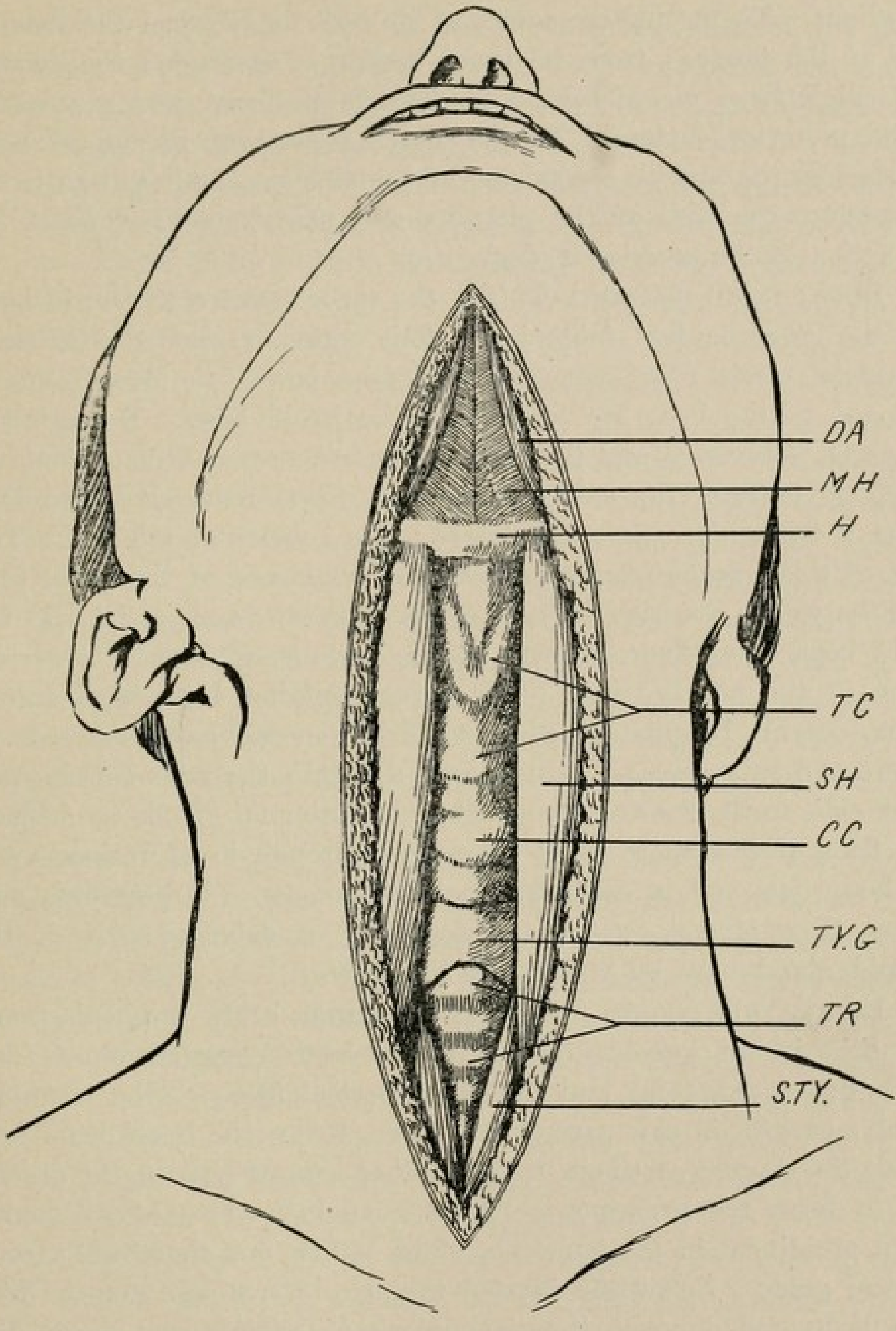

Fig. 137.—Front of the Neck. *CC*, cricoid cartilage; *DA*, anterior belly of digastric; *H*, hyoid bone; *MH*, mylo-hyoid muscle; *SH*, sterno-hyoid muscle; *S.TY*, sterno-thyroid muscle; *TC*, thyroid cartilage; *TR*, trachea; *TY.G*, isthmus of thyroid gland.

tebra. To it are attached numerous muscles, coming from different directions. To the upper surface of its body is attached the base or root of the tongue; from its lower border is suspended the larynx. The epiglottis is placed behind the body of the bone, and is attached to its posterior surface. To the upper surface of its lateral horn is attached the middle constrictor of the pharynx, and it thus serves to support the wall of the pharynx and provide a fixed point for the action of the muscles in deglutition.

SUPRAHYOID REGION.—This is the space between the hyoid bone and the lower border of the jaw. This region is covered with skin, superficial fascia (fat), platysma, and deep fascia; the deep fascia is attached to the body and cornua of the hyoid bone. Beneath the platysma, between it and the deep fascia, are several venous branches which go to form the anterior jugular. Upon removal of the deep fascia a triangular space is exposed: the submental triangle. The apex of this triangle corresponds to the symphysis of the lower jaw, its sides to the anterior belly of either digastric, and its base to the hyoid bone. Its floor consists of the mylo-hyoid muscle, with its raphé in the middle line. This space contains, beneath the deep fascia, several lymphatic nodes, which are occasionally the seat of disease and may demand extirpation. Beneath the mylo-hyoid, upon either side, in the floor of the mouth, the sublingual glands are lodged. The floor of this space is, at times, cut through in operations upon the lower jaw and in order to reach the tongue. A distended, persistent thyro-glossal duct or an accessory or detached part of the thyroid gland may be present in this space.

INFRAHYOID REGION.—This is the region below the hyoid bone. The skin is but loosely attached to the underlying structures; beneath the skin are fat and the deep cervical fascia. The platysma is not met with in this part of the neck. Below the hyoid bone may be felt the thyroid cartilage, that of either side uniting in the middle line to form the prominence "Adam's apple." The Adam's apple is not prominent in the female or child, and is not, therefore, a good surgical guide. Below the thyroid the cricoid cartilage may be felt. This is located opposite the sixth cervical vertebra, and marks the point where the omo-hyoid muscle crosses the common carotid artery. The cricoid is a ring of cartilage which is rather narrow anteriorly, but of considerable breadth posteriorly; it is always very readily felt, and is therefore a good guide. From the cricoid down to the upper border of the sternum the space is occupied by the trachea. Just below the cricoid cartilage the isthmus of the thyroid gland lies transversely across the front of the trachea, each lobe of the gland extending outward and upward beneath the sterno-hyoid and sterno-thyroid muscles, reaching upward upon the side of the thyroid cartilage and getting into close proximity to the common carotid artery and its adjoining structures. Between the cricoid cartilage and the isthmus of the thyroid gland there is usually a space about one-half inch wide. On either side of the middle line, passing from the hyoid bone and thyroid cartilage down to the sternum, are two long, flat, ribbon-like muscles, one superimposed upon the other: the sterno-hyoid and sterno-thyroid. The sterno-thyroid lies beneath the sterno-hyoid, being partly concealed by the latter. The sterno-thyroid is attached to the side of the thyroid cartilage and does not reach the hyoid bone, but is continuous with the short thyro-hyoid muscle, which is attached to the hyoid bone. The inner edges of these muscles do not meet in the middle line of the neck, but are connected with each other through the intervening deep cervical fascia. They partly cover the trachea and sides of the larynx and the lateral lobes of the thyroid gland. Between the edges of the muscles, in the middle line, from above downward, and covered only by the interposed deep fascia, are the thyroid and cricoid cartilages, the isthmus of the thyroid gland, and the trachea.

Between the hyoid bone and the upper border of the thyroid cartilage there is a space which is filled in by the thyro-hyoid membrane. This membrane is pierced on either side by the superior laryngeal vessels and the internal laryngeal branches of the superior laryngeal nerve. This membrane may be cut in attempts at suicide: cut throat. Between the lower border of the thyroid cartilage and the upper border of the cricoid there is also a space which is filled in by a membrane: the crico-thyroid. This may also be divided in cut throat. Above the hyoid bone, running transversely inward and anastomosing with the branch of the opposite side, is the hyoid branch of the lingual artery. Below the hyoid bone there is a similar transverse branch, the hyoid, which is derived from the superior thyroid and which passes likewise inward, anastomosing across the middle line with its fellow of the opposite side. A third transverse branch passes inward, above the cricoid cartilage, upon the membrane between the lower border of the thyroid cartilage and upper border of the cricoid cartilage. This is the crico-thyroid branch of the superior thyroid artery. It also anastomoses with its fellow of the opposite side. Below the level of the cricoid cartilage there are no arterial branches crossing the middle line except through the isthmus of the thyroid gland.

The œsophagus lies behind the trachea, closely applied to its posterior wall, and when empty is flattened out against the vertebræ. It projects a considerable distance to the left of the trachea, and is therefore easier to reach through an incision upon the left side of the neck than upon the right. Above, the œsophagus is continuous with the pharynx, into the commencement of which the larynx opens, the orifice of the larynx being protected by the overhanging epiglottis, which is situated below and behind the root of the tongue. The posterior wall of the larynx, which is formed by the broad posterior portion of the cricoid cartilage, is in close relation with the front wall of the pharynx. Only a thin layer of connective tissue intervenes between the anterior wall of the pharynx, which consists merely of a layer of mucous membrane, and the posterior part of the larynx, which is made up chiefly of the broad posterior part of the cricoid cartilage. When the pharynx is empty it is flattened out against the vertebral column, and the larynx, under these circumstances, also lies close to the vertebral column.

From the cricoid cartilage down, the œsophagus and trachea, although in close proximity to each other, form two distinct tubes, which may be readily separated, one from the other. The posterior wall of the trachea, which is in direct relation with the œsophagus, is devoid of cartilaginous bands, and therefore a foreign body, lodged in the œsophagus, might press upon this contiguous, non-cartilaginous portion of the wall of the trachea and cause symptoms of strangulation. In the recess between the trachea and œsophagus, on either side, the recurrent laryngeal nerve ascends to enter the lower back part of the larynx.

The Laryngeal Region is covered in front by skin and deep fascia, but laterally by the muscles, the sterno-hyoid and sterno-thyroid and thyro-hyoid, and by the lobes of the thyroid gland.

The interior of the larynx may be examined after splitting the thyroid cartilage, taking care to make this section in the middle line, between the anterior attachments of the vocal cords. The true and false vocal cords are then exposed to view. The true cords are the lower, and are attached anteriorly, upon either side of the middle line, to the thyroid cartilage, midway between the lowest part of the incisura in its upper border and the lower border; posteriorly the true vocal cords are attached to the arytenoid cartilages, which rest, swivel-like, upon the upper surface of the cricoid cartilage.

The false vocal cords are the loose folds of mucous membrane which are situated above the true cords, inclosing much loose connective tissue; these may readily become œdematous—œdema glottis—and act as a dangerous obstruction to respiration.

THE THYROID GLAND.—The isthmus is the narrowest part of the thyroid gland. It joins the two lobes of the gland across the middle line, resting transversely upon the upper part of the trachea. At times there projects from the upper border of the isthmus a process of glandular tissue, the so-called middle or pyramidal lobe, which is located in front of the larynx and which may be encountered in operations in this locality. The thyroid gland is inclosed in a distinct connective-tissue capsule which will be found considerably thickened in cases where pathological processes affect the gland. Penetrating into the substance of the gland in all directions are connective-tissue processes or septa which are given off from the capsule and which support the parynchyma dividing the gland into lobes and lobules, and in which the lymphatics course. The thyroid gland is fixed to the cricoid and thyroid cartilages by bands of connective tissue. These bands connect the isthmus of the gland to the cricoid cartilage and the lateral lobes, adjacent to the isthmus, to the sides of the thyroid cartilage. It is necessary to divide those bands that connect the isthmus to the cricoid cartilage before the isthmus can be dislocated downward in order to expose the upper rings of the trachea in performing the operation of high tracheotomy. The two lobes of the thyroid gland, one on each side, are prolonged backward and upward upon the sides of the trachea and larynx, reaching as far back as the œsophagus and thus getting into close relationship with the common carotid artery and its adjacent structures. As the recurrent laryngeal nerve of each side ascends in the recess between the trachea and œsophagus to enter the lower, posterior part of the larynx it lies beneath the corresponding lateral lobe of the thyroid gland and must be carefully avoided in operations upon the thyroid gland. The isthmus of the thyroid lies just beneath the skin and deep fascia, whereas the lateral lobes extend upward and backward underneath the sterno-hyoid and sterno-thyroid muscles.

On account of the intimate relationship that exists between the thyroid gland and the trachea, tumors involving the gland may press upon the trachea, greatly narrow its lumen, or push it to one side.

If tracheotomy becomes necessary in these cases it may be difficult to locate the trachea. When the thyroid is enlarged by tumors, etc., it may be seen to rise and fall with the larynx in movements of swallowing. The thyroid is supplied by the superior and inferior thyroid arteries of each side, and drained by the superior, middle, and inferior thyroid veins. At times an arterial branch from the transverse portion of the arch of the aorta ascends upon the front of the trachea to reach the lower part of the gland: the arteria thyroidea ima. The arterial and venous branches form a network upon the surface of the capsule of the gland. See page 227 for description of the superior and inferior thyroid arteries.

The Parathyroid Bodies.—The parathyroid bodies are variable in number, usually four, occasionally more. They are small, reddish, glandular structures situated in the connective-tissue layer that surrounds the thyroid gland, usually posterior to the gland and in more or less close relationship to the capsule of the gland. They are 6 to 7 mm. long, 3 to 4 mm. wide, and 2.5 mm. thick. The parathyroid bodies are not constant in their position. Two are usually found upon the posterior aspect of the œsophagus, about on a level with the cricoid cartilage, and closely related to the posterior aspect of the corresponding lobe of the thyroid gland. The lower parathyroid bodies are situated, as a rule, in close relationship to the lower poles of the thyroid gland near the sides of the trachea. The parathyroid bodies receive their blood-supply chiefly from terminal branches of the inferior thyroid artery. Both inferior thyroid arteries should not be ligated in any operation upon the thyroid gland. It is essential that the parathyroid bodies be not injured or removed in operations upon the thyroid gland; nor should the inferior thyroid arteries of both sides be ligated in any operation upon the thyroid gland.

The function of the parathyroid bodies is not clearly understood, but it is certain that their removal results in tetany that inevitably terminates fatally. It is difficult or impossible to recognize these bodies during the course of operations upon the thyroid gland, and therefore, in order to avoid them, the posterior portion of the capsule behind which they are situated must be left undisturbed. If the parathyroids have been removed or damaged the symptoms of tetany that result may be controlled by the administration of the nucleoproteids of the parathyroids of beeves (Beebe).

The Suprasternal Region is the space in the lower front part of the neck above the upper border of the sternum and limited on either side by the anterior border of the sterno-mastoid. The surface shows a depression here known as the suprasternal fossa, or fossa jugularis. This region is covered by the skin, beneath which lies the deep cervical fascia, which splits into two layers, an anterior and a posterior; these layers are attached below to the anterior and posterior edges of the upper border of the sternum, inclosing a space —the suprasternal—between them which is occupied by some connective tissue and lymphatic glands. A communicating venous branch which connects the anterior jugulars of either side is also included between these two layers. The suprasternal space is shut off from the mediastinum by the posterior layer of the deep cervical fascia, and pus in this space is thus hindered from breaking into the mediastinum and is more apt to open externally through the skin.

Beneath the deep fascia lies the trachea, its anterior surface being readily accessible for operation. This part of the trachea may be lengthened by throwing the head back. If the trachea is incised transversely the wound gapes, and, if completely severed it retracts into the chest to such an extent that it may be difficult or impossible to reunite it. At times the arteria thyroidea ima ascends in front of this lower part of the trachea and might complicate an operation upon this part of the tube.

Descending obliquely downward and outward, from the lower part of the thyroid gland, are the inferior thyroid veins. These enter the right and left innominate veins or both may enter the left innominate, within the chest, behind the first piece of the sternum. The inferior thyroid veins are large and lie one on either side of the middle line. As they descend they get farther away from the middle line, so that they are not likely to be encountered in the operation of low tracheotomy if the incision is kept strictly in the median line.

The Blood-vessels of the Neck. THE COMMON CAROTID ARTERY. —This vessel ascends in the neck from behind the sterno-clavicular articulation to the level of the upper border of the thyroid cartilage, where it divides into the external and internal carotid. The course of the artery is indicated by a line drawn from the sterno-clavicular articulation to a point midway between the angle of the jaw and the mastoid process. The muscular guide to the artery is the anterior border of the sterno-mastoid.

The common carotid is crossed about the level of the cricoid cartilage by the omo-hyoid muscle; so that the lower part of the artery lies in the inferior carotid triangle and the upper part in the superior carotid triangle. The artery is more accessible for ligation in the upper triangle. In the lower part of its course, below the omohyoid, the artery lies beneath the anterior edge of the sterno-mastoid, whereas above, in the superior carotid triangle, it does not lie beneath the edge of the sterno-mastoid, but rather in front of it, and is here quite superficial, being covered only by the integument, platysma, and deep cervical fascia. Opposite the thyroid cartilage the lateral lobe of the thyroid gland comes into close relation with the artery, the latter grooving the gland. In its course up the neck the artery is accompanied by the internal jugular vein, which lies close upon its outer side, and by the pneumogastric nerve, which lies between the vein and the artery, but on a plane posterior to both. These structures are lodged in a loose, connective-tissue bed, which is continuous below with the connective tissue of the mediastinum.

Upon the front of the artery, opposite the middle of the thyroid cartilage, the descendens and communicans noni form a loop from which some branches are given off to supply the depressor muscles of the hyoid bone. Posteriorly the artery rests upon the transverse processes of the lower cervical vertebræ and the attachments of the vertebral muscles. The sympathetic nerve lies behind the artery and is closely related to the fascia that covers the prevertebral muscles. Below, opposite the sixth cervical vertebra, the inferior thyroid artery, which arises from the first part of the subclavican, curves inward, behind the carotid, etc., to reach the lower part of the thyroid gland. A prominent tubercle, the tubercle of Chassaignac, marks the transverse process of the sixth cervical vertebra. To the inner side of the artery are the trachea and œsophagus, and, higher up, the larynx and the lower part of the pharynx. The larynx projects forward between the arteries of either side. Ascending between the trachea and the œsophagus is the inferior, recurrent, laryngeal nerve. Opposite the thyroid cartilage the artery, as mentioned above, is in close relation with the lateral lobe of the thyroid gland. Upon the outer side of the artery the internal jugular vein is situated, and in close proximity to the vein a chain of lymphatic nodes. The common carotid artery is crossed above the omo-hyoid muscle by the superior thyroid vein and about its middle—*i.e.,* below the omo-hyoid—by the middle thyroid vein. Both these veins terminate in the internal jugular. Lower in the neck the artery is crossed by the anterior jugular vein, which, as a rule, terminates in the external jugular.

The artery is covered by the integument, superficial fascia, platysma, and deep fascia. The lower part of the artery lies beneath the sterno-mastoid, and this muscle must therefore be drawn aside in order to expose the vessel. Above, upon a level with the thyroid cartilage, the artery lies quite superficial, not being overlapped by the sterno-mastoid, but in front of it, and here its pulsation may be both felt and seen.

THE INTERNAL CAROTID is continued upward in the same course as the common carotid, lying alongside of the pharynx. The internal jugular vein lies along its outer side, and the pneumogastric nerve lies beneath both, but on a plane posterior. At the base of the skull the artery enters the carotid canal in the petrous portion of the temporal bone, and after traversing this canal enters the cranium through the middle lacerated foramen. In the neck the internal carotid lies in the superior carotid triangle, covered by the anterior edge of the sterno-mastoid; it is situated deeper than the external carotid and upon a plane posterior to it. The stylo-glossus and stylo-pharyngeus muscles, as they pass forward to the tongue and to the side of the pharynx, are interposed between the internal and external carotids. Behind, the artery rests upon the transverse processes of the upper cervical vertebræ and upon the rectus capitis anticus major muscle. The sympathetic nerve, with its superior ganglion, lies behind the artery, between it and the anterior vertebral muscles. Internally the artery is in relation with the side of the pharynx. The superior laryngeal nerve descends between it and the pharynx. At its origin the artery lies quite superficial, being covered by the integument, platysma, and deep fascia and overlapped by the anterior margin of the sterno-mastoid muscle. In the upper part of its course it lies deep in the neck beneath the posterior belly of the digastric and stylo-hyoid muscles and the parotid gland and the stylo-pharyngeus and stylo-glossus muscles, these two latter muscles separating it from the external carotid.

At the base of the skull the internal jugular vein leaves the internal carotid artery and enters the skull through the jugular foramen. This foramen is located external and posterior to the opening which marks the commencement of the carotid canal. Just below the base of the skull the glosso-pharyngeal nerve passes forward between the internal jugular vein and the internal carotid artery and then continues forward, below the stylo-glossus muscle, to reach the side of the base of the tongue. Just above the level of the hyoid bone the hypoglossal nerve curves forward between the artery and the vein. The spinal accessory, at the base of the skull, is situated between the internal carotid artery and the internal jugular vein, but passes backward and outward to reach the deep surface of the sterno-mastoid muscle.

The External Carotid Artery, at its origin, is located in the superior carotid triangle in front of the internal carotid artery. It passes upward to a point between the posterior border of the ramus of the jaw, and the mastoid process, and here, within the substance of the parotid gland, divides into the temporal and internal maxillary. As it ascends upon the side of the neck it describes a gentle curve with the convexity forward and is placed upon a plane anterior to the internal carotid, giving off many branches to the muscles and structures in the neck and to the tongue. It lies in front of the anterior border of the sterno-mastoid, being covered only by the skin, platysma, and deep fascia; higher up, on a level with the angle of the lower jaw, it is covered by the posterior belly of the digastric and stylo-hyoid, and at its bifurcation into its terminal branches it lies deep within the substance of the parotid gland.

The external carotid artery does not lie as deep in the neck as the internal carotid; upon a level with the angle of the lower jaw these two vessels are separated from each other by the stylo-glossus and stylo-pharyngeus muscles (together with the glosso-pharyngeal nerve). Both these muscles arise from the styloid process and pass forward, between the external and internal carotid arteries, in their course to reach the side of the tongue and the pharynx.

As the external carotid artery lies within the parotid gland it is crossed, upon a level with the lower border of the lobe of the ear, by the divisions of the facial nerve. The temporo-maxillary vein, which is formed by the junction of the temporal and internal maxillary veins, also lies superficial to it. Below the angle of the jaw the artery is crossed by the temporo-facial vein; this vessel is formed by the facial and a large branch from the temporo-maxillary, and after receiving the lingual and sometimes the superior thyroid, terminates in the internal jugular.

Below the level of the hyoid bone the external carotid gives off the superior thyroid. This branch passes forward and downward to the lateral lobe of the thyroid gland and gives branches to the larynx. The next branch given off above the superior thyroid is the lingual. This vessel passes forward, beneath the digastric and stylo-hyoid muscles and beneath the hyo-glossus, to supply the tongue. The next branch above is the facial. The facial is directed forward and upward and curving over the inferior border of the lower jaw, in the groove just in front of the masseter muscle, ascends upon the side of the face, nose, etc. At its origin the facial artery lies beneath the posterior belly of the digastric and stylo-hyoid muscles close to the posterior border of the submaxillary gland, which it grooves and supplies; here it gives off its submental branch, which runs forward upon the under surface of the mylo-hyoid muscle close to the body of the lower jaw. From its posterior aspect, upon a level with the origin of the facial, the external carotid artery gives off its occipital branch. This vessel passes upward and backward across the internal jugular vein and ascends beneath the anterior border of the sterno-mastoid muscle to reach the occipital region of the head. Above the origin of the occipital, also from its posterior aspect, the external carotid gives off the posterior auricular. This vessel courses upward and backward, running close behind the ear and supplying this and the mastoid region. The hypoglossal nerve swings forward across the outer side of the external carotid artery upon a level with the origin of the occipital.

The Internal Jugular Vein lies close to the outer side of the common carotid artery and its continuation, the internal carotid. This vessel is large, as big around as the little finger, very thin walled, and lies in the same connective-tissue bed with the artery and the pneumogastric nerve. It is formed above, at the base of the skull, by the union of the lateral (sigmoid) and inferior petrosal sinuses. These vessels emerge from the interior of the skull through the jugular foramen, which is situated behind and external to the commencement of the carotid canal; the pneumogastric, spinal accessory, and glosso-pharyngeal nerves also emerge from the cranium through the jugular foramen. Just outside the skull the lateral and the inferior petrosal sinuses join and form a bulbous dilatation, which marks the commencement of the internal jugular vein. At the root of the neck the internal jugular terminates by joining with the subclavian to form the innominate. In its course through the neck the vein receives a number of large branches: the temporo-facial, lingual, and superior and middle thyroids. A chain of lymphatic nodes is situated along the outer side of the vein, close to its wall, and these may be diseased and require extirpation. On the right side, in the root of the neck, where the internal jugular unites with the subclavian, the right lymphatic duct is seen to enter the vessel. Upon the left side of the neck the thoracic duct enters the vein at its junction with the subclavian.

The thoracic duct ascends out of the thorax into the root of the neck, arches forward and outward over the first part of the subclavian artery, and empties into the internal jugular vein in the angle formed by the junction of this vein with the subclavian.

The Subclavian Artery.—This vessel upon the right side is derived from the innominate, which bifurcates behind the right sterno-clavicular articulation into the common carotid and subclavian. The left subclavian is given off from the left end of the transverse part of the arch of the aorta and ascends in the upper part of the chest as far as the left sterno-clavicular articulation.

From the sterno-clavicular articulation, upon either side, the subclavian artery arches outward across the root of the neck and passes into the axilla to become the axillary. In the root of the neck the artery is found in the subclavian triangle resting directly upon the first rib.

The tendon of the scalenus anticus, at its attachment, is situated in front of the subclavian artery, and thus, for purposes of description, serves to divide the vessel into three parts. The first part of the artery corresponds to that portion which is included between its origin and the inner margin of the tendon of the scalenus anticus; the second part of the artery corresponds to the portion immediately behind the tendon of the scalenus, and the third part of the artery reaches from the outer border of the tendon of the scalenus anticus to the point where it enters the axilla to become the axillary. The first and second parts of the artery are in intimate relation with the apex of the lung and dome of the pleura; the third portion rests upon the upper surface of the first rib. The trunks of the brachial plexus in their course through the subclavian triangle are situated above the subclavian artery. The subclavian artery gives off several large branches; from its first part the vertebral, internal mammary, and thyroid axis (inferior thyroid, suprascapular, transversalis colli); from the second part, the superior intercostal. The origin of these branches varies in different individuals and in the same individual upon either side.

The subclavian vein is the continuation of the axillary. It passes inward across the root of the neck, beneath the clavicle and in front of the scalenus anticus tendon, resting upon the upper surface of the first rib and lying in front and to the inner side of the artery. It is situated a considerable distance away from the artery, from which it is separated by the tendon of the scalenus anticus. The subclavian vein joins with the internal jugular to form the innominate. Upon the right side where these two veins join they receive the right lymphatic duct, and upon the left side, at their junction, they receive the thoracic duct.

The Inferior Thyroid Artery is seen deep in the lower part of the inferior carotid triangle. It is a branch of the thyroid axis which arises from the first part of the subclavian. The inferior thyroid artery passes upward and inward along the inner border of the scalenus anticus muscle. In this part of its course it lies behind the common carotid artery. Upon a level with or just below the transverse process of the sixth cervical vertebra—this process is readily identified by the prominent tubercle which marks it, the tubercle of Chassaignac—the artery turns inward toward the middle of the posterior border of the lateral lobe of the thyroid gland. The artery disappears underneath the border of the gland and then turns downward toward the lower pole of the lobe, where it breaks up into a number of branches to enter this part of the gland. As the vessel turns inward upon a level with the sixth cervical vertebra it lies behind the common carotid artery, and is crossed by the cervical sympathetic nerve. The middle cervical ganglion lies in front of the artery. Just before the inferior thyroid artery reaches the thyroid gland the recurrent laryngeal nerve passes across it, usually in front of the artery, sometimes behind it, also upon the level of the transverse process of the sixth cervical vertebra. The recurrent laryngeal nerve of each side is situated well behind the corresponding lobe of the thyroid gland in the recess between the trachea and œsophagus.

The Superior Thyroid Artery is the first branch given off from the external carotid just above the bifurcation of the common carotid, about upon a level with the upper border of the thyroid cartilage. The artery ascends a short distance and then curves downward and disappears underneath the omohyoid muscle in its course to the upper pole of the lateral lobe of the thyroid gland, where it divides into two main branches, one going to the anterior and the other to the posterior surface of the thyroid gland. The artery is accompanied by the superior thyroid vein. It may be necessary to ligate the superior thyroid vessels in cases of hyperthyroidism preliminary to extirpating a lobe.

The Vertebral Artery lies deep in the lower part of the neck. It arises from the first part of the subclavian between the scalenus anticus muscle in front and the longus colli behind and enters the foramen in the base of the transverse process of the sixth cervical vertebra. The prominent tubercle on the transverse process of this vertebra is a good guide to the artery. The artery may be reached through the subclavian triangle by drawing the sterno-mastoid forward toward the middle line or by nicking or incising its posterior border.

The Cervical Sympathetic Nerves.—The cervical sympathetic is found deep in the neck behind the carotid artery, internal jugular vein, and vagus nerve, resting upon the prævertebral muscles—the rectus capitis anticus major above and the longus colli below. The nerve lies in intimate contact with these muscles beneath the fascia that covers them,—the fascia prævertebralis. At the root of the neck the nerve descends into the thorax.

The cervical portion of the sympathetic is marked by three swellings or ganglia,—the superior, middle, and inferior.

The superior ganglion, the largest, is fusiform in shape and about one inch in length. It is found resting upon the rectus capitis major muscle opposite the second and third vertebræ, behind the internal carotid artery and to the inner side of the vagus nerve. Among other branches it gives off the superior cardiac nerve.

The middle ganglion is the smallest of the three. It is sometimes absent or it may be double. It is situated at the point where the sympathetic nerve crosses the inferior thyroid artery, opposite the prominent tubercle on the transverse process of the sixth vertebra,—the tubercle of Chassaignac. This ganglion gives off thyroid branches that accompany the inferior thyroid artery to the thyroid gland. The middle cardiac nerve is derived from the middle ganglion.

The inferior cervical ganglion is larger than the middle. It is irregular in shape and is frequently merged with the first thoracic ganglion. It is situated opposite the neck of the first rib, between the scalenus anticus and longus colli muscles and under cover of the vertebral vessels. A branch from the inferior cervical ganglion curves around the subclavian artery and ascends to communicate with the middle cervical ganglion; it is called the ansa Vieussenii. The inferior ganglion gives off the inferior cardiac nerve.

Pupillo-dilator fibers are derived from the superior ganglion through branches to the Gasserian ganglion and then through the ophthalmic division of the fifth and the long ciliary nerves.

Branches from the middle ganglion are distributed to the thyroid gland.

Accelerator fibers to the heart are divided from all three ganglia and from the first thoracic ganglion.

The Cervical Lymph-nodes.—These are pinkish bodies ranging in size from a small bead to a bean. They usually occur in groups or chains along the course of the large veins. Occasionally they are found singly. They may be described as consisting of two groups, superficial and deep. Both groups communicate freely with each other. The lymph-nodes are aggregations of lymph-tissue situated along the course of the lymphatic vessels. The lymph-nodes readily become affected, enlarged, tender, when infectious material, absorbed by the capillary lymph-spaces and channels, reaches them.

The Superficial Lymph-nodes are lodged in the subcutaneous connective-tissue layer, just underneath the skin, between the superficial and deep fasciæ. They are situated along the course of the external jugular vein and its tributaries. The superficial lymph-nodes may become affected in connection with lesions of the face, neck, scalp. They tend to soften, break down, and open through the skin. If it becomes necessary to incise them the skin layer only need be penetrated. After they have been incised and evacuated they may be swabbed out with tincture of iodin and packed with iodoform gauze. If enlarged as the result of some chronic process and not broken down, they may be shelled out readily by blunt dissection.

The Deep Cervical Lymph-nodes.—They are found deep in the neck, underneath the deep cervical fascia, in the connective-tissue spaces along the course of the great vessels of the neck. They are found lying very close to the walls of the internal jugular vein and its tributaries. The different groups of lymph-nodes may be named according to their situation in the various triangular spaces of the neck. The deep lymph-nodes may be affected secondarily to infection of the superficial or they may become enlarged (swollen) as a result of infection that enters through the tonsils and glandular tissue of the naso-pharynx, mouth, base of the tongue, etc. The inflammatory process may be acute, in which case the lymph-glands may suppurate and break down, and all that will be necessary is simple incision and drainage. Frequently the glands are found to be the seat of tuberculous disease. They become swollen, some cheesy in the center; others suppurate and break down. Those glands that have not yet broken down may be readily enucleated. Those that have suppurated are often very firmly adherent to adjacent structures, walls of veins, etc., and require much care in dissecting them out. Operation to be successful must be thorough.

Anatomically and also for the purpose of surgical interference the lymph-nodes may be grouped according to their situation in the various triangular spaces as follows:—

Superior carotid triangle.
Inferior carotid triangle.
Submaxillary triangle.
Occipital triangle.
Subclavian triangle.

Less frequently gland-masses are found in the front of the neck, in the submental triangle and in the laryngeal region. The enlarged glands may be fairly well confined to one triangle or may involve several spaces or all the glands of one or both sides of the neck may be affected.

OPERATIONS UPON THE NECK.

Ligation of Blood-vessels. The Common Carotid Artery.—The common carotid may be tied either above or below the point where the omo-hyoid crosses it, which is upon a level with the cricoid cartilage. It is ligated preferably and more readily in the so-called superior carotid triangle: above the crossing of the omo-hyoid.

The linear guide to the common carotid is a line drawn from a point midway between the angle of the jaw and the mastoid process to the sterno-clavicular articulation. The muscular guide is the anterior border of the sterno-mastoid muscle.

The incision is made about two inches long, corresponding to the anterior border of the sterno-mastoid, its midpoint upon a level with the cricoid cartilage. This incision penetrates through the skin and subcutaneous fatty layer, including the platysma, and should expose the anterior border of the sterno-mastoid muscle. The edge of the sterno-mastoid should be recognized and drawn outward, and then, after carefully incising the underlying layer of deep cervical fascia,—the fascia that separates the vessels from the sterno-mastoid muscle,—the vessels, surrounded by some loose connective tissue, are exposed—first, the internal jugular vein, big and thin-walled, lying to the outer side of the artery, and then the common carotid, whose pulsation is readily felt and seen and which lies to the inner side of the vein. The pneumogastric nerve, which is located between the artery and vein, but behind them, is not seen. The anterior belly of the omo-hyoid is seen as it crosses the vessels opposite the cricoid cartilage. The loop formed by the descendens and communicans noni may also be recognized upon the front of the vessels. The superior thyroid vein crosses the artery from within outward above the omo-hyoid muscle, and the middle thyroid vein below this muscle. If these vessels are cut, they should be clamped and tied.

The connective-tissue sheath which incloses the artery should be picked up with mouse-tooth forceps, and nicked with the point

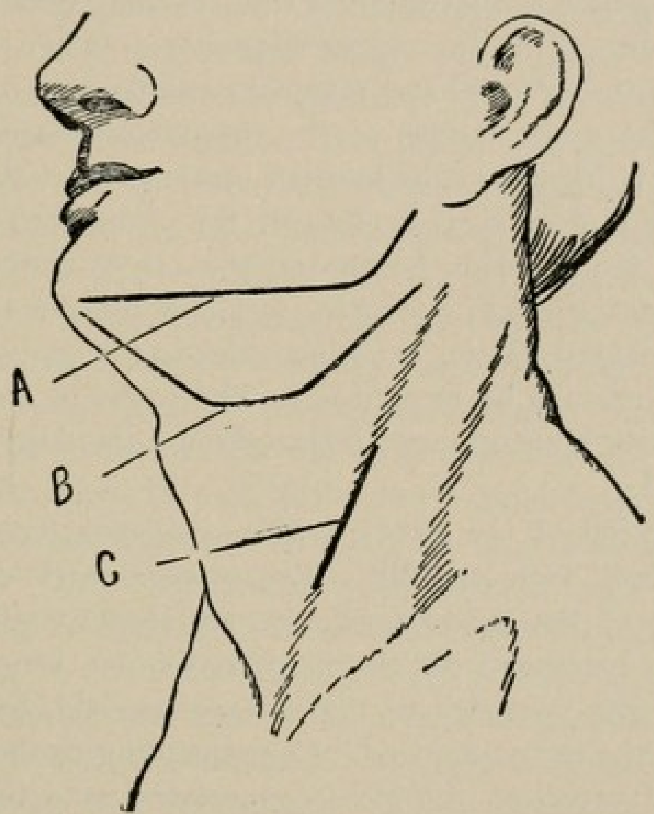

Fig. 138.—*A*, incision for removal of lower jaw; *B*, incision for ligation of lingual artery and Kocher's amputation of tongue; *C*, incision for ligation of common carotid and for œsophagotomy.

of the knife in the direction of the long axis of the vessels; into the opening thus made, a director is introduced, and, working close to its wall, the vessel is separated all around, taking care to avoid the pneumogastric nerve, which lies posteriorly. A blunt-pointed aneurism needle is then introduced into the opening and carried around the artery from without inward, entering between the artery and the vein. The ligature is then drawn around the vessel, and we are ready to tie. The ligature should be of ordinary catgut and tied with a square knot. After the ligature is in place and before it is tied the parts should be again inspected in order to make sure that the nerve is not included. Some surgeons tie the artery double and divide it between the ligatures, but this is probably unnecessary. The incision is closed with a catgut suture.

The External Carotid.—The ligation of the external carotid is practiced as a preliminary to many bloody operations about the mouth, jaws, etc., and to control hemorrhage from parts supplied by its branches when the branches themselves are not accessible. The linear guide to the artery is the same as that for the common carotid; the muscular guide is the anterior edge of the sterno-mastoid. At the upper border of the thyroid cartilage the common carotid artery bifurcates into the external and internal carotids, and it is close to its origin, near the upper border of the thyroid cartilage, that the external carotid is ligated. The incision commences at the level of the hyoid bone and is carried downward, for a distance of about two inches, along the anterior border of the sterno-mastoid. The incision penetrates through the skin, fat, and platysma muscle down to the deep cervical fascia, exposing the edge of the sterno-mastoid muscle, which should be recognized. The edges of the incision are drawn apart with blunt-pronged retractors and the deep cervical fascia is then incised.

The pulsation of the artery, within its connective-tissue sheath, may now be both seen and felt. The external carotid artery lies a little in front of the anterior edge of the sterno-mastoid. The internal carotid, together with the internal jugular vein and pneumogastric nerve, lies posterior to the external carotid, beneath the anterior edge of the sterno-mastoid. Corresponding to the upper border of the thyroid cartilage, the loose connective tissue that invests the artery is picked up with a thumb forceps and snipped with the point of the knife, cutting in a direction corresponding to the long axis of the vessel; into the opening which is thus made a blunt director is introduced and worked around the vessel, sticking close to its wall. Through the path thus made by the director a ligature is carried around the vessel in the eye of an aneurism needle. The ligature is then tied and the incision closed. After the ligature has been carried around the artery it may be left untied, with its ends hanging out of the incision, to be tied only in case an emergency arises calling for its use.

The Internal Carotid.—The ligation of the internal carotid is but seldom called for. The internal carotid may be tied through an incision similar to that for ligation of the external carotid. The vessel is found underneath the anterior edge of the sterno-mastoid, which is the muscular guide to it. The internal carotid has the same relations to the internal jugular vein and pneumogastric nerve that the common carotid has, the internal carotid being really the continuation of the common; and these structures must be avoided in isolating the vessel and passing the ligature.

The Subclavian Artery.—The third part of the subclavian artery is tied after it is exposed in the subclavian triangle.

The patient is placed with the shoulders somewhat raised and the head thrown back and turned toward the opposite side, the arm being drawn down to depress the shoulder. The incision corresponds to the middle third of the clavicle. It is placed just above the clavicle, and extends from the anterior border of the trapezius forward and inward almost as far as the outer border of the sterno-mastoid muscle; the incision falls a little short of the edge of the sterno-mastoid muscle in order to avoid the external jugular vein. The incision in the skin may be made by drawing the integument of the neck downward over the surface of the clavicle and then cutting through it, down upon the surface of the clavicle; when the skin is released, the incision is found to lie just above and parallel with the clavicle. This incision reaches through the skin, fat, and platysma down to the deep fascia. The deep fascia, which reaches from the edge of the trapezius muscle behind to the sterno-mastoid in front, is now incised, avoiding the external jugular vein, which pierces the deep cervical fascia behind the outer edge of the sterno-mastoid muscle. Beneath the deep fascia the venous plexus, formed by the transversalis colli and suprascapular, is encountered. These veins may be wounded, but are readily clamped; often, however, they can be avoided, as the knife may be discarded after the deep fascia has been incised. Beneath the deep fascia there is also a considerable quantity of loose fat and connective and lymphatic tissue.

The posterior belly of the omo-hyoid muscle, which lies pretty low down near the clavicle, is now sought and must be drawn upward to show the subclavian triangle, of which it forms the upper boundary, the anterior boundary being formed by the sterno-mastoid and the inferior boundary by the clavicle.

Within the triangle, passing transversely outward, are the transversalis colli and suprascapular arteries. These vessels should be avoided. The tendon of the scalenus anticus, which is the guide to the subclavian artery, may be felt as a tense cord passing straight up and down beneath the posterior or outer border of the sterno-mastoid and attached below to the first rib. The phrenic nerve passes obliquely downward across the front of the tendon of the scalenus anticus into the thorax. If this tendon is followed downward as far as its attachment to the first rib, one may locate the subclavian artery as it passes outward and forward from behind the tendon of the scalenus anticus muscle, resting directly upon the upper surface of the first rib. That part of the subclavian artery which lies upon the first rib is the part which is ligated. The subclavian vein lies a considerable distance to the inner side of, and anterior to, the artery, the tendon of the scalenus anticus intervening between them, and is not apt to be encountered during the operation. Within the triangle, above the subclavian artery, may be seen the three cords of the brachial plexus. These pass obliquely downward and outward from behind the scalenus anticus muscle, and should not be mistaken for the artery, which is the lowest structure in this triangle and rests directly upon the upper surface of the first rib. These structures may all be exposed by blunt dissection, separating with the finger or handle of the knife, after the deep fascia has been incised.

With blunt retractors the wound is held open and the connective-tissue sheath, which envelops the artery, picked up and snipped with the scissors and the artery then separated from the adjoining structures with a blunt director, working around the artery close to its wall. The aneurism needle is passed around the artery from without inward, avoiding the cords of the brachial plexus. The subclavian vein, which lies below and internal to the artery, is not apt to be in the way.

It should also be remembered that the dome of the pleura reaches above the clavicle into the subclavian triangle, and that the subclavian artery (second part), as it lies behind the tendon of the scalenus anticus, rests upon the pleura, and care should be taken to avoid injuring this structure, especially in making way for the passage of the ligature.

The ligature is tied with a square knot, deep in the wound, without lifting the artery too much out of its bed.

The Lingual Artery.—This artery is usually ligated preliminary to amputation of the tongue. For incision, etc., see page 262.

The Superior Thyroid Artery.—The superior thyroid artery is ligated during the course of operations upon the thyroid gland.

The artery, together with the superior thyroid vein which accompanies it, is found close to its origin in the space between the upper border of the thyroid cartilage and the lateral horn of the hyoid bone. The artery and vein are picked up on the blunt ligature carrier and tied.

The superior thyroid arteries of both sides may be ligated some days or weeks before undertaking extirpation of the thyroid gland in cases of exophthalmic goitre, where the symptoms are so exaggerated as to counterindicate the more radical operation.

The incision, about two and one-half inches long, is made from the anterior edge of one sterno-mastoid muscle, across the front of the neck, to the anterior edge of the other. The incision follows the natural crease of the neck and is placed just above the cricoid cartilage, midway between the cricoid cartilage and the hyoid bone. The artery is found just underneath the deep fascia, close to its origin from the external carotid, in the space between the upper border of the thyroid cartilage and the lateral horn of the hyoid bone. The superior thyroid vein is included with the artery in the ligature. The vessels are picked up upon the blunt ligature-carrier and tied with twenty-day catgut.

The Inferior Thyroid Artery.—This vessel is ligated during the course of operation upon the thyroid gland. This artery is the largest branch of the thyroid axis. It ascends deep in the root of the neck along the inner border of the scalenus anticus muscle and opposite the prominent anterior tubercle of the sixth cervical vertebra, the tubercle of Chassaignac, passes inward behind the common carotid artery, etc., to reach the lower part of the lateral lobe of the thyroid gland. It is crossed by the sympathetic nerve, the middle cervical ganglion resting upon the artery either anterior or posterior to it. The recurrent laryngeal nerve as it ascends in the root of the neck a'so crosses the artery.

An incision about three inches in length is made along the anterior border of the sterno-mastoid reaching downward as far as the clavicle. The incision extends through the skin and fat down to the deep cervical fascia. This layer is divided in front of the sterno-mastoid and the common carotid artery and adjacent structures, internal jugular vein, pneumogastric nerve, drawn outward with a blunt hook. With the finger in the wound, the tubercle on the transverse process of the sixth cervical vertebra is sought. This is the guide to the artery. At this level the vessel passes inward to reach the lateral lobe of the thyroid gland. A ligature is carried around the vessel with an aneurism needle and securely tied. The ligature should be applied to the vessel some little distance away from the thyroid gland so as to avoid the inferior recurrent laryngeal nerve which passes across the artery as it ascends in the neck.

Facio-hypoglossal Nerve Anastomosis.—The facial nerve is occasionally injured, divided, during the course of operations upon the mastoid antrum, result of gun-shot, etc., and it may be desirable to make an anastomosis between its peripheral portion and the proximal portion of some other nerve—the hypoglossal or spinal accessory—with the object of correcting the paralysis of the muscles of the face, etc. Usually the hypoglossal is selected because of the fact that its nucleus of origin is quite adjacent to that of the facial; it is quite readily accessible in the neck, and the paralyses resulting from its division are not so objectionable, etc.

The facial nerve is reached through an incision that commences above, just behind the ear, above and in front of the tip of the mastoid process, and passes downward along the anterior border of the sterno-mastoid muscle as far as, or beyond, the level of the hyoid bone. The nerve is sought deep in the parotid space, between the ramus of the jaw in front and the mastoid process behind. The parotid gland is exposed and detached posteriorly so that it may be drawn well forward with the blunt-pronged tractor. The sterno-mastoid muscle is retracted toward the back. All hemorrhage must be controlled so that the wound is dry. The nerve may be seen as it passes forward external to the styloid process and the posterior belly of the digastric muscle on its way to enter the parotid gland. It enters the posterior border of the parotid gland about one cm. above and one cm. internal to the tip of the mastoid process. The nerve is followed up toward the stylo-mastoid foramen and cut square through as high up as possible, and the end brought down ready for anastomosis with the nerve chosen for the purpose—usually the hypoglossal.

The hypoglossal nerve is sought in the lower part of the incision. The nerve is found as it curves from behind, forward, across the external carotid artery, just above the point where the common carotid bifurcates and just behind the posterior belly of the digastric muscle. The hypoglossal is cut and the proximal end brought up to meet the distal end of the facial. The ends of the nerves are joined together accurately with several very fine silk or catgut sutures. The sutures are introduced with a fine needle, and should include only the sheaths of the nerves in their bite.

Occasionally it is necessary to expose and stretch the facial nerve for spasm of the facial muscles.

Resection of Cervical Sympathetic (Jonnesco).—Total bilateral resection of the cervical sympathetic including the three cervical ganglia and the first thoracic ganglion. The operation is done for

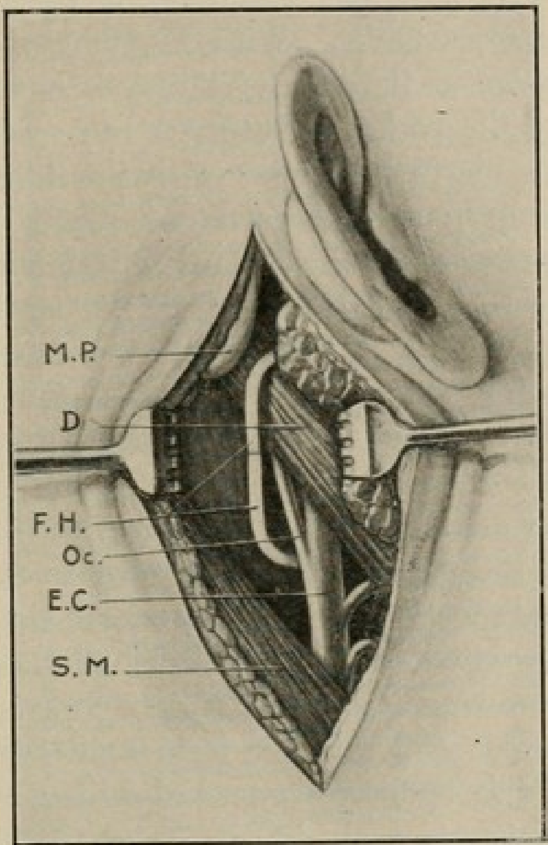

Fig. 139.—Fascio-hypoglossal Anastomosis (*Frazier*). The Stump of the Facial Nerve has been turned down and Anastomosed to the Stump of the Hypoglossal. *D.*, digastric muscle; *E.C.*, external carotid artery; *F.H.*, anastomosed facial and hypoglossal nerves; *M.P.*, mastoid process; *Oc.*, occipital artery; *S.M.*, sterno-mastoid muscle.

the cure of exophthalmic goitre (Basedow's disease). An interval of about two weeks should elapse between the first operation for extirpation of the nerve on the one side and the second operation for extirpation of the nerve on the other side.

Two incisions are made,—one in the upper part of the neck in order to reach the superior ganglion, and one on the lower part of the neck to gain access to the middle and inferior ganglia, etc.

The upper incision commences at the posterior border of the mastoid process, and is carried downward along the posterior border of the sterno-mastoid for a distance of about 5 cm. After penetrating between the fibers of the sterno-mastoid muscle, the layer of deep cervical fascia that lines its under surface is incised. The finger is then introduced into the wound and the sterno-mastoid is separated bluntly from prævertebral muscles that lie beneath it. This separation is not difficult, the finger working in the natural connective-tissue space that exists between the fascia that lines the deep surface of the sterno-mastoid and that which covers the prævertebral muscles, the fascia prævertebralis. With the finger this separation is carried as far upward as the base of the skull and as far downward toward the root of the neck, as the finger can reach. With a blunt retractor the sterno-mastoid, together with the internal jugular vein, internal carotid artery, and vagus nerve, is drawn well forward and the sympathetic nerve sought. The nerve is found lying upon the prævertebral muscles, to the inner side of the anterior tubercles of the transverse processes and underneath the fascia prævertebralis. When this layer of fascia is snipped through the nerve comes into view, and is readily identified by the thickened portion that represents the superior ganglion.

The lower end of the ganglion is grasped with an artery forceps and the trunk of the nerve followed upward as far as the base of the skull. All the branches that it gives off are cut with the scissors and the nerve then seized as high as possible above the ganglion and with gradually increasing traction it is torn away. The end of the nerve with the forceps still attached is brought out through the incision. The wound is temporarily packed with gauze.

A second incision is made in the lower part of the neck. It commences just above the clavicle and extends upward, corresponding to the posterior border of the sterno-mastoid for about 4 cm. The posterior edge of the sterno-mastoid is exposed and then, after incising the underlying layer of deep cervical fascia, the finger is introduced into the wound. The finger enters the lower part of the same connective-tissue space that was already explored with the finger through the upper incision. The finger is pushed downward in the space as far as the clavicle or first rib. A blunt retractor is then introduced and the edge of the sterno-mastoid—together with the bundle of structures consisting of the internal jugular vein, carotid artery, vagus nerve, etc.—is drawn toward the middle line and the wound thus opened wide. The inferior thyroid artery is sought. It crosses the root of the neck upon a level with the prominent anterior tubercle of the transverse process of the sixth vertebra,—the tubercle of Chassaignac. The middle cervical ganglion is found usually behind, though sometimes in front of the inferior thyroid artery. At times the ganglion is absent and represented by a plexus that surrounds the inferior thyroid artery; or this plexus may be absent, the trunk of the nerve passing down across the artery without any interruption. Traction may be made upon the nerve in the upper and lower incision in order to positively identify it.

With the director the nerve is separated and raised from its bed, working simultaneously through both the upper and lower incisions, and is then drawn down and out through the lower incision. The detachment of the nerve where it crosses the inferior thyroid artery is easier when it descends in front of the vessel. As a rule, the nerve descends behind the artery. The branches that are distributed from the ganglion to the artery must be divided; also the median cardiac nerve which may be identified by its course inward, and the anterior branch of the ansa Vieussenii. The trunk is then drawn down under the artery.

Following the course of the nerve downward the inferior ganglion is reached. This ganglion is situated behind the clavicle, resting upon the neck of the first rib, between the scalenus anticus and longus colli muscles, partly covered by the vertebral vein and artery. The nerve is seized with the forceps near the ganglion and drawn a little upward and the vertebral vein which covers the ganglion exposed and drawn outward with a blunt hook; likewise the vertebral artery. There is then exposed to view the inferior ganglion with its many small branches, including the nervus cardiacus inferior and nervus vertebralis. These branches are all divided with the scissors. The further separation of the ganglion is made with the fingers working downward past the first thoracic ganglion, which is also detached. As the final step of the operation the first thoracic ganglion is seized with the forceps and with gradually increasing traction is torn out. The entire cervical sympathetic, including its three ganglia, and the first thoracic ganglion are thus extirpated. The incisions are closed with suture without drainage.

The most difficult part of the operation is the separation, etc., of the inferior cervical ganglion. The subclavian artery lies at a deeper level and is not usually encountered. The phrenic nerve lies to the outer side crossing the scalenus anticus obliquely from above downward.

The plan of operating through two short incisions avoids division of the superficial branches of the cervical plexus, the spinal accessory nerve, and the external jugular vein.

Cervical Adenectomy.—Removal of the lymph-nodes of the neck for tuberculosis, adeno-sarcoma, etc. The incision varies according to the location of the affected glands and whether those in one triangle or those in several triangles are involved.

Superior and Inferior Carotid Triangles.—To expose the chain of glands underneath the anterior border of the sterno-mastoid muscle, in the superior and inferior carotid triangles, an incision is made along the anterior border of the sterno-mastoid muscle through the skin and fat. The external jugular and some of its tributaries will be encountered in the fat layer. These are clamped and ligated when cut or they may be recognized and ligated double before they are cut. The fascia is then incised along the anterior edge of the sterno-mastoid muscle, plainly exposing the fibers of the muscle. The edge of the sterno-mastoid is an important landmark. The edges of the incision are drawn widely apart with blunt-pronged tractors. The layer of deep cervical fascia is next incised and the diseased gland mass thus exposed. The incision should be sufficiently large to freely expose the mass. Glands which have not already broken down may be seized with the fingers or with a volsella forceps and enucleated by blunt dissection with the fingers or blunt-pointed, curved scissors. It may be necessary to snip occasional connective-tissue strands with the scissors. They are cut very close to the gland mass. Glands that have suppurated will be found more intimately attached to the adjacent structures through adhesions resulting from periadenitis. These glands are pulled upon—not too forcibly—and are dissected free from the immediately adjacent parts with the blunt-pointed, curved scissors, with the fingers, etc., working close to the surface of the gland mass and making moderate traction at the same time. Usually during the course of the dissection the internal jugular vein or in dissection of the upper carotid triangle, the large temporo-facial branch will be exposed. In removing gland masses that lie in close relation to these vessels it is desirable to deliberately expose the vessels and clean them away from the gland mass. With the vessels thus exposed there is much less danger of wounding them, and if they are accidentally torn or incised it is comparatively easy to secure the bleeding point and ligate it. It is dangerous to operate deep in the neck through a small incision. It is necessary to see plainly and to recognize structures as they are met during the progress of the operation. Sudden profuse hemorrhage which cannot be located is best controlled by making compression with the finger in the wound. The wound is wiped dry and upon removing the finger the point from which the blood comes is seen and secured. The large veins and the hemorrhage that may result if they are cut are practically the only obstacles encountered during the course of operations in this part of the neck.

The gland masses may extend forward into the submaxillary triangle, and it will then be necessary to carry another incision forward, above and parallel with the hyoid bone, and curving upward toward the middle of the chin. Occasionally it will be necessary to divide the sterno-mastoid muscle in order to reach diseased glands which lie well underneath the muscle. Usually partial division of the muscle will suffice. The ends of the muscle are reunited by several mattress sutures of chromic catgut.

All bleeding points must be secured and ligated before closing the incision.

The wound is packed with iodoform gauze and the incision is closed with interrupted silk-worm sutures except at the lower end, where the gauze drain emerges. The drain is removed on the fourth or fifth day.

Submaxillary Triangle.—Gland masses may extend into this space from the carotid triangles or they may be limited to this space alone. This space is opened up by an incision that commences at the anterior border of the sterno-mastoid muscle upon a level with the angle of the jaw; it passes downward and forward to the hyoid bone, then forward above and parallel with the hyoid bone, and terminates by curving upward toward the middle of the chin. The incision penetrates the skin, fat, and the platysma down to the deep fascia. The facial vein will be exposed and may be divided, and will require ligation. The deep fascia is next incised, thus opening up the contents of the triangle. In enucleating diseased lymph-glands from this triangle, especially toward the back, the facial artery and the temporo-facial vein which empties into the internal jugular will be exposed and may require ligation.

Posterior or Occipital Triangle.—This triangle may contain enlarged lymph-nodes—tuberculous, sarcomatous, etc.—that require excision. To expose the contents of this triangle an incision is made along the posterior border of the sterno-mastoid muscle down through the skin and fat layers. The external jugular vein or its large tributary, the posterior jugular, may be divided in making this incision and will require ligature. The posterior edge of the sterno-mastoid is exposed—it is a good landmark,—and is drawn forward with the blunt-pronged retractor. The deep fascia is then incised and the gland masses are exposed and may be enucleated. The spinal accessory nerve passes across this triangle. It appears at the posterior border of the sterno-mastoid muscle at the junction of its upper and middle thirds, and passes obliquely downward and backward across the space, and disappears under the anterior edge of the trapezius muscle, which it supplies. If the nerve is touched or pulled upon the trapezius contracts and indicates that the nerve is in evidence.

It may be necessary to continue the dissection down into the subclavian triangle. In this case the incision is prolonged down along the posterior border of the sterno-mastoid as far as its attachment to the clavicle, and from the lower end of this incision, another is carried outward, above and parallel with the clavicle, as far as the edge of the trapezius.

Subclavian Triangle.—This space often contains diseased lymph-glands—tuberculous, sarcomatous, carcinomatous—continuous with the glands in the axillary space.

In order to expose the contents of this space an incision is made which runs above and parallel with the clavicle, from the posterior border of the sterno-mastoid to the anterior edge of the trapezius. From the inner end of this incision another is carried upward along the posterior edge of the sterno-mastoid for a sufficient distance to give free access to the space. The incision goes through the skin and fat layers down to the deep fascia. The lower end of the external jugular vein, just before it pierces the deep cervical fascia, may be exposed and may require ligation. Next, the deep fascia is incised when the gland mass is exposed. The gland mass must be enucleated by blunt dissection with the finger or with the blunt-pointed, curved scissors, working all the time very close to the surface of the gland mass, and occasionally snipping connective-tissue strands that show when traction is made on the gland mass. Traction is made on the mass and the adjacent structures slowly and deliberately peeled away from it. During the course of the enucleation some branches of the transverse cervical and the subscapular veins will be seen. These may be pushed aside or they may

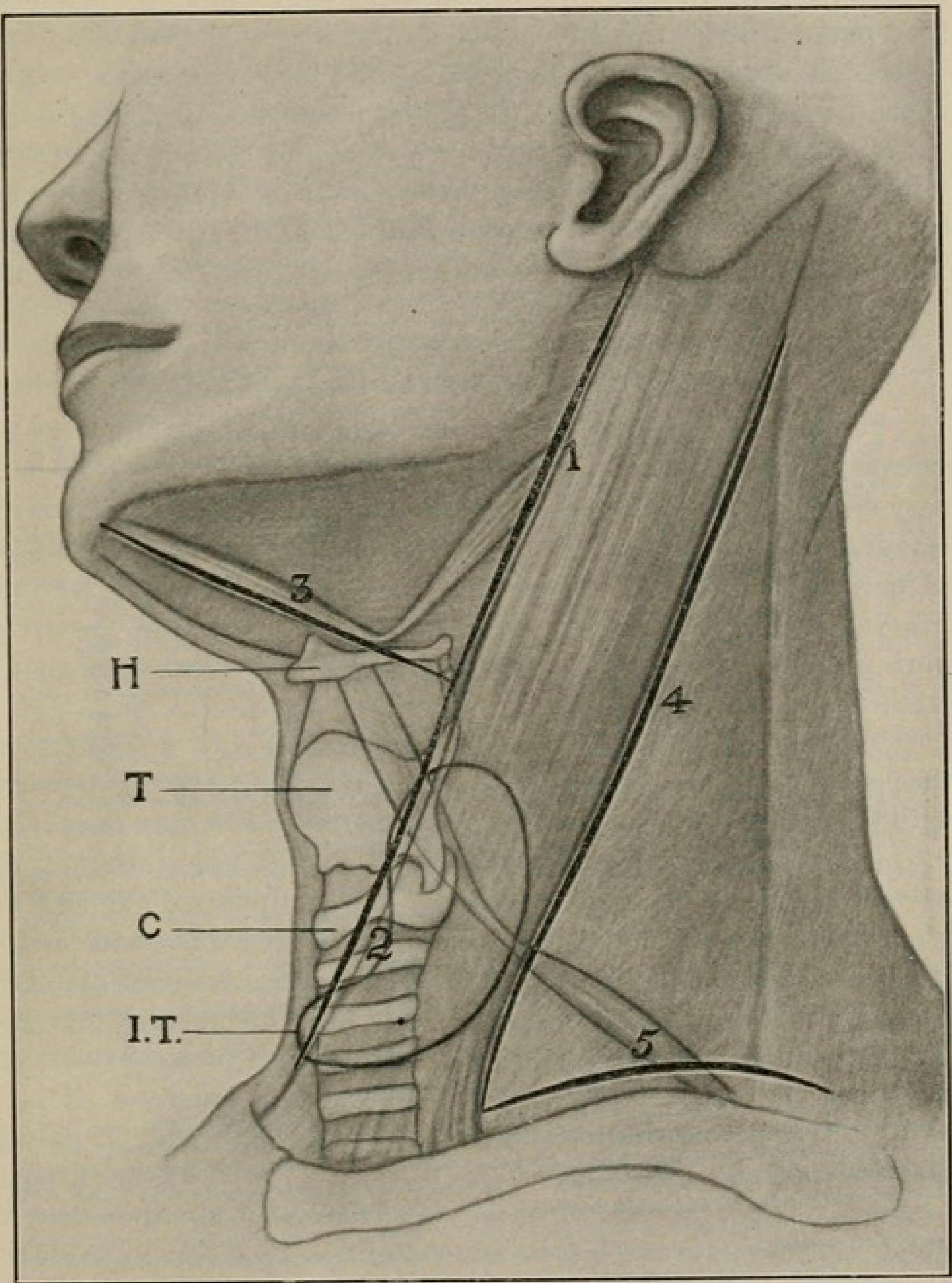

Fig. 140.—Incisions for Gaining Access to the Various Triangles of the Neck. *C.*, cricoid cartilage; *H.*, hyoid bone; *I.T.*, isthmus of the thyroid gland; *T.*, thyroid cartilage. 1-2, for glands situated along the anterior border of the sterno-mastoid muscle and along the course of the internal jugular vein; 1-3, for opening up the submaxillary triangle; 2, for ligation of the common carotid artery, etc.; 4, for glands along the posterior border of the sterno-mastoid muscle; 4-5, for glands situated in the subclavian triangle; 5, for ligation of the subclavian artery.

be divided or torn and will require ligation. After the mass has been removed there will be exposed, in the bottom of the rather deep wound, the cords of the brachial plexus, the subclavian artery resting upon the first rib, and the dome of the pleura. The phrenic nerve passes obliquely across the front of the tendon of the scalenus anticus into the thorax. Usually there is little danger of injuring this structure. All hemorrhage must be controlled before the incision is closed. The incision is closed in part with several interrupted sutures and a strip of gauze left for drainage.

OPERATIONS UPON THE TRACHEA AND LARYNX.

Tracheotomy means opening into the air-passage either as an emergency operation for relief when obstruction exists or as a preliminary step to other operations; for example, extirpation of the larynx, amputation of the tongue, etc. In 1869, as a preliminary to excision of the jaw, Nussbaum performed a tracheotomy and tamponed the pharynx with a compress to prevent blood from entering the larynx during the operation, the anæsthetic being administered through the tracheotomy tube.

Tampon of the Trachea.—Trendelenburg uses a tracheotomy tube which is surrounded by a thin, balloon-like structure provided with a cannula so that it may be inflated after it has been introduced into the trachea, in this way plugging the trachea and preventing the entrance of blood, etc. The anæsthetic is administered through the tracheotomy tube, to which a long rubber tube provided with a funnel is attached; in the bottom of the funnel there is a wad of cotton upon which the anæsthetic is dropped. The tracheotomy tube and tampon may be allowed to remain in the trachea for seven or eight days after the operation.

The Site of Operation.—The opening into the air-passage may be made:—

1. Through the trachea above the isthmus of the thyroid gland (high tracheotomy). This is the preferable operation and usually includes, in addition, division of the cricoid cartilage (crico-tracheotomy).

2. Through that part of the trachea which is covered by the isthmus of the thyroid gland (median tracheotomy).

3. Through the trachea below the isthmus of the thyroid gland (low tracheotomy). This operation is rather less preferable, because at this level the trachea lies deeper—farther away from the surface,

and, besides, one may meet the inferior thyroid veins or some of their branches or there may be an arteria thyroidea ima present. This is the site usually selected for a preliminary tracheotomy in conjunction with operations upon the larynx; for example, extirpation of the larynx.

4. Through the crico-thyroid membrane. This is really a laryngotomy, but it is well to include it with the tracheotomies.

HIGH TRACHEOTOMY (CRICO-TRACHEOTOMY).—This is the operation usually performed, and has the advantage that no vessels of moment are met with; and that this part of the air-tube is located quite superficially, near the surface.

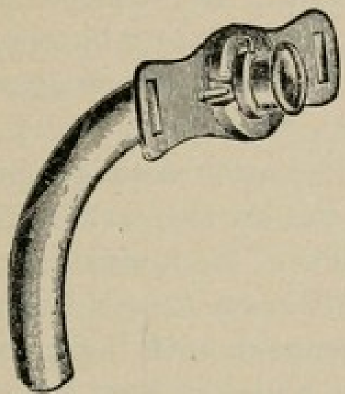

Fig. 141.—Tracheotomy Tube.

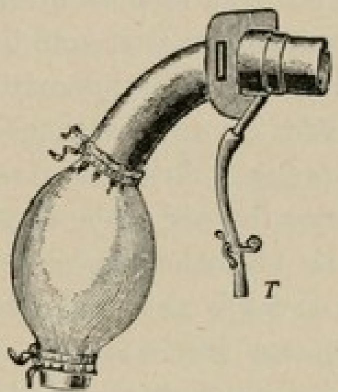

Fig. 142.—Trendelenburg Tampon Cannula. *T*, tube to inflate balloon. Anæsthetic is given through a long tube and funnel attached to tracheotomy tube.

The patient lies upon the back with the shoulders raised and the head thrown back. If the symptoms of suffocation are urgent, one may dispense with an anæsthetic or may give simply a few whiffs of chloroform. The operation may be done under cocain anæsthesia.

By palpation, the ring-like cricoid cartilage, which is the best landmark, is readily located. In men the prominent thyroid cartilage may be felt and seen as Adam's apple, but in women and children this is not prominent and is not, therefore, a good guide.

An incision is made through the skin and subcutaneous fat from the lower border of the thyroid cartilage—just above the cricoid—downward, in the middle line of the neck, for a distance of one and one-half inches. In making this skin incision some small tributaries of the anterior jugular vein may be encountered; to these clamps are applied and the skin retracted, exposing thus the deep cervical fascia which unites the edges of the sterno-hyoid muscles of either side with each other. This layer of fascia is incised along the middle line, corresponding to the incision in the integument. The edges of the wound being now retracted, there are exposed, above the cricoid cartilage and just below the cricoid, lying transversely across the front of the trachea, the isthmus of the thyroid gland. The isthmus of the thyroid gland is located about one-half inch below the cricoid cartilage to which it is connected by a process of the deep cervical fascia. This slip of fascia covers or conceals the upper two rings of the trachea; so that, in order to expose these, it is necessary to pick up this band and snip it transversely, after which the isthmus may be drawn downward and the upper rings of the trachea exposed to view.

The next step is to enter the air-passage, but before doing this all bleeding points should be clamped. At times, during the operation, the larynx moves violently up and down in forced efforts at respiration, and in order to steady it a tenaculum must be employed. This is introduced into the larynx above the cricoid cartilage, piercing the crico-thyroid membrane, and hooks the cricoid cartilage firmly upon its posterior aspect a little to the right of the middle line. The operator holds this tenaculum with the left hand, thus steadying the larynx and trachea, and, with a sharp-pointed knife held short in the right hand, the cricoid and one or two upper rings of the trachea are cut deliberately from above downward. One guards the knife blade in order to avoid injuring or perforating the posterior wall of the trachea. Having made an opening in the air-tube about one-half inch long and still retaining the tenaculum which was hooked into the cricoid to the right of the middle line, a second tenaculum is now hooked into the other side of the cricoid, to the left of the middle line, and the incision in the air-passage thus held open while the tube is being introduced.

Occasionally the thyroid gland has a well-marked middle lobe occupying the site of the isthmus and ascending upon the front of the cricoid. This extra lobe is seldom present, but, when it is, it must be dislocated downward in order to expose the cricoid and the upper part of the trachea. Usually it is not necessary to apply any ligatures as the cut vessels cease bleeding after a few minutes' application of the artery forceps; still, if any spurting vessels are met, they should be ligated. The edges of the skin may be brought together with two interrupted catgut sutures, one above and the other below the tube.

The tube is held in place by a tape tied around the neck and the wound dressed with gauze packed loosely into the wound and about the tube.

Low Tracheotomy.—The opening is made into the trachea below the isthmus of the thyroid gland. This is not usually the site of choice, although it is at times indicated. This part of the trachea lies farther away from the surface, deeper, and one may meet the inferior thyroid veins, which descend in front of the trachea, although they usually lie well to either side of the middle line, thus leaving the line of incision free. At times there is an arteria thyroidea ima ascending in front of this part of the trachea: a rather unusual condition.

The incision, in the middle line of the neck, commences above at a point just below the cricoid cartilage, and is continued downward toward the sternum, for a distance of one and one-half to two inches. The incision penetrates first through the skin and fat, and is then continued deeper through the deep cervical fascia, exposing the front of the trachea. After the trachea has been exposed all bleeding points must be clamped; usually the hemorrhage is only venous and ceases after the artery forceps have been applied for a few minutes. The operator is now ready to make the opening in the trachea, which should be placed below the level of the isthmus of the thyroid gland; the isthmus may be drawn upward toward the cricoid cartilage in order to give more room. All bleeding should be controlled before the trachea is opened.

Before making the incision in the trachea a tenaculum is introduced into the trachea, just below the isthmus of the thyroid gland and a little to one side of the middle line, to steady the trachea, and with a sharp-pointed knife, held short by the blade, an incision is made into the trachea from below upward, cutting two or three rings. Still steadying the trachea with the first tenaculum, a second tenaculum is introduced into the incision in the trachea, and while it is thus held open the tube is introduced. The tenacula are not withdrawn until the tube is in the trachea.

Any spurting vessels or large veins may be ligated, and one or two stitches may be taken in the skin wound. The left innominate vein is not in danger if, in incising the trachea, the knife is not carried below the level of the sternum.

Median Tracheotomy.—The opening into the trachea is made beneath the isthmus of the thyroid gland, which is divided in order to expose this part of the trachea.

The incision passes through the skin and fat and reaches from the cricoid cartilage downward, in the middle line of the neck, for a distance of one and one-half to two inches. The incision is then carried deeper through the deep fascia, between the edges of the sterno-hyoid muscle, when the isthmus of the thyroid gland is exposed. The isthmus is divided and the trachea recognized. In dividing the isthmus we cut several venous branches which bleed and must be clamped. The bleeding should be controlled before the trachea is opened. Bleeding points may be clamped and their ligation postponed until after the tube has been introduced into the trachea if time is limited. The trachea is steadied with a tenaculum and incised, and the tube introduced, as in the foregoing operation.

TRANSVERSE LARYNGOTOMY.—This is an emergency operation and may be rapidly performed. The windpipe is opened after locating the cricoid cartilage and using this as a guide, by cutting transversely through the skin and crio-thyroid membrane: *i.e.,* between the upper border of the cricoid and the lower border of the thyroid cartilage. There is some probability of wounding the crico-thyroid artery, a small branch, yet this is not very likely as the incision is made transversely: parallel with the course of the artery.

Thyrotomy.—Division of the thyroid cartilage may be either incomplete or complete.

INCOMPLETE THYROTOMY.—The incision is placed in the middle line of the neck and commences, above, at a point just below the upper border of the thyroid cartilage, and is continued downward to a point just below the cricoid cartilage; it is about one and one-half to two inches long and reaches through the skin and deep fascia, exposing the cricoid and thyroid cartilages. The edges of the wound are retracted and the crico-thyroid membrane incised, thus entering the larynx. In incising the crico-thyroid membrane the crico-thyroid branches may be cut; these are small branches, but they should be clamped if they bleed, as even a small quantity of blood sucked into the wind-pipe may seriously embarrass respiration. We then proceed to enlarge the opening into the larynx by dividing the cricoid cartilage and the lower part of the thyroid cartilage, to an extent sufficient to permit the extraction of foreign bodies, etc. One should avoid, if possible, incising the thyroid cartilage beyond the level at which the true vocal cords are attached.

If this operation is done for the removal of a foreign body, one may close the opening in the larynx and omit the introduction of a tube; still it is probably not unwise to insert the tube and leave it for a few days in all cases, because, as a result of the operation, there may be some œdema of the glottis caused.

Complete Thyrotomy consists of a median section through the thyroid cartilage. This operation is done for the purpose of exploring the interior of the larynx and for the removal of foreign bodies, growths, etc.

During the operation the trachea must be kept clear of blood. The operation should be performed with the patient in the Rose position unless a tampon cannula is used, when the patient may be placed in the usual tracheotomy position with the shoulders raised and the head thrown back. The tampon cannula may be introduced through a preliminary high tracheotomy done at the same sitting, previous to opening the larynx, or else the cannula may be inserted through the incision that is made in the larynx and which may be prolonged downward, through the cricoid and upper rings of the trachea for this purpose. Instead of a high tracheotomy, a preliminary low tracheotomy may be performed and the tampon cannula introduced at this point.

The incision is placed in the middle line of the neck, reaching from the hyoid bone, above, to a point below the level of the cricoid cartilage. The incision extends through the skin and deep fascia and exposes the thyroid cartilage.

The next step is to open the larynx. The point of the knife is introduced through the crico-thyroid membrane between the cricoid and the lower border of the thyroid cartilage. In doing this the crico-thyroid branch may be cut and should be clamped and tied. Then, with a curved probe-pointed knife which is introduced into the larynx and passed upward between and beyond the vocal cords the thyroid cartilage is split into its two halves from within outward, in the middle line, throughout its entire length up to or into the thyro-hyoid membrane. The thyroid cartilage may also be divided from without inward. At times the thyroid cartilage is ossified, and it will be necessary to use a strong scissors in order to accomplish its division.

After the thyroid cartilage has been split its edges are held apart with sharp retractors or tenacula, and the interior of the larynx may then be freely explored. We may, in addition, divide the cricoid cartilage and the upper rings of the trachea if this has not already been done, or if more room is required, or in order to introduce a tampon cannula.

In cutting into the thyro-hyoid membrane one should avoid the superior laryngeal vessels and nerve, which pierce this membrane upon either side to enter and supply the larynx.

It may not be necessary to suture the two halves of the thyroid cartilages, as these often adapt themselves very well without suture, especially if the cricoid cartilage has not been divided. It is probably wise, however, in all cases, to introduce two or three chromicized catgut sutures through the perichondrium to hold the edges of the two halves of the thyroid cartilage in contact or one silver wire suture may be passed through each edge of the cartilage. The incision in the skin may be partly closed with catgut sutures.

The tampon cannula, if used, may be left in place for a few days if it is well borne, as it prevents the entrance of blood and discharges into the trachea and lungs.

Laryngectomy (Extirpation of the Larynx).—This operation should be preceded by a low tracheotomy, which may be done a week or more in advance of the major operation in order to accustom the patient to the presence of the tube and to bring about fixation of the trachea to the skin, etc., of the neck.

If the preliminary tracheotomy has not been done, the operation should be performed with the patient in the Rose position, or, if the operation is done with the patient in the customary tracheotomy position, it will be necessary, as soon as the larynx has been isolated and all the vessels that supply it ligated, to cut the larynx away from the trachea below and then, at once, introduce the tampon cannula into the upper end of the trachea. The preliminary tracheotomy, with the introduction of the tampon cannula, is probably the most preferable plan.

The incision is made in the middle line from the hyoid bone to a point below the cricoid cartilage; to this incision a second transverse incision may be added which extends outward, parallel with the hyoid bone, between the hyoid bone and upper border of the thyroid cartilage, as far as the anterior border of the sterno-mastoid muscle of each side, thus making a T-shaped incision. This latter supplementary incision is especially advantageous if the lymphatic glands, etc., are involved in the pathological process. The incision extends through the skin and subcutaneous fat and deep cervical fascia, and exposes the thyroid cartilage.

The edges of the sterno-hyoid muscles are next recognized and the muscles of either side divided transversely either partially or completely. The parts being now retracted, we expose the sterno-thyroid and thyro-hyoid muscles, which are attached upon either side of the thyroid cartilage. The lateral lobes of the thyroid gland reach well upward upon the sides of the thyroid cartilage underneath the sterno-thyroid muscles.

We now begin the isolation of the larynx, separating all the soft parts either with an elevator or with the knife, the edge of the instrument working close to the surface of the thyroid cartilage. If the elevator is used, this is pushed under the thyro-hyoid muscle, between it and the thyroid cartilage, and the muscle separated from the side of the thyroid cartilage, detaching the sterno-thyroid at the same time; the separation of these muscles may be accomplished in part with the knife. These two muscles are really one and the same continuous muscle; so that, after they have been detached from the thyroid cartilage they hang together as one continuous flat band. Instead of detaching these muscles as described they may be simply cut away from the sides of the thyroid cartilage with the knife. The soft parts are then retracted and a tenaculum is hooked into the side of the thyroid cartilage, and with this the larynx is drawn forward and to one side, so that we are enabled to reach the superior laryngeal artery and its accompanying nervous branch, as they pierce the side of the thyro-hyoid membrane to enter the larynx; the vessel is tied double and cut. The lateral lobe of the thyroid gland, which lies upon the side of the larynx (in the natural relation of the parts being covered by the sterno-thyroid muscle), is readily separated from the side of the larynx with the elevator or the finger. At this stage of the operation the superior thyroid artery, which ramifies upon the upper front surface of the thyroid gland, is usually met with. This vessel need not be cut. The thyroid isthmus is also liberated from its attachment to the cricoid cartilage and pushed downward out of the way.

The crico-thyroid branch of the superior thyroid, which runs forward and inward transversely across the crico-thyroid membrane, may be cut and should be clamped and tied. There is also an inferior laryngeal branch, from the inferior thyroid, which accompanies the inferior laryngeal nerve into the larynx; it enters the lower back part of the larynx, behind the articulation between the cricoid and thyroid cartilages, beneath the lateral lobe of the thyroid gland; this branch may be cut and should be tied. The small transverse branch, from the superior thyroid, which runs transversely inward across the thyro-hyoid membrane, below the hyoid bone, to anastomose with its fellow of the opposite side, is also cut and tied. The larynx is drawn toward the opposite side and the above-described procedures are repeated upon the other, the remaining, side.

The isolation of the larynx is continued. The soft parts are strongly retracted to one side and with a sharp hook or volsella the larynx is drawn to the opposite side; then, with the knife, the inferior constrictor of the pharynx is separated from the side of the thyroid cartilage. This muscle is attached upon the side of the thyroid cartilage close to its posterior border which may be readily felt by the fingers in the wound. This muscle is separated from the cricoid cartilage also. Care should be exercised to work close to the surface of the cartilage in separating this muscle so as to avoid opening into the pharynx, and also to avoid division again of the vessels that have already been divided and tied. The parts are then separated in a similar manner upon the other side of the larynx and we are ready for the final step of this part of the operation: the separation of the larynx from the hyoid bone above, from the anterior wall of the pharynx behind, and from the trachea below.

The knife is introduced through the thyro-hyoid membrane between the thyroid cartilage and the hyoid bone, and this membrane is cut in a direction outward and backward, at the same time drawing the side of the larynx forward with a sharp hook or volsella. In performing this step of the operation we should avoid again cutting the superior laryngeal artery upon the proximal side of its ligature if it has already been divided and tied. The other half of the thyro-hyoid membrane is then cut in a similar manner. If it is desired to excise the epiglottis also, and this is usually wise, a probe-pointed knife may be introduced through the incision in the thyro-hyoid membrane, between the upper border of thyroid cartilage and the hyoid bone, in a direction upward and backward; so that, as the cut is made, the blade of the knife passes between the base of the tongue and the epiglottis. The finger in the mouth may serve to guide the knife. If the epiglottis is to be left, we cut directly backward between the upper border of the thyroid cartilage and the hyoid bone, thus leaving the epiglottis attached to the posterior aspect of the hyoid bone and to the root of the tongue. The front of the larynx is then seized with a sharp hook or volsella forceps and drawn directly forward; so that its posterior wall, composed of the broad posterior part of the cricoid cartilage, may be separated from the anterior wall of the pharynx; the anterior wall of the pharynx is very thin, consisting practically only of a layer of mucous membrane. If the growth involves the anterior wall of the pharynx, this part may be excised together with the larynx. If the pharynx has not yet become involved in the disease, the separation of the larynx from the pharynx will not be found to be difficult of accomplishment.

After the separation of the larynx from the pharynx has been completed to a point below the level of the cricoid cartilage, the larynx is cut away from the trachea, from behind forward, below the level of the cricoid cartilage. In thus severing the larynx from the trachea the inferior laryngeal arteries and nerves are cut, and, if the vessels have not already been tied, they should be secured as they spurt. Thus the extirpation is complete.

Instead of operating as described above, we may, after freeing the larynx upon the sides, etc., complete the operation by cutting the larynx away from the trachea below the level of the cricoid cartilage, packing the stump of the trachea at once with a pad to prevent the entrance of the blood (a preliminary tracheotomy having been done); and then, drawing the larynx forward with a sharp hook or volsella, this is separated from the anterior wall of the pharynx from below upward; and, as the final step of the operation, the larynx is cut away from its attachment to the hyoid bone by carrying the knife through the thyro-hyoid membrane.

The superior laryngeal arteries, that enter the larynx upon the sides, are best secured before beginning the actual isolation of the larynx, but they may be again divided accidentally during the final steps of the operation, and in this case should be again clamped and tied; other vessels may be secured as they are encountered during the course of the operation. The wound is best left open in part. If the accessory lateral skin incisions have been made, and the sterno-mastoids have been divided, these parts may be brought together with sutures. The opening in the pharynx should be closed as nearly completely as possible with interrupted silk sutures, their ends being left long to facilitate their removal later. It may be possible in some cases to close off the pharyngeal space from the wound completely by uniting the upper cut edge of the pharynx to the soft parts which are attached to tissues below the hyoid bone. This is done with a sufficient number of interrupted silk sutures placed fairly close together, and is a great advantage, as it very considerably diminishes the likelihood of infection.

It is necessary to arrange good drainage with the head low, so as to avoid the entrance of wound secretions into the trachea. It is well to leave the tampon cannula in the trachea for a few days if it has been used during the operation. The wound should be properly packed and the dressings changed at rather frequent intervals.

After the operation the patient is fed per rectum or else through a tube introduced into the stomach either through the mouth or through the nose. If a tracheotomy has not preceded the laryngectomy by a week or more, the stump of the trachea should be sutured to the skin in order to prevent too great retraction of the trachea. In cases where the disease has not spread beyond the larynx, the operation is comparatively easy and not accompanied by much hemorrhage.

Before proceeding with the radical operation the larynx may be split in the middle line for the purpose of exploration. It may be that in some early cases the removal of one-half of the larynx will suffice.

Extirpation of Half of the Larynx.—This operation is quite analogous to the one described in the preceding paragraphs, and may be practiced in those cases where the disease is still limited to one side of the larynx.

The larynx is first split in the middle line, without injuring the vocal cords, and then, if the condition found upon investigation warrants, the operation of extirpation of one-half of the larynx may be undertaken.

The advantages of partial removal of the larynx in appropriate cases are undoubted. It is a much less difficult and dangerous procedure and there is no greater likelihood of recurrence after this less radical operation when the disease is still confined to one side of the larynx. The voice may be almost perfectly retained and the ability to swallow food is quickly regained.

OPERATIONS UPON THE THYROID GLAND.

These may consist of partial extirpation, enucleation, ligation of blood-vessels, etc. Operation is indicated as soon as the tumor begins to interfere seriously with respiration or shows inflammatory changes or a tendency to malignant degeneration. Tumors that grow downward into the root of the neck or mediastinum, causing pressure upon the trachea, should be operated upon early. Operation should be undertaken for exophthalmic goitre just as soon as symptoms of Basedow's disease begin to make their appearance. In those cases of exophthalmic goitre that show very marked symptoms of thyroidism, marked exophthalmos, very rapid, irregular pulse, dyspnœa, tremor, sweating, marked nervous irritability, sleeplessness, etc., it is desirable to do the operation in several stages; to first ligate the superior thyroid arteries and veins, on one or both sides, usually on both, leaving the extirpation of the gland until later—until the exaggerated symptoms of excessive thyroidism have abated—usually for several weeks. In cases where there is already degeneration of the heart muscle and of other essential organs, operation will almost certainly result fatally and is counterindicated. The operation may be performed under local anæsthesia—regional anæsthesia method (Kocher, Reverdin, Roux) or a general anæsthetic may be used. If a general anæsthetic is employed care must be exercised during its administration, because urgent symptoms due to interference with respiration may arise. Of the general anæsthetics, ether is the preferable one. The patient should be placed in that position which causes the least obstruction to breathing, usually with the shoulders raised upon a sandbag and the head thrown back. It is often of distinct advantage to raise the upper end of the table so that it will have an inclination of about thirty degrees. With the patient in this position there is much less venous hemorrhage and much less interference with respiration. The anæsthetic can be given with the Gwathmey apparatus, using the foot-pump to force the air through the bottle containing the anæsthetic, and with the Lumbard nasal tubes. Thus the anæsthetist has his hands free and is able to hold the jaw forward during the course of the operation. Many operators prefer ether given by the drop method. The services of an additional assistant will then be necessary to hold the jaw forward.

A cloth screen suspended from two uprights, one upon either side of the table, may be dropped down so as to shut the field of operation off from the face—mouth and nose—of the patient. This also serves to exclude the anæsthetist from the field of operation. In the absence of the screen the field of operation can be walled off from the mouth by placing a folded towel wrung out in bichloride solution across the neck just below the chin and just above the line of the transverse incision in the neck.

Partial Extirpation.—As a rule, but one lobe is extirpated. If the disease involves both lobes, then one entire lobe, the larger, should be excised and the other lobe only in part. At least one-fourth or one-fifth of the gland substance should be left. The entire organ should never be extirpated. Even if the whole gland is apparently involved a portion, at least one-fourth or one-fifth, should be permitted to remain.

Two essential points to be observed in operating are to prevent severe hemorrhage during the course of the operation and to avoid injuring the important structures that are situated posterior to the thyroid gland—the recurrent laryngeal nerve and the parathyroid bodies. The main vessels supplying the gland are ligated early in the operation and finally, in extirpating the gland, the posterior portion of the capsule is left to cover over and insure the safety of the structures that lie behind it.

A transverse incision passing across the front of the neck from the edge of one sterno-mastoid muscle to the edge of the other is made. If the tumor is situated low down, in the root of the neck, the incision should be placed low, just above the sternal notch.

Instead of the incision above described the tumor may be exposed through a right angle incision which commences upon the side of the neck behind the inner edge of the sterno-mastoid muscle at the level of the thyroid cartilage; from that point the incision is carried transversely inward to the middle line and then downward as far as the sternal notch. This incision is adapted to those tumors that are situated high up and are of unusual size and confined strictly to one lobe. The incision penetrates through the skin, fat, and platysma muscle, and exposes the sterno-hyoid and sterno-thyroid muscles, covered by the deep cervical fascia, and the sterno-mastoid muscle. Several subcutaneous venous branches are divided,—the anterior jugular and communicating branch from the external jugular; these should be clamped and tied or they may be ligated doubly before they are severed. The external jugular is usually not cut.

The bluish (slate-colored) tumor mass may now be seen bulging beneath the depressor muscles of the hyoid bone (the sterno-hyoid and sterno-thyroid), which are usually found displaced more or less toward that side of the neck which lodges the tumor. The tumor is exposed by cutting through the deep cervical fascia between the edges of the sterno-hyoid muscles. This incision in the deep fascia should be sufficiently liberal. If more room is required the fingers may be hooked under the sterno-hyoid and sterno-thyroid muscles and these may be divided near the hyoid bone. It may be necessary to extend the incision into the anterior margin of the sterno-mastoid. At this stage the operator should assure himself that he has penetrated completely through the loose connective-tissue envelope right down to the true capsule of the gland. The capsule will be found considerably thickened in cases where pathological processes affect the gland.

Sweeping around in all directions with the fingers close to the surface of the tumor mass, the effort is made to separate it and deliver it partly through the incision. Connective-tissue bands that hold the tumor and resist its delivery and which are usually vascular should be hooked up with the finger or ligature carrier, clamped double, and divided with the scissors. After the tumor has been thus partly detached it is drawn still farther out of the incision and the operator is then ready for the next step of the procedure, the ligation of the principal vessels.

While the mass is pulled downward and toward the opposite side the superior thyroid vessels are sought near the upper pole of the tumor. The superior thyroid is readily found just after its origin from the external carotid, in the space between the upper border of the thyroid cartilage and the hyoid bone. It is accompanied by the superior thyroid vein, which may be included in the same ligature as the artery. The ligature is passed with the blunt carrier, tied double, and the vessels divided between the ligatures. The inferior thyroid artery is found deep in the root of the neck. It is a branch of the thyroid axis. Emerging from behind the common carotid artery, it passes inward to reach the middle of the posterior border of the lateral lobe of the gland, crossing the inferior recurrent laryngeal nerve in its course. Firm traction must be made upon the tumor, drawing it upward and over toward the opposite side and the skin and muscles well retracted. With the fingers in the wound the pulsating vessel may be felt as it passes forward across the side of the trachea to reach the gland. The prominent tubercle upon the transverse process of the sixth cervical vertebra—the tubercle of Chassaignac—is a good guide. About on a level with or just below this tubercle the artery passes across the front of the recurrent laryngeal nerve, which ascends in the recess between the trachea and œsophagus to enter the larynx. The artery should be carefully isolated, taking pains not to injure the nerve, and a ligature passed around it with a blunt carrier and tied. The inferior thyroid veins are picked up upon the carrier, tied double, and severed. An arteria thyroidea ima is occasionally encountered ascending toward the lower part of the gland; this vessel and its accompanying veins are readily recognized and should be ligated double and divided between the ligatures.

There remains now to make the section through the isthmus. This is detached and squeezed between the blades of a heavy compression forceps. The forceps is then removed and the isthmus ligated, the ligature being placed so as to secure the isthmus at the site of the groove made with the compression forceps. If a third, pyramidal, lobe is present, it should also be detached and removed together with the tumor mass. The venous branches that unite the veins of the two lobes of the gland across the isthmus, corresponding to its upper and lower borders, may be clamped and ligated separately.

The blood-vessels having been ligated and the isthmus divided, etc., there now remains, in order to complete the operation, the extirpation of that portion of the gland which is to be removed. It is still attached to the side of the trachea and larynx. Care must be again exercised, in separating it from these structures, not to injure the recurrent laryngeal nerve and the parathyroid bodies that lie posterior to the capsule. Injury to these structures is best avoided by leaving the posterior part of the capsule to cover and protect them. The capsule is incised along the outer, posterior border of the lateral lobe (tumor mass), and the mass peeled away from this part of the capsule, even leaving a thin layer of thyroid tissue covering the surface of the portion of capsule that is left behind.

After all hemorrhage has been controlled the wound is flushed out with salt solution. If muscles have been divided their ends should be reunited by suture. A cigarette drain which is allowed to remain for twenty-four hours is introduced. The edges of the skin are brought into accurate apposition with suture except below, in the middle or at either end, where the drainage strips emerge.

ENUCLEATION.—This method of treatment is adapted to those cases that present isolated diseased masses in the midst of apparently normal gland tissue.

The incision and subsequent steps of this procedure until the stage is reached where the capsule of the gland is exposed are the same as those described in the preceding operation. The capsule is incised in a situation where it is fairly free from blood-vessels. Vessels that are divided are clamped and ligated. Penetrating through the gland substance with the finger the mass that is to be enucleated is shelled out; if any additional masses are to be felt these are also enucleated through the same opening. If the mass

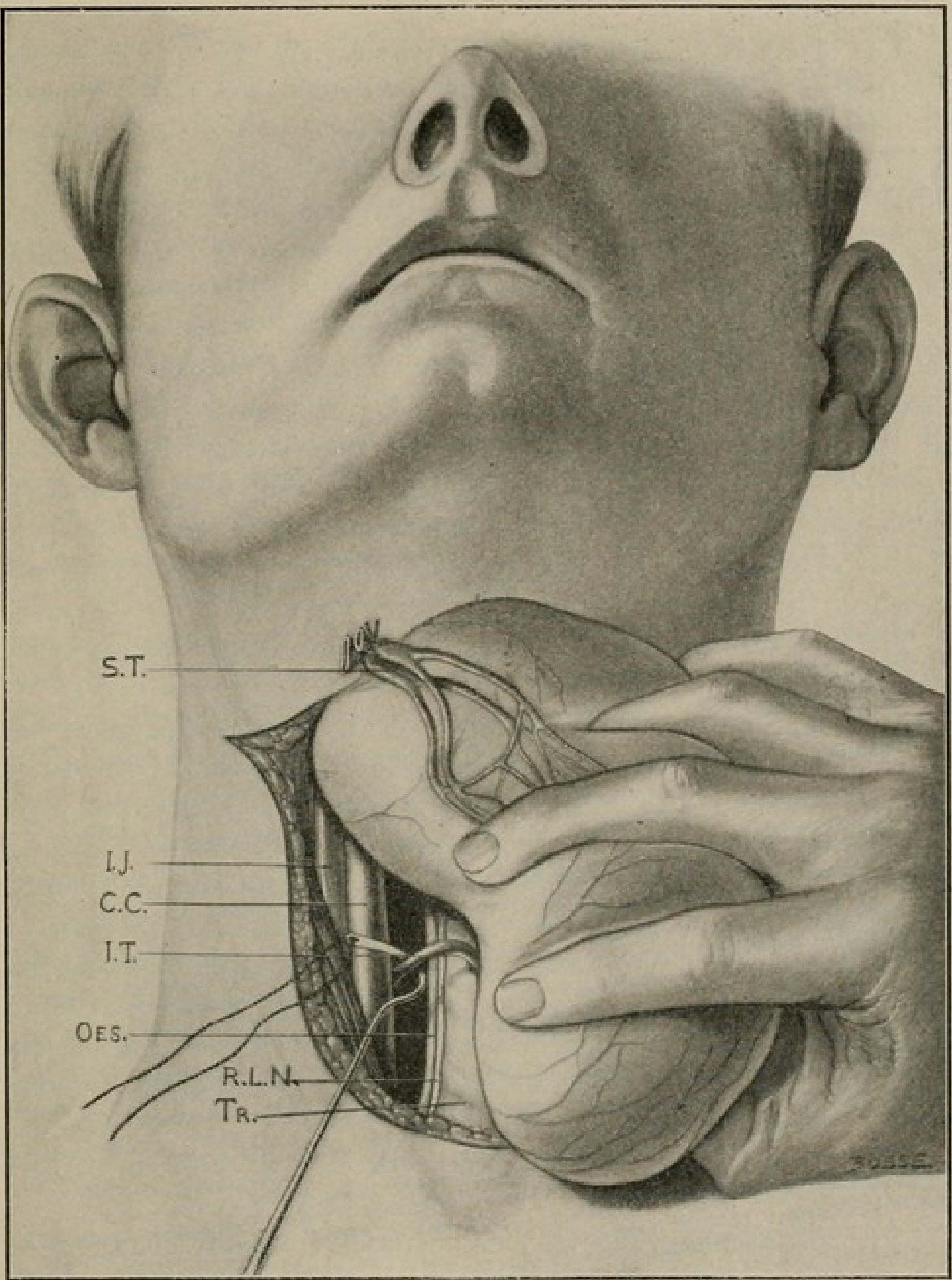

Fig. 143.—Thyroidectomy. The enlarged right lobe of the thyroid gland is delivered out of the incision. The superior thyroid artery and vein have been ligated double and divided between the ligatures. The inferior thyroid artery is picked up upon the ligature carrier. *C.C.*, common carotid artery; *I.J.*, internal jugular vein; *I.T.*, inferior thyroid artery; *Oes.*, Œsophagus; *R.L.N.*, recurrent laryngeal nerve; *S.T.*, superior thyroid artery and vein; *Tr.*, trachea.

ruptures (cystic goitre) during this step the wall of the cyst should be peeled out.

The cavity is packed, temporarily, with strip gauze to check the hemorrhage. The packing is allowed to remain for a few minutes and then removed. If the hemorrhage has ceased a plug of strip gauze is introduced into the cavity and the incision in the capsule sutured except its lower part where the gauze drain emerges. If the temporary tamponade fails to control the hemorrhage then the incision in the capsule must be held wide open with retractors and individual bleeding points sought for and ligated. If the hemorrhage is a profuse general oozing the packing may be replaced and firm pressure applied with a snug bandage. Caution must be exercised that the pressure of the bandage is not sufficient to compress the trachea to such a degree as to interfere seriously with respiration. In order finally to control the bleeding it may be necessary to ligate the main arterial branches that supply the gland or else to extirpate the half of the gland that has been incised.

The incision in the skin is closed by suture except the part below where the drainage strips emerge.

Ligation of Thyroid Arteries.—This plan of treatment has been employed in the hope of bringing about a permanent shrinkage of the goitre, but it has failed to yield satisfactory results.

Ligation of the superior thyroid arteries and veins of one or of both sides, or of the superior thyroid artery and vein and the inferior thyroid artery of the same side, is frequently practiced in cases of exophthalmic goitre where the symptoms of thyroidism are very exaggerated. By this plan the supply of blood to the gland is reduced and the urgent symptoms ameliorated to such a degree that the extirpation of the gland may be undertaken with more prospect of success at a subsequent date.

For the method of exposing the superior and inferior thyroid arteries, etc., see page 234.

External Œsophagotomy.—This operation is usually done for the removal of a foreign body impacted in the œsophagus. The patient lies upon the back, with the shoulders raised and the head thrown back and over toward the right side.

A soft-rubber tube, or, better, a steel sound, is introduced into the œsophagus as far as it will go to serve as a guide. The œsophagus is approached through an incision in the left side of the neck because it is more accessible upon this side than upon the right.

The incision is made about three inches long, corresponding to the anterior border of the left sterno-mastoid muscle, the midpoint of the incision being upon a level with the cricoid cartilage. The incision is carried through the skin and fat, including the platysma, and exposes the anterior edge of the sterno-mastoid muscle. The sterno-mastoid is drawn aside and the underlying layer of deep cervical fascia is incised, when the internal jugular vein and the common carotid artery, lying in their connective-tissue sheath and crossed by the anterior belly of the omo-hyoid muscle, are exposed. These vessels are drawn outward with a blunt retractor. The lateral lobe of the thyroid gland, partly covered by the sterno-hyoid and sterno-thyroid muscles, is then recognized. These structures are drawn toward the middle line with a blunt retractor. The trachea, which may now be readily felt with the fingers, is a guide to the œsophagus, the œsophagus being located posterior to the trachea and protruding well beyond its left border. The tube in the œsophagus assists in locating it, and the foreign body, if present, may also be felt. The middle thyroid vein, as it passes outward from the thyroid gland to enter the internal jugular, may be met with, and, if it is in the way, may be cut and tied. The inferior thyroid vein may also be seen.

The œsophagus is entered in the inferior carotid triangle,—*i.e.*, below the omo-hyoid,—and, if necessary, this muscle may be drawn to one side or divided. The recurrent laryngeal nerve, as it ascends to enter the larynx, lies in front of the œsophagus, in the space between the trachea in front and the œsophagus behind, and should be avoided in incising the œsophagus. The nerve, during the course of the operation, is usually not encountered, and may be avoided by making the opening in the œspohagus well upon the side and thus keeping away from the front of the tube.

The wall of the œsophagus is picked up with two mouse-toothed forceps, and an incision made corresponding to its long axis and of sufficient length to permit the extraction of the foreign body or any other necessary manipulation.

In incising the œsophagus one should make a c'ean cut in order to avoid getting between the layers of the wall of the tube, which may readily happen owing to the looseness of the tissue between its muscular and mucous coats. Some œsophageal branches of the inferior thyroid may be divided in making the opening in the wall of the œsophagus and these must be clamped and ligated.

The wound in the wall of the œsophagus may be closed with several interrupted sutures of silk or chromicized catgut, but the external wound in the neck, leading down to the incision in the œsophagus, should be packed and left unsutured.

If the object of the operation is to establish a permanent fistula (œsophagostomy), the edges of the incision in the œsophagus, including its mucous and muscular coats, may be fixed to the edges of the skin incision with several interrupted silk stitches.

OPERATIONS UPON THE TONGUE.

Amputation of the Tongue (Kocher), with Preliminary Ligation of the Lingual Artery.—Amputation of the tongue according to the method of Kocher has many advantages. The hemorrhage is easily controlled, diseased glands are readily removed, and the incision is well placed for drainage.

The first step of the operation consists in ligating the lingual artery upon the side corresponding to the diseased half of the tongue.

The lingual artery is a vessel of considerable size, that of each side supplying the corresponding half of the tongue. It is sought for and tied in the lingual triangle.

The patient lies upon the back with the shoulders raised upon a sand-bag, and the head thrown back and turned a little toward the other side.

Ether is probably the best anæsthetic, administered either by the drop method or with the Gwathmey vapor apparatus and Lumbard's nasal tubes. It is of advantage to give the patient, one-half hour before the operation, one-quarter grain of morphin and one-one hundred and fiftieth of atropin by hypodermic.

An incision is made which corresponds to the boundaries of the submaxillary triangle. It commences in front at the symphysis mentis and is carried down to the hyoid bone, thence backward above and parallel with the greater horn of the hyoid bone and then in a direction upward and backward toward the mastoid process as far as the angle of the lower jaw (see Fig. 138). The incision penetrates through the skin, fat, and platysma, down to the deep fascia. The apex of the flap, which is thus marked out, is seized with the fingers and reflected upward upon the side of the face as far as the lower border of the jaw-bone. In reflecting this flap we may, toward the back, cut the external jugular vein, and this should be clamped and tied. The deep fascia is incised and the contents of the triangle exposed. These consist of the submaxillary salivary gland and a number of lymph-nodes. The lymph-nodes will be found diseased and matted together, and adherent to the submaxillary salivary gland so that these structures will usually be removed in one mass. The mass is seized with volsella forceps and enucleated by cutting with the knife close to the surface of the mass, or by blunt dissection with the handle of the knife or with the fingers. The mass is finally cut away by dividing the duct of the submaxillary gland, which is seen to disappear anteriorly beneath the posterior border of the mylo-hyoid muscle on its way to open into the anterior part of the floor of the mouth. The facial artery, if not previously cut, is usually divided in enucleating the gland mass from the triangle and should be tied when cut, or, still better, it may be secured and tied before it is cut, close to its origin and before it reaches the submaxillary gland. The facial vein is also usually divided during this part of the operation; this vessel bleeds freely, but may be clamped and ligated.

The boundaries of the submaxillary triangle are readily recognized after its contents have been dissected out. Above the lower border of the jaw and, below, in front and behind the anterior and posterior bellies of the digastric muscle. The floor of the submaxillary triangle is formed in front by the oblique fibers of the mylo-hyoid and behind by the perpendicular fibers of the hyo-glossus, which muscle lies on a deeper plane than the mylo-hyoid, being partly overlapped by the posterior margin of the latter. Passing from behind, horizontally forward, above and parallel with the hyoid bone and lying directly upon the hyo-glossus muscle is the hypo-glossal nerve; this nerve disappears anteriorly beneath the posterior edge of the mylo-hyoid muscle. This nerve marks the upper boundary of the lingual triangle, which is really the apex of the submaxillary triangle. The base of the lingual triangle is formed by the hypo-glossal nerve, and its lower borders, in front and behind, by the anterior and posterior bellies of the digastric. The floor of the lingual triangle is formed by the hyo-glossus, and beneath this muscle the lingual artery, accompanied by a vein, is located; so that, if this muscle is picked up with tooth forceps and snipped through with the knife or scissors, the lingual artery is readily found and may be hooked up with an aneurism needle and tied. Locating and tying the lingual artery in this triangle is not difficult.

After the diseased submaxillary lymph-nodes and the submaxillary salivary gland have been dissected out and the lingual artery ligated and all bleeding points clamped and tied, we are ready to proceed with the next step of the operation—the actual excision of the tongue. Before beginning this step of the operation, however, measures must be taken to prevent the entrance of blood into the larynx. The patient may be placed with the head hanging low in the Rose position; or a preliminary tracheotomy may be done and a Trendelenburg tampon cannula introduced, or an ordinary tracheotomy tube may be used and the pharynx tamponed with gauze.

An incision is made with the knife through the floor of the submaxillary triangle,—*i.e.*, through the mylo-hyoid muscle and the mucous membrane of the mouth,—close to the inner surface of the body of the lower jaw. This opening may be farther enlarged with the scissors or fingers. The tip of the tongue is then seized with a forceps and drawn out into the wound in the neck, through the opening in the floor of the mouth, and making considerable traction, first to one side and then to the other, the tongue is cut away from its attachment to the floor of the mouth, as far back toward the base as possible. This is done with the blunt-pointed curved scissors, snipping through the septum of the tongue and working close to its under surface. During this step of the operation, and while traction is being made upon the tongue, one should examine occasionally with the finger for bands, etc., which tend to bind the tongue within the mouth. The anterior pillars of the fauces, which are attached to the sides of the tongue, near its base, should be cut close to the surface of the tongue, and then it will be observed that the organ can be drawn out of the mouth for a considerable distance, when it may be amputated quite close to its root. This is done with the scissors.

The half of the tongue, corresponding to the side upon which the lingual has been tied, may be cut through without occasioning any bleeding; but, if the lingual artery of the other side has not been previously tied, the hemorrhage, when this second half of the tongue is cut through, may be embarrassing, as there may be some difficulty in catching the cut end of the artery. This, however, may be provided against by seizing the base of the tongue with a toothed clamp behind the point where it is intended to amputate it before cutting through; so that, when we divide this half of the tongue, we may pull the stump forward, and seize the divided vessel, when it spurts, with an artery clamp.

The wound in the side of the neck is closed with interrupted silkworm-gut sutures, except its posterior part, which is left open and packed to carry off the secretions, etc., from the mouth. The packing should be introduced well into the cavity of the mouth.

The patient is given fluids—saline solution—freely by rectum for the first twenty-four or forty-eight hours. Later the patient may be fed through a stomach tube which is passed through the nose. The patient lies with the head low and turned upon the side to facilitate drainage.

Extirpation of the Tongue through the Mouth with Preliminary Ligation of the Lingual Artery on Both Sides.—This plan is applicable to all those cases of cancer of the tongue where the floor of the mouth is not yet involved—where the tongue is not fixed—and it would seem that these are really the only cases that offer a favorable prospect of cure through operation.

The lingual artery corresponding to the side of the tongue which is diseased is exposed by an incision similar to that already described on page 262, which opens up the submaxillary triangle. The contents of the triangle are dissected out and the lingual artery tied. The lingual artery of the other side is exposed by making an incision reaching from the middle line backward, above and parallel with the hyoid bone, and curving upward, posteriorly, toward the mastoid process. The incision on this side of the neck does not need to be as extensive as upon the other side unless the lymph-nodes, etc., upon this side are also diseased and require to be extirpated. The lingual artery upon this side is secured and ligated. The incisions on both sides of the neck are closed with a sufficient number of interrupted sutures, without drainage.

The anæsthetic is now withdrawn and the patient permitted to come partly out so that he can keep his larynx clear of blood. The shoulders are raised high upon a sandbag—Rose position—and the mouth held wide open with a gag. The tongue is seized at the tip and drawn forcibly forward out of the mouth, and cut away from its attachment to the floor with blunt-pointed scissors and amputated far back with the scissors. This part of the operation can be done very quickly; there is little or no hemorrhage, and the patient will have recovered sufficiently from the influence of the anæsthetic to keep the larynx clear of blood by coughing and expectorating. It is necessary to precede the operation by administering a liberal dose of morphin and atropin hypodermically. The edges of the stump of the tongue can be brought together with one or two sutures of heavy silk. These sutures are introduced with a small, stout, full-curved needle.

Within a short time the patient can swallow fluids without much gagging and may sit up and get out of bed in a few days.

Extirpation of a Portion of the Tongue.—The patient may be placed in a half-sitting posture. Anæsthesia is not complete. A liberal dose of morphin may be administered hypodermically shortly before the operation, and only sufficient ether or chloroform used to keep the patient fairly quiet. In this way sufficient reflex is retained to enable the patient to keep the larynx clear of blood by coughing and expectorating.

This operation may be advisable in early suspicious cases where the disease is strictly limited and for purpose of obtaining a specimen for microscopic examination before resorting to amputation of the entire tongue.

The jaws are separated with a gag and the mouth held wide open with flat, angular retractors placed in either corner. A strong silk suture is passed through the tip of the tongue and with this as a tractor the tongue is drawn well forward and the diseased portion resected with the scissors. It may be desired to resect the entire half of the tongue which is diseased. If so, the tongue is split down the middle with the scissors, and the diseased half separated from the floor of the mouth and amputated as far back toward the root of the organ as desired. If the lingual artery has not been tied as a preliminary step to the operation, the bleeding vessel must be seized with the artery forceps in the stump of the tongue and ligated. In excising a portion of the tongue one should cut wide of the apparent diseased area. The edges of the raw surface are brought together with interrupted sutures of rather heavy silk. This operation will probably suffice for very early cases where the disease is distinctly local and the lymphatics are not yet involved.

Amputation of the Tongue (Regnoli-Billroth).—This method is applicable to those cases where the floor of the mouth is considerably involved in the disease.

The patient is placed in the Rose position, or if a preliminary tracheotomy has been done and a Trendelenburg tampon cannula introduced into the trachea, or if an ordinary tracheotomy tube has been introduced and the pharynx has been tamponed, the patient may lie in the usual position with the shoulders raised and the head thrown back.

An incision is made along the lower border of the body of the jaw about 6 cm. long, the midpoint of the incision corresponding to the symphysis mentis. This incision penetrates through all the soft parts down to the bone and extends backward, upon either side, nearly as far as the anterior edge of the masseter muscle. In making this incision, the facial artery, as it turns up over the lower border of the jaw-bone, just in front of the masseter, may be avoided.

From either end of this incision additional ones are made which reach straight downward as far as the hyoid bone, passing through the integument and the platysma. Through the lateral incisions, on either side, the lingual artery may be sought and tied, at the same time extirpating any diseased glands, etc.

The cavity of the mouth is now entered by severing the muscles attached to the inner surface of the body of the lower jaw with a knife. They should be cut fairly close to the bone, and the point of the knife may be guided with the finger in the mouth. Those muscles that are attached to the inner aspect of the symphysis in the middle line are divided first. A suture should be passed through the tip of the tongue or it may be seized with a toothed clamp in order to exercise traction and prevent its falling back into the pharynx and obstructing the breathing during the course of the operation.

After a sufficiently large opening has been made in the floor of the mouth, the tongue is drawn through the wound, under the jaw, and may then be removed together with the floor of the mouth as far back as the epiglottis.

If the lingual arteries have not been previously ligated, the base of the tongue should be seized with a volsella forceps before it is amputated, in order to facilitate the clamping of these vessels in the stump of the tongue.

The flap of skin and soft parts is replaced and the wound closed except posteriorly, on one or both sides, where the incision is left open and packed in order to drain the cavity of the mouth.

Extirpation of the Tongue through the Floor of the Mouth, with Division of the Lower Jaw.—The operation is preceded by a tracheotomy and the introduction of a Trendelenburg tampon cannula, or an ordinary tracheotomy tube may be used and the pharynx tamponed. After the operation the patient is fed per rectum or through a rubber tube which is passed through the nose down into the stomach.

SEDILLOT'S METHOD, WITH DIVISION OF THE LOWER JAW IN THE MIDDLE LINE.—The first incisor tooth of the lower jaw is extracted. An incision is made, as in the Regnoli-Billroth operation, along the lower border of the jaw and reaching as far as the masseter on either side. The lower lip is then split in the middle line, the incision being carried down to the bone through the gum and periosteum. The lower jaw is then sawn through with a Gigli saw, and the muscles and the mucous membrane composing the floor of the mouth incised close to the inner surface of the body of the lower jaw-bone.

Each half of the jaw is now drawn well outward, away from the middle line, thus giving very free access to the tongue and to the floor of the mouth. The tongue and that part of the floor of the mouth which is involved in the disease may then be extirpated.

If the linguals have not been previously tied, they may be clamped after the tongue has been amputated, drawing the stump of the tongue forward with a volsella in order to facilitate this.

The tonsils and the pillars of the fauces may also be reached in this operation, and, if the lower jaw-bone is involved, it can be resected in part. Diseased lymphatic glands in the neck may also be excised through this incision, which may be made as extensive as necessary.

One should attempt to bring the raw surfaces in the mouth together, at least in part, with interrupted chromicized catgut or silk sutures, their ends being left long to facilitate their removal later.

The two halves of the jaw are brought together and carefully wired, and the incision closed except at its posterior part on one or both sides, where it is left open for packing and drainage.

LANGENBECK'S METHOD, WITH DIVISION OF THE LOWER JAW ON ONE SIDE.—Upon the side corresponding to the disease an incision is carried from the corner of the mouth through the lower lip as far as the lower border of the jaw, whence it is continued downward through the integument of the neck as far as the side of the hyoid bone. The upper part of this incision splits the lip and gum, passing through the periosteum down to the bone; the lower part of the incision passes through the skin, fat, and platysma. All bleeding points are clamped.

Through the lower part of the incision, after cutting through the deep fascia, the submaxillary gland and the neighboring diseased lymphatic nodes of this side may be removed, and the lingual artery tied as it lies in the lingual triangle, above the hyoid bone and beneath the hyo-glossus muscle.

The canine tooth of the lower jaw is extracted and an opening made in the floor of the mouth so as to allow the passage of the wire saw with which the jaw-bone is divided. The section through the jaw should be, not straight up and down, but obliquely from above downward and inward toward the symphysis, so that the tendency to dislocation caused by the pull of the masseter muscle may thus be counteracted. The jaw-bone may be divided with a narrow, flat saw or with a wire saw.

The segments of the divided jaw-bone, especially the shorter piece, are now drawn well apart with sharp retractors, and the soft parts, muscles and mucous membrane, which form the floor of the mouth, separated from their attachment to the inner surface of the bone, as far back, if need be, as the anterior pillars of the fauces. The tongue is then seized with the toothed forceps and drawn well forward and over toward the well side and removed. One may excise the floor of the mouth, the pillars of the fauces, and the tonsils, if they are diseased, and also resect a part of the jaw-bone if this is involved.

If the linguals have not been previously ligated, we may clamp them in the stump after the tongue has been amputated. The segments of the jaw-bone are brought into apposition and wired, and the wound in the soft parts, except its lower part, which is left open and packed to carry off the secretions from the mouth, is closed with interrupted silkworm-gut sutures.

One should try to diminish the raw surface left in the buccal cavity as much as possible by drawing the parts together with separate chromicized catgut sutures.

Billroth's Method, with Bilateral Division of the Lower Jaw.—This is probably not so satisfactory as the preceding operations, owing to the difficulty of getting union of the loose segment of the jaw.

The canine tooth upon either side of the lower jaw is extracted, and an incision made from each corner of the mouth, through the lower lip, gum, and periosteum, down to the bone, and continued downward, in the neck, through the skin, fat, and platysma as far as the hyoid bone.

Corresponding to the place upon either side where the canine tooth has been extracted the lower jaw is sawn through, from its upper border downward to its lower border; this may be done with the wire, or flat saw.

The soft parts, which correspond to the floor of the mouth and which are attached to the middle, loose segment of the jaw-bone, are separated upon the inner aspect of the bone, and the flap of soft parts, which includes the free middle segment of the bone, is reflected downward.

The lingual arteries may be ligated and diseased glands removed through the incisions in the neck previous to amputating the tongue, or the arteries may be clamped and ligated in the stump after the tongue has been cut away. We gain free access to the floor of the mouth, tonsils, etc., in this operation.

The segments of the jaw are finally wired together and the incisions closed except the lower part, upon one or both sides, which may be left open and packed for drainage.

PART IV.

THE THORAX.

THE SURGICAL ANATOMY OF THE THORACIC WALL.

The Skeleton of the Thorax.—The thorax consists of a conical cage of bone and cartilage. Entering into its construction are the dorsal vertebræ, ribs, sternum, and interposed costal cartilages. The spaces between the ribs and costal cartilages are filled in, and the walls of the chest thus completed, by the intercostal muscles.

The thoracic cavity is rather cone-shaped, with its base below and its small end above, and is somewhat flattened from before backward.

The upper orifice of the thorax is kidney-shaped, narrow from before backward, and broader from side to side. It is bounded in front by the upper border of the sternum, behind by first dorsal vertebra, and laterally, on each side, by the first rib. The first rib is set very obliquely; so that its anterior end strikes a much lower level than its posterior end. The upper border of the sternum is opposite the intervertebral cartilage between the second and third dorsal vertebræ.

The lower opening of the thorax is large. It is bounded by the lower border and tip of the twelfth rib, the tip of the eleventh and the costal cartilages of the tenth, ninth, eighth, and seventh ribs. Anteriorly, in the middle line, is the ensiform cartilage; posteriorly is the body of the last dorsal vertebra.

A transverse section through the middle of the thoracic cavity shows it to be rather heart-shaped, owing to the projection forward of the bodies of the vertebræ. On either side of the vertebral column there is a longitudinal recess, which serves to deepen the space for the accommodation of the lungs; this is called the fossa pulmonis. The cartilages of the lower ribs, the seventh to the tenth, meet at the lower end of the sternum and form an angle the apex of which corresponds to the ensiform cartilage. This is known as the costal angle.

The thoracic cavity is closed in, below, by the diaphragm, which projects upward, dome-like, into the cavity of the chest, forming its floor and at the same time the roof of the abdominal cavity. By the projection of the diaphragm upward into the chest the capacity of the chest cavity is diminished and that of the abdomen correspondingly increased. In the living body the chest appears to be broader above, at the shoulders, than below at the waist; this appearance is due to the broad shoulder girdle, which partially encircles the chest above and which is made up of the clavicle and the scapula of either side.

The space within the chest consists of an air-tight compartment on either side, each containing one of the lungs, and a middle space called the mediastinum, in which are lodged the heart and the great vessels at its base, the trachea, œsophagus, thoracic duct, and the thymus gland or its remains.

The Dorsal Vertebræ. — These are twelve in number and form the back part of the skeleton of the chest. They give stability to the thorax and at the same time, on account of the presence of the elastic intervertebral pads, free motion is allowed in all directions.

This part of the vertebral column shows a sagittal curve with its concavity forward and a slight lateral curve with its concavity toward the left (aorta).

The Ribs are twelve in number (may be eleven or thirteen) on each side. They are flat bones articulated behind to the vertebræ and directed obliquely downward and forward. They form the bony frame-work of the back, sides, and part of the front of the chest.

The lower the rib is situated, the greater is its inclination downward. They increase in length from the first to the eighth.

The first to the seventh are true ribs: *i.e.*, they are each connected individually, through their cartilages, with the sternum.

The eighth to the twelfth are false ribs: their cartilages do not articulate with the sternum. The eighth, ninth, and tenth ribs are indirectly connected with the sternum through the junction of their respective costal cartilages with those of the ribs which immediately adjoin them above.

The eleventh and twelfth are floating ribs; they are short and their cartilages are free.

The lower border of each rib, upon its inner aspect, is grooved for the lodgment of the corresponding intercostal vein, artery, and nerve, that being their order from above downward.

The first rib is important surgically. It is very short, and its surfaces look almost directly upward and downward. It is set so obliquely that its posterior end, head, articulates with the upper part of the body of the first dorsal vertebra, whereas its anterior end, at its attachment to the sternum, is upon a level with the intervertebral pad between the second and third dorsal vertebræ. The inner border of this rib presents a tubercle for the attachment of the scalenus anticus muscle; external to this tubercle, upon the upper surface of the rib, there is a groove for the subclavian artery. The subclavian vein also passes across the upper surface of the first rib, but internally to the artery, the tendon of the scalenus anticus being interposed between the two vessels.

The inner border of the first rib is in direct relation with the dome of the pleura and the apex of the lung.

The Costal Cartilages.—These are the elastic bands which join the ribs to the sternum (except the eleventh and twelfth). The cartilage of the first rib is very short. The first and second costal cartilages, as they pass to the sternum, are directed somewhat downward like their ribs. The cartilage of the second rib articulates with the sternum at the junction of the manubrium with the gladiolus. The cartilage of the third rib is directed horizontally; the cartilages of the fourth, fifth, sixth, and seventh ribs are directed upward with increasing obliquity as they pass to the sternum. The cartilages of the eighth, ninth, and tenth make quite a sharp turn upward toward the sternum at the angle of junction with their ribs, and do not reach the sternum directly, but are fixed each to the cartilage immediately above, and finally, through the junction of the cartilage of the eighth rib with that of the seventh, to the sternum. The cartilages of the eleventh and twelfth ribs are short and free.

The Sternum.—This bone is rarely fractured, owing to the elasticity of the parts with which it articulates. It consists of a manubrium, or handle; a gladiolus, or body; and a cartilaginous tip, the ensiform or xiphoid cartilage. The junction between the manubrium and the body is marked by a prominent transverse line, and presents an angle directed forward: angulus Ludovici. This transverse ridge, which is readily felt under the skin, is an important landmark in counting the ribs: it corresponds to the articulation of the costal cartilage of the second rib with the sternum.

The ensiform cartilage varies in length and shape; its lower extremity is usually on a level with the tenth dorsal vertebra; it may be bifurcated or deflected to one side. The junction of the ensiform cartilage with the body of the sternum corresponds with the line that marks the lower border of the heart as it lies within the chest behind the sternum.

The Muscles of the Chest Wall. THE INTERCOSTAL MUSCLES are placed between the ribs and costal cartilages, and consist of two sets: external and internal.

The External Intercostals.—The fibers of the external intercostals have a direction similar to those of the external oblique muscle of the abdomen: that is from above downward and forward. In front, between the costal cartilages, the muscular fibers are absent, their place being taken by aponeurotic bands, the ligamenta intercostalia anterior, which represent the muscles.

The Internal Intercostals.—The direction of the fibers of the internal intercostal muscles is the reverse of those of the external. They correspond to the internal oblique muscles of the abdomen, and their fibers have a similar direction: upward and forward. Behind, the internal intercostals are deficient, their place being occupied by aponeurotic sheaths: the ligamenta intercostalia posterior.

THE TRIANGULARIS STERNI is situated anteriorly within the chest. It is a thin sheet of muscle which is attached along the lateral border of the posterior aspect of the sternum. It spreads upward and outward in four or five processes, which are attached separately to the inner surfaces of the cartilages of the second to the sixth ribs. The internal mammary artery is located between this muscle and the costal cartilages. The costal layer of the pleura is applied directly against the posterior surface of the triangularis sterni. The triangularis sterni is the transversus thoracis anterior of Henle.

THE MUSCULI SUBCOSTALES are a few sets of muscular fibers that are found upon the internal surfaces of the posterior ends of the ribs near the vertebral column; the direction of the fibers of these muscles is similar to that of the internal intercostals: they reach from the inner surface of one rib to the first or second rib above. These muscles correspond to the musculus transversus thoracis posterior of Henle, and together with the triangularis sterni are the analogues of the transversus abdominis, the deepest of the flat muscles of the abdomen.

The Fasciæ of the Chest.—A thin fascia covers the outer surface of the ribs and the external intercostals. A similar fascia is spread over the inner surface of the ribs and the internal intercostals, triangularis sterni, and subcostales. This fascia corresponds to the fascia transversalis of the abdomen, and is known as the fascia endothoracica. The fascia endothoracica is also spread over the thoracic surface of the diaphragm. It lines the whole inner surface of the thoracic cavity, and is everywhere interposed between the parietal layer of the pleura and the inner surface of the chest, serving thus to bind the pleura to the chest wall and at the same time to strengthen it. Upon the posterior surface of the sternum this fascia forms a strong fibrous layer. Above it projects into the root of the neck together with the dome of the pleura, which it strengthens and fixes to the vertebræ and to the deep surface of scaleni muscles, etc.

The Internal Mammary Artery supplies the front part of the intercostal spaces and the diaphragm and gives perforating branches to the muscles of the chest and to the mammary gland. At its origin from the first part of the subclavian artery it lies behind the subclavian vein, resting upon the pleura, and is crossed by the phrenic nerve. It passes down into the thoracic cavity and descends alongside of the sternum, a distance of from 5 to 10 mm. intervening between it and the lateral border of this bone. Behind the seventh costal cartilage the internal mammary artery divides into the musculo-phrenic and the superior epigastric. The musculo-phrenic continues downward parallel with the free border of the ribs, supplying branches to the intercostal spaces. The superior epigastric enters the posterior sheath of the rectus, anastomosing with the deep epigastric, which is derived from the external iliac, and in this way forms an important communication between this trunk and the subclavian. The internal mammary artery is accompanied by two veins, one upon either side, but above these two unite to form a single vein, which lies to the inner side of the artery. The artery is also accompanied by a chain of lymphatic glands.

Within the chest the artery rests upon the costal cartilages and the internal intercostal muscles, alongside the sternum, and is separated from the parietal pleura by the fascia endothoracica and the triangularis sterni muscle. Opposite each intercostal space the internal mammary gives off an intercostal branch, which, passing outward, divides into two, and these, anastomosing with the intercostal branches from the aorta, serve to establish a communication between the subclavian and the aorta. These intercostal branches are located between the internal and the external intercostal muscles close to the upper and lower borders of the contiguous ribs. The internal mammary gives off perforating branches, which pass forward through the intercostal spaces to supply the muscles of the breast and the mammary glands. Those which pass through the second, third, and fourth intercostal spaces are large, and are distributed to the mammary gland.

The Diaphragm.—The lower orifice of the thorax is closed in by the diaphragm. This is a musculo-tendinous partition which separates the thorax from the abdominal cavity. It forms the floor of the thoracic cavity and the roof of the abdomen. The thoracic surface of the diaphragm is covered by the fascia endothoracica and the diaphragmatic portion of the parietal pleura. Its middle part from before backward forms the floor of the mediastinum, and upon either side of this it forms the bottom of each pleural cavity.

The position of the diaphragm, immediately after death, corresponds with that found at the end of quiet expiration during life, but after a short time, owing to the further collapse of the lungs, it reaches to a still higher level.

Luschka places the highest point reached by the diaphragm at the end of forced expiration upon the right side at the level of the fourth rib. Most authors say that this is too high and give, instead, the fourth intercostal space. Upon the left side the diaphragm does not reach as high as upon the right by the breadth of one rib.

The upper orifice of the thoracic cavity is shut in on either side by the arching subclavian artery, scalenus anticus and medius muscles, and the fascia endothoracica. This fascia is intimately blended with the dome of the pleura, and attaches the same to the adjacent fixed points.

THE REGIONS OF THE THORAX.

The following imaginary lines serve to facilitate the location of points upon the thorax:—

1. The midsternal, which passes through the middle of the sternum.

2. The lateral sternal, which corresponds to the lateral border of the sternum.

3. The mammary, which is drawn through the nipple.

4. The parasternal, which is drawn midway between the lateral border of the sternum and the mammary line.

5. The axillary, which is located midway between the anterior and the posterior borders of the axilla.

6. The scapular passes through the lower angle of the scapula.

The chest is divided into a number of regions as follows:—

1. The sternal.

2. The upper anterior pectoral, which is subdivided into a clavicular, an infraclavicular, and a mammary.

3. The lower anterior pectoral.

4. The lateral pectoral.

The Sternal Region.—This region corresponds to the sternum. It is depressed below the level of the rest of the chest, especially in muscular subjects and in females.

The skin of this region, in the male, is usually covered with hair and is rich in sweat-glands. The subcutaneous tissue is poor in fat and allows ready palpation of the sternum beneath. The skin and periosteum covering the sternum are so intimately blended with each other that separation between these two layers is somewhat difficult, and, therefore, collections of blood or pus beneath the skin in this region remain circumscribed, as is the case in the subcutaneous tissue of the scalp. Above, we observe the upper notched border of the sternum with the sterno-clavicular articulation upon either side and the attachment of the tendon of the sterno-mastoid. Below is the ensiform cartilage, to which is attached the linea alba. The junction of the manubrium with the body of the sternum is marked by a prominent transverse ridge and presents an angle directed forward: the angle of Ludovici. The sternum forms the anterior wall of the mediastinal space, and its posterior surface is in close relation with the pleura and the edges of the lungs. Below, the heart, inclosed in the pericardial sac, lies close behind the sternum.

The Upper Anterior Pectoral Region.—This area corresponds to the region of the pectoralis major muscle, and shows the prominence of the breast surmounted by the nipple and the areola. The skin is soft, especially in women, and during lactation is marked by blue lines, which correspond to large superficial veins. The skin is freely movable, owing to the looseness of the subcutaneous tissue, which is rich in fat and within which the mammary gland is contained. The mammary gland is freely movable upon the underlying pectoralis major muscle. The anterior surface of the pectoralis major is covered by a thin, cellular fascia, which also lines the posterior aspect of this muscle. Beneath the pectoralis major are the pectoralis minor and the subclavius muscle. The pectoralis major and minor form the front wall of the axilla.

The Pectoralis Major is a broad, flat muscle which occupies all of this region. It takes its origin from the cartilages of the six or seven upper ribs and from the edge of the sternum: the sternal portion of the muscle. It also arises from the inner half of the anterior surface of the clavicle: the clavicular portion of the muscle. From these points of origin the fibers converge to form a flat tendon, about two inches broad, which is attached to the outer edge or lip of the bicipital groove: a depression which marks the upper part of the front of the humerus. The pectoralis major muscle is covered by a thin fascia, which dips down between its fasciculi and from which the overlying fat and mammary gland are readily separated. This fascia is rich in lymphatics, which may become involved in disease of the mammary gland. Below, this fascia is continuous with the superficial fascia which covers the abdominal muscles and laterally with that which covers the serratus magnus. It dips down into the space between the deltoid and the pectoralis major, and is there continuous with the loose fascia that invests the pectoralis minor and the posterior surface of the pectoralis major.

The Pectoralis Minor.—This muscle is exposed by dividing the tendon of the pectoralis major close to its insertion and reflecting the muscle downward. The pectoralis minor arises from the tip of the coracoid process; passing downward and inward and becoming broader, it is attached to the third, fourth, and fifth ribs. The pectoralis minor is invested by a fascia which is continued upward and inward beyond the upper border of the muscle, covering in the first part of the axillary artery and adjoining structures and the subclavius muscle. This layer of fascia is called the costo-coracoid membrane and is attached to the under surface of the clavicle and to the first rib. It is somewhat thickened, and perforated by various vascular and nervous branches, which pass to and from the axillary vessels and adjacent nerves.

The Subclavius Muscle.—This muscle is exposed after the costo-coracoid membrane has been removed. It arises from the under surface of the clavicle and passing downward and inward is attached to the cartilage of the first rib.

This upper anterior pectoral region may be considered as the clavicular, the infraclavicular, and the mammary regions.

The Clavicular Region. — The clavicle can be readily palpated beneath the freely movable integument which covers it from its inner end, where it articulates with the sternum, to its outer end, where it articulates with the acromion process of the scapula. The acromion process of the scapula forms the most external and prominent point of the shoulder.

Beneath the skin in the clavicular region are found the platysma and the deep fascia.

To the upper surface and posterior border of the clavicle are attached, internally, the sterno-mastoid muscle, and externally the trapezius. To the inner half of the front surface of the clavicle is attached the pectoralis major muscle (clavicular portion), and, to its outer half, the deltoid muscle.

The under surface of the clavicle shows, at its inner end, the attachment of the rhomboid ligament. This ligament extends between the under surface of the clavicle and the cartilage of the first rib. External to this the subclavius muscle arises from the under surface of the clavicle.

The inferior surface of the outer end of the clavicle is connected with the coracoid process of the scapula by strong ligamentous bands.

Beneath the clavicle, between it and the first rib, the blood-vessels and nerves pass from the root of the neck into the axilla.

The Infraclavicular Region.—This is the region below the clavicle. Between the pectoralis major and the deltoid muscle, close to the clavicle, there is a triangular depression, the fossa of Mohrenheim: the infraclavicular fossa.

In the space, or groove, between the pectoralis major and the deltoid are lodged the cephalic vein and the descending branch of the acromio-thoracic artery, which is given off from the axillary. If the two muscles are widely separated, we expose the upper part of the pectoralis minor, covered by its fascia, some loose connective tissue and fat, and the coracoid process. This process is readily felt underneath the skin, and in thin persons can be seen.

If the pectoralis major is cut away from its attachment to the clavicle and from the upper part of the sternum and reflected downward, the infraclavicular region proper is uncovered. The pectoralis minor muscle is now more freely exposed. The cephalic vein may be seen passing from without inward across the pectoralis minor into a mass of fat and connective tissue on the inner side of the muscle, where it disappears through an opening in the costo-coracoid membrane to reach the first part of the axillary vein, which lies underneath this membrane.

The acromio-thoracic and branches of the superior thoracic which are derived from the axillary artery are seen to emerge through openings in the costo-coracoid membrane, as is also the external anterior thoracic nerve, which supplies the pectoralis major.

The costo-coracoid membrane is a sheet of fascia which is continued from the inner or upper border of the pectoralis minor muscle upward and inward, and is attached to the under surface of the clavicle and to the first rib; it covers in the first part of the axillary artery and the structures that accompany it and the subclavius muscle. When the costo-coracoid membrane is removed, we expose the first part of the axillary artery and its acromio-thoracic and superior thoracic branches, the cords of the brachial plexus, which lie above the artery, and the axillary vein, which lies below and internal to the artery. The cephalic vein may be seen passing across the axillary artery to enter the axillary vein. All these structures are gathered together into a single bundle, and are accompanied by a mass of fat, connective tissue, and lymphatics (see Fig. 318).

The Mammary Region (Breast). — The mammary gland is rudimentary in the male and naturally well developed in the female. It rests upon the pectoralis major muscle from the third to the sixth rib. In unmarried and in young females it is hemispheroidal, firm, and projects forward; but after child-bearing, and especially in some races more than others, it is pendulous, and hangs down over the lower part of the thorax.

The skin of this region is thin and fine and is freely movable upon the underlying tissue. The superficial veins may show through the skin as irregular blue streaks. The skin of the nipple is especially thin and pigmented, and may be fissured and split, and shows the orifices of the milk-ducts, fifteen to twenty in number, as very fine, needle-point openings; through these infection may reach the mammary gland tissue proper.

In the unpregnant the nipple is depressed and pinkish, but is prominent and dark colored during pregnancy. The nipple is surrounded by a pigmented area, areola, which is fixed to the underlying tissue and marked by little nodules which correspond to sebaceous and sweat-glands.

In the unmarried the mammary gland proper is small, the prominence of the breast being due chiefly to the abundance of the fatty tissue in which the gland is imbedded. It does not reach its full development until after pregnancy. The mammary gland is a tegumentary organ inclosed within its own proper fibrous capsule and lodged in the subcutaneous fat. It consists of a number of lobules, which are separate and distinct from each other; so that the secretion of milk and nursing may be continued even after one or more lobules have become the seat of a suppurative process. Between the mammary gland and the anterior surface of the pectoralis major muscle there is a layer of loose fatty tissue, which permits the gland to be freely moved about upon the surface of the muscle.

Occasionally a process of gland tissue almost entirely disconnected from the main gland may be found lying under the border of the pectoralis major, dipping beneath the muscle into the axilla. This process of gland tissue is often difficult to recognize. All the ducts of the gland converge from the periphery toward the nipple; they may become occluded and distended, giving rise to cystic tumors whose contents consist of milk or of a buttery material: galactocele.

The arteries of the breast consist of perforating branches from the internal mammary, especially the second and third and branches of the long thoracic from the axillary. Of the veins, the superficial ramify beneath the skin and the deep ones accompany the arteries.

The lymphatics are important and of these there are two sets: those of the integument and those which drain the gland proper. The lymphatics of the integument are very superficial and numerous, especially upon the nipple and in the areola; corresponding to the region of the areola, they form a fine capillary net-work which spreads outward toward the periphery, some branches dipping inward to enter a plexus which surrounds the milk-ducts beneath the skin of the areolar region. The lymphatics from the gland proper, from the acini and substance of the gland, are abundant. According to Sappay, they all tend toward the surface and end as good-sized vessels in the plexus already mentioned which surrounds the milk-ducts beneath the skin of the areola. The lymph from this subareolar plexus is collected into two main channels: one above and one below the nipple. These lymphatic vessels pass outward toward the outer border of the gland, and, after being joined by one or two vessels from the periphery of the gland, terminate in the nearest lymphatic nodes, which are found near the anterior wall of the axilla in the neighborhood of the third and fourth ribs, being covered usually by the edge of the pectoralis major. These are, as a rule, the first lymphatic nodes to become involved in disease of the mammary gland. The lymphatic nodes in the root of the neck also receive tributaries from the breast, and may be found involved when the mammary gland is diseased.

The Lower Anterior Pectoral Region.—This is the area which lies between the lower limits of the pectoralis major muscle and the free border of the ribs. This region is important surgically only on account of the structures which lie beneath it, within the chest and abdomen.

The Lateral Pectoral Region.—This space is included between the border of the pectoralis major in front and that of the latissimus dorsi behind. It presents the ribs covered by serrations of the serratus magnus and by the latissimus dorsi and obliquus abdominis externus.

The arteries of this region are derived from the axillary (long thoracic) and intercostals. The posterior thoracic nerve is found in this region descending upon the serratus magnus, which it supplies.

THE MEDIASTINUM AND CONTENTS.

The mediastinum is a space within the chest, between the two pleural cavities, which is occupied by the heart and pericardium, the thymus or its remains, the trachea, œsophagus, aorta, and several nerves, and a mass of loose connective tissue and lymphatics.

Rather more of the space lies to the left of the middle line than to the right. It is limited in front by the sternum, behind by the vertebral column, and its floor is formed by the diaphragm. Above, the loose connective tissue of this space is continuous into the root of the neck with that which surrounds the œsophagus and trachea and the great vessels in the neck. Laterally the mediastinum is walled off on either side from the pleural cavity by the parietal pleura (mediastinal portion of the parietal pleura).

The mediastinum, as mentioned above, is not an empty space, but is fairly closely occupied by various organs. In the lower part of this space, in front, is the heart, inclosed within its pericardial sac; behind the heart, between it and the vertebral column, the space is not large, and is occupied by the œsophagus, thoracic duct, thoracic aorta, vena azygos, vena hemiazygos, and various nerves. In the upper part of the mediastinum, in front, is the thymus or its remains, and behind this the trachea and œsophagus, the latter lying just in front of the vertebral column. Immediately above the base of the heart are the great vessels connected with the heart—the arch of the aorta, vena cava superior, pulmonary artery and its branches —and the bifurcation of the trachea. A number of lymphatic glands which communicate with the lymphatics of the neck and axilla are packed in between these structures.

The Pericardium.—The heart, occupying the lower anterior part of the mediastinum, lies close to the anterior wall of the chest (sternum) inclosed within its own serous sac, the pericardium. The pericardium, as a thin serous layer, is closely applied to the whole surface of the heart and to the great vessels at its base for a part of

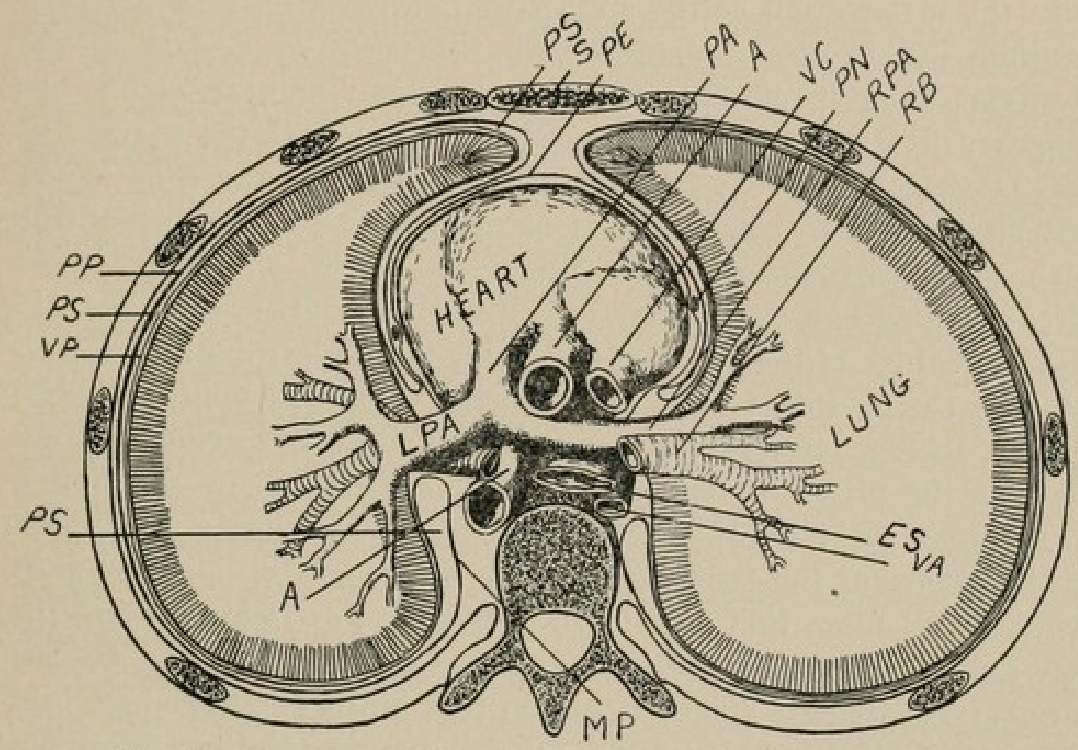

Fig. 144.—Transverse Section through Thorax just Above the Heart and Root of the Lungs. *A*, *A*, aorta; *ES*, œsophagus; *LPA*, left pulmonary artery; *MP*, mediastinal pleura passing forward to the posterior aspect of the root of the lung; *PA*, pulmonary artery; *PE*, pericardium; *PN*, phrenic nerve; *PP*, parietal layer of pleura; *PS*, space between parietal and visceral layers of the pleura; *RB*, right bronchus; *RPA*, right pulmonary artery; *S*, sternum; *VA*, vena azygos; *VC*, vena cava superior; *VP*, visceral layer pleura.

their extent; above, after inclosing the first or ascending part of the arch of the aorta, it is reflected as a thin, loose, membranous sac, which completely envelops the heart and is attached below by its broad base to the dome of the diaphragm. The highest limit, or the apex, of the pericardial sac is that portion which incloses the first part of the arch of the aorta. Its broad base, which is below, corresponds to its attachment to the diaphragm. The pulmonary artery is also included within the pericardial sac as far as its bifurcation, but its two divisions are not included. The vena cava superior is also partially invested.

In front, the pericardial sac is in relation with the sternum and the costal cartilages, from which it is separated by the interposed pleura and the edges of the lungs. Behind the lower part of the sternum there is a triangular space—with its apex above upon a level with the fourth costal cartilage, a little to the left of the middle line, and its base below, corresponding to the junction of the body of the sternum with the ensiform cartilage: *i.e.*, on a level with the articulation of the sixth costal cartilage—where the pericardium lies in direct relation with the posterior surface of the sternum. Corresponding to this area the pleura and the edge of the lung are not interposed between the sternum and the pericardial sac. Occasionally, according to some descriptions, the edge of the left pleura fails to reach the left border of the sternum behind the fifth costal cartilage and fifth intercostal space, and under these circumstances one could puncture through the fifth space close to the left border of the sternum and enter the pericardial sac without meeting the pleura. In all cases the edge of the left lung is notched in this region, incisura cardiaca; so that, although one might encounter the pleura in puncturing in this situation, he would not, in any case, meet the lung. Corresponding to the incisura cardiaca is the region of the "cardiac impulse," and here the heart is most exposed. Behind, that part of the pericardial sac which covers the left auricle is in close relation with the œsophagus. The trachea bifurcates just above and close to that part of the pericardial sac that covers the left auricle. On each side the pericardium is firmly adherent to the mediastinal portion of the parietal pleura, and between the apposed layers of both these structures, upon either side, the phrenic nerve descends in its course to reach and supply the diaphragm.

The Heart.—The heart, inclosed within the pericardial sac, is located in the lower anterior part of the mediastinum, almost completely surrounded by the lungs, which show a hollowed-out cavity on their internal surface corresponding to the size and shape of the heart. The impression upon the left lung is deeper than that upon the right.

Behind the heart is the vertebral column, and in the space between the heart and the spinal column, in the lower back part of the mediastinum, are the œsophagus, accompanied by the pneumogastric nerves; the thoracic aorta and thoracic duct; the vena azygos, which lies to the right of the vertebral column; and the vena hemiazygos, which lies to the left of the column.

The heart, with its long axis directed downward, forward, and to the left, rests with its posterior surface, which is composed chiefly of the left ventricle, upon the central tendon of the diaphragm. Here the diaphragm is somewhat flattened, and to the right of the middle line is perforated for the passage of the vena cava inferior. This vessel, after passing through the diaphragm, enters almost immediately the lower contiguous part of the right auricle.

The anterior surface of the heart, composed mainly of the right ventricle and auricle, lies close to the posterior surface of the sternum and costal cartilages, from which it is separated, for the most part, by the pleura and the lungs, these being interposed between the heart and the sternum and costal cartilages.

The base of the heart, which is directed upward and backward toward the spinal column, is made up of the auricles; the right auricle is placed anteriorly, and receives above the vena cava superior and below the vena cava inferior; the left auricle forms the posterior part of the base, lying close to the œsophagus, and receives the pulmonary veins from either lung.

The apex of the heart, the lowest part of the left ventricle, is found in the fifth left intercostal space midway between the parasternal and mammary lines.

Above the heart are the arch of the aorta, with the superior vena cava placed close upon the right side of its first or ascending part, the pulmonary artery and its bifurcation, the bifurcation of the trachea, and a mass of lymphatic glands and fat.

THE OUTLINES OF THE HEART UPON THE CHEST WALL.—The lower border of the heart corresponds to the line of junction between the body of the sternum and its ensiform cartilage. The upper border of the heart corresponds to the upper border of the third costal cartilage. To the right of the sternum lies the right auricle, its boundary corresponding to a curved line which is drawn from the articular end of the third costal cartilage downward and through the fifth costal cartilage close to its articulation with the sternum. The right ventricle reaches over for a considerable distance to the left of the sternum, with a portion of the left ventricle adjoining and forming the left border of the heart. The apex, the extreme end of the left ventricle, is situated in the fifth intercostal space midway between the parasternal and the mammary lines.

One-third of the heart lies to the right and two-thirds to the left of the middle line.

The pulmonary orifice, valve, corresponds to a line which is

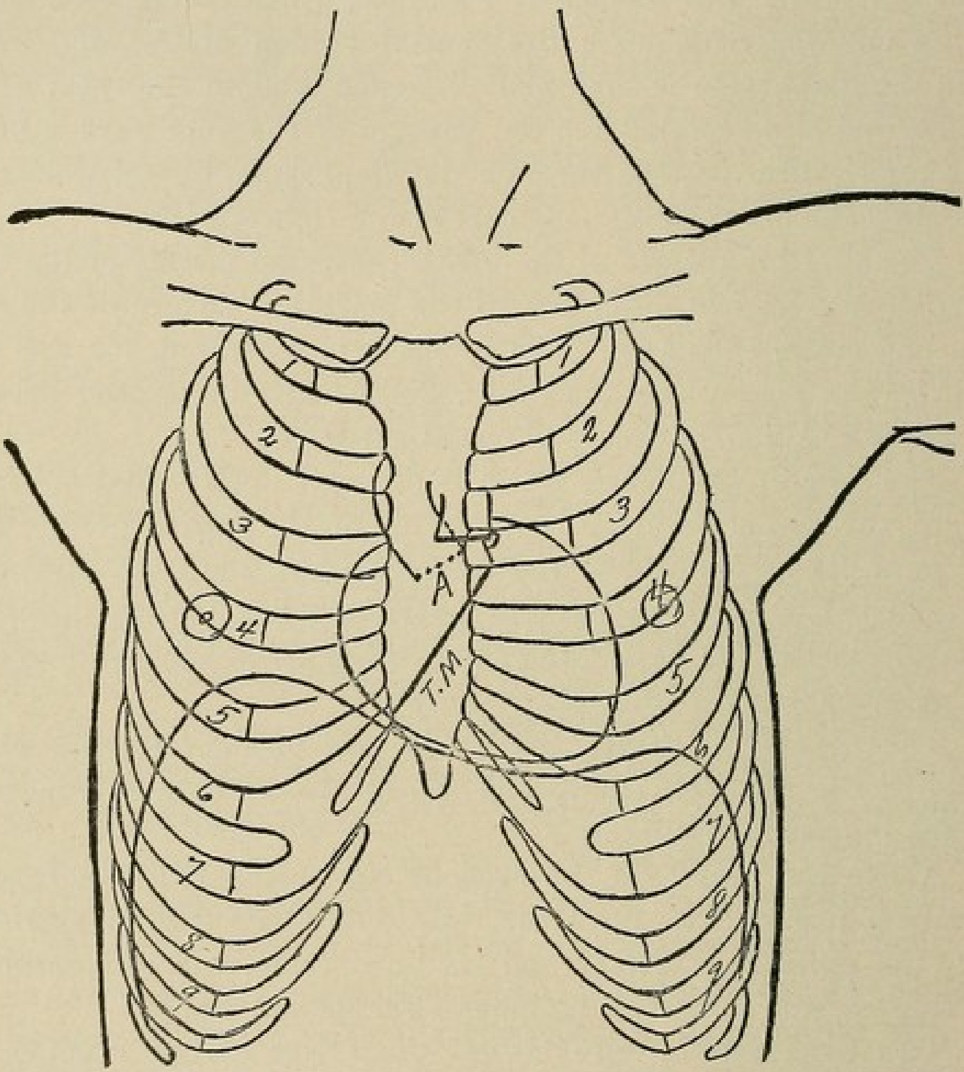

Fig. 145.—Outline of Heart and Location of Valves. *A*, aortic orifice, left semilunar valve (dotted line); *P*, orifice of pulmonary artery, right semilunar valve; *T.M.*, line of right and left auriculo-ventricular orifice. Upper part of line corresponds to left auriculo-ventricular orifice, mitral valve. Lower part of line corresponds to right auriculo-ventricular opening, tricuspid valve. Position of the diaphragm is indicated by the curved line that passes below the inferior border of the heart.

placed upon the junction of the third costal cartilage with the left border of the sternum, half of the line upon the cartilage and half upon the sternum.

The aortic orifice, valve, may be indicated by a line drawn from the junction of the third costal cartilage with the left border of the sternum, just below the line indicating the pulmonary valve and diverging from this, as far as the middle line, to a level with the third space.

The auriculo-ventricular openings are represented by a line extending from the lower border of the third left costal cartilage, one finger's breadth beyond the left border of the sternum, downward and toward the right, across the body of the sternum, as far as the junction of the sixth right costal cartilage with the right border of the sternum. The lower part of this line represents the tricuspid (right auriculo-ventricular) orifice and the upper part represents the mitral (left auriculo-ventricular) orifice.

The Thymus.—The thymus body in the newborn is located in the upper front part of the mediastinum behind the sternum and in front of the upper part of the pericardial sac. Its upper portion reaches well upward, in front of the trachea, into the root of the neck. In the upper part of the mediastinal space the thymus lies directly in front of the trachea, the left innominate vein, which passes from left to right, across the front of the trachea, being interposed between them. In the root of the neck the thymus lies upon the front of the trachea, and is in relation, on either side, with the common carotid artery and the internal jugular vein.

The lower part of the thymus lies behind the body of the sternum and in front of the great vessels at the base of the heart, dipping down between the pericardial sac and the edges of the lungs and pleura.

The thymus increases in size from birth until the second year, and then remains stationary or atrophies slowly until puberty. After puberty it atrophies rapidly, undergoing fatty changes.

The Arch of the Aorta. — The arch of the aorta is well surrounded by the lungs, the edges of which nearly meet behind the sternum.

It arises from the left ventricle, and at its origin lies behind the root of the pulmonary artery. It first passes upward, forward, and toward the right as far as the right border of the sternum; it then turns backward and toward the left, arching over the left bronchus; and near the upper border of the body of the fourth dorsal vertebra, upon its left side, it turns downward and is continued as the thoracic aorta.

The arch, as it passes backward and to the left over the left bronchus, reaches its highest point, which is upon a level with the upper border of the first costal cartilage.

The Ascending Part of the Arch.—Upon the right side and close to the ascending or first part of the arch lies the superior vena cava, which enters the upper part of the right auricle; this part of the arch and the superior vena cava are situated in front of the root of the right lung. The vena azygos, passing forward from the right side of the vertebral column, crosses the root of the right lung and empties into the vena cava superior through its posterior wall.

The Transverse Part of the Arch.—The transverse part of the arch passes from right to left and from before backward, from the right border of the sternum to the left side of the body of the fourth dorsal vertebra, arching over the root of the left lung. Its upper border is upon a level with the upper border of the first costal cartilage. From the upper aspect of the transverse part of the arch are given off the innominate and the left common carotid and subclavian arteries.

Below the transverse part of the arch is the pulmonary artery and its bifurcation, the branches passing transversely—one to the hilum of each lung—and lying in front of the bronchi. Behind the transverse part of the arch, in the back part of the mediastinum, the trachea and the œsophagus are located.

In front of the transverse part of the arch are the sternum, the thymus or its remains, and the edges of the pleura and the edges of the lungs, which nearly meet directly behind the sternum. A little above and in front of the transverse part of the arch, passing from left to right across the middle line, is the left innominate vein. The left superior intercostal vein passes forward from the third left intercostal space near the spinal column and enters the left innominate in front of this part of the arch. To the left of the middle line, the left pneumogastric nerve descends in front of and close to the transverse part of the arch, and gives off its recurrent laryngeal branch, which curves around the arch and ascends into the neck. Also descending in front of the transverse part of the arch, but nearer the middle line than the left pneumogastric, is the left phrenic nerve.

The Pneumogastric Nerves.—These pass through the thoracic cavity, in close relation with the œsophagus, on their way to the stomach.

The right pneumogastric, at the root of the neck, lies between the common carotid artery and the internal jugular vein. It descends into the chest, across the front of the first part of the subclavian artery, between it and the subclavian vein. Within the chest it passes obliquely backward, close to the right side of the trachea and across the posterior aspect of the root of the right lung, where it takes part in the formation of the posterior pulmonary plexus. The nerve then approaches the middle line and descends upon the posterior surface of the œsophagus and through the œsophageal opening in the diaphragm, to be distributed to the posterior surface of the stomach.

The left pneumogastric dips into the chest between the left carotid and subclavian arteries, behind the left innominate vein, and, descending across the front of the left end of the transverse part of the arch of the aorta, is continued downward, behind the root of the left lung and thence upon the front surface of the œsophagus and through the diaphragm, to be distributed to the anterior surface of the stomach.

THE INFERIOR RECURRENT BRANCHES. — Upon the right side the inferior recurrent is given off from the pneumogastric as it passes across the front of the first part of the subclavian artery. Curving around this vessel, it ascends in the neck, in the recess between the œsophagus and the trachea, to enter the lower part of the larynx.

Upon the left side the recurrent is given off as the pneumogastric passes across the front of the transverse part of the arch of the aorta. It winds around the lower border of this part of the arch and ascends in the neck, having a similar relation to the œsophagus and trachea as that of the right side.

The Phrenic Nerves.—In the root of the neck the phrenic nerve of either side may be seen crossing the front of the scalenus anticus tendon in a direction from above downward and inward. After entering the chest they pass down in front of the root of either lung; the left, in its course, passes across the front of the transverse part of the arch of the aorta parallel with the left pneumogastric, but more internally, nearer the middle line; the right passes down upon the right side of the superior vena cava. They then descend between the pericardium and the mediastinal portion of the pleura as far as the diaphragm, which they supply.

The Trachea.—This is an elastic membranous tube which is put upon the stretch when the head is extended. Set into its wall are a number of cartilaginous plates, each forming part of a circle. These cartilaginous plates are absent in the posterior part of the trachea.

The trachea is the continuation of the larynx. It begins in the neck below the cricoid cartilage at the sixth cervical vertebra, and in this part of its course lies quite superficial. As it passes downward it gets to lie deeper, farther away from the surface. In the chest, opposite the fifth dorsal vertebra, just above the base of the heart, the trachea divides into the two bronchi.

In front of the trachea, in the upper part of the mediastinum, are the sternum, the thymus or its remains, connective tissue, and fat. It is crossed from left to right and obliquely from above downward by the left innominate vein; into this vein in front of the trachea, one on each side of the middle line, empty the inferior thyroid veins.[1] Occasionally a large arterial branch, the thyroidea ima, arises from the upper aspect of the transverse part of the arch of the aorta and ascends upon the front of the trachea. Lower down, the trachea is crossed by the transverse part of the arch of the aorta and the vessels arising from the superior aspect of this vessel. The innominate and left carotid arteries, at their origin, are placed in front of the trachea. The right pneumogastric, in the upper part of the chest, lies close to the right side of the trachea. The œsophagus is situated behind the trachea. It is intimately related to the posterior, non-cartilaginous wall of the trachea; so that foreign bodies lodged in the œsophagus may, by pressure upon the posterior wall of the trachea, seriously narrow its lumen and produce symptoms of strangulation. In the immediate neighborhood of the bifurcation of the trachea are twenty to thirty lymphatic nodes.

The Œsophagus. — The œsophagus is the continuation of the pharynx, and consists of a thick muscular coat with a mucous membrane lining. The mucous membrane is connected with the muscular coat by a very loose submucous connective tissue.

When collapsed, the œsophagus appears as a flat, transverse band, with the mucous membrane thrown into longitudinal folds, and upon cross section it shows a stellate figure.

The œsophagus commences behind the cricoid cartilage on a level with the sixth cervical vertebra; it descends through the neck and thorax, piercing the diaphragm upon a level with the tenth

[1] The right inferior thyroid often empties into the right innominate.

dorsal vertebra, and terminates at the cardiac end of the stomach upon a level with the eleventh dorsal vertebra.

In the neck and upper part of the thorax, as far as the fourth dorsal vertebra, the œsophagus lies close to the front of the vertebral column, but from this point downward it gets to lie farther away, and as it passes through the diaphragm it is located quite some distance in front of and to the left of the tenth dorsal vertebra.

The œsophagus, throughout its course, is surrounded by loose, cellular tissue by which it is connected with adjoining structures. The average length of the œsophagus is about 35 cm., and the distance from the teeth to the cardiac orifice of the stomach is about 50 cm. To get the distance from the mouth to the cardiac orifice of the stomach, in any individual case, one may measure from the spinous process of the eleventh dorsal vertebra to that of the vertebra prominens, and thence across the shoulder to the mouth.

The lumen of the œsophagus is narrowest at its commencement behind the cricoid cartilage, again narrow opposite the third or fourth dorsal vertebra and again as it passes through the diaphragm. At its narrowest part the caliber of the œsophagus has a diameter of 14 mm., but it is capable of much distension beyond this.

Relations of the Œsophagus. *In the Neck* the œsophagus lies upon the front of the spinal column and immediately behind the trachea, to the posterior non-cartilaginous wall of which it is united by loose connective tissue. The œsophagus, situated behind the trachea, protrudes a considerable distance beyond the left border of the latter, and is therefore in closer relation with the common carotid artery, internal jugular vein, etc., upon the left side of the neck than upon the right side. In the recess between the trachea in front and the œsophagus behind, upon either side, the recurrent laryngeal nerve ascends to enter the lower part of the larynx. Above, where the lateral lobes of the thyroid gland rest upon the sides of the trachea, they reach backward so as to get into close proximity with the œsophagus.

Within the Chest.—In the upper part of the chest the œsophagus is still situated in front of the spinal column close behind the trachea, protruding somewhat beyond the left border of the latter. Opposite the third dorsal vertebra it is placed, together with the trachea, behind the transverse part of the arch of the aorta. Opposite the fourth dorsal vertebra the descending part of the arch of the aorta lies to the left side of the œsophagus, pushing it (the œsophagus) a little over toward the right; but immediately below this the azygos vein, appearing upon the right side of the œsophagus, forces it again to the left, and here at this level the œsophagus is found behind the root of the left lung, to which it is loosely attached by connective tissue. As the œsophagus descends it remains in close relation with the aorta, which vessel gradually passes behind it in order to reach the middle line in front of the vertebral column. Opposite the eighth dorsal vertebra the œsophagus lies in front of the aorta, and opposite the tenth, as it pierces the diaphragm to terminate in the stomach, it lies in front and to the left of the aorta and spinal column.

In the space behind the heart, between it and the vertebral column, in the lower back part of the mediastinum, the œsophagus lies in close proximity, anteriorly, with the left auricle, which is enveloped in the pericardial sac. In this space, upon the right side of the vertebral column, is the azygos vein; upon the left, the hemiazygos; and in front of the vertebral column, the thoracic duct; the aorta is situated behind the œsophagus. The mediastinal portion of the pleura, as it passes forward to the root of the lung, is reflected upon either side of the œsophagus. Descending upon the anterior wall of the œsophagus is the left pneumogastric, and, upon its posterior wall, the right pneumogastric nerve. These nerves accompany the œsophagus through the œsophageal opening in the diaphragm and are distributed to the stomach.

The Thoracic Aorta.—This is the continuation of the arch. It lies at first upon the left side of the bodies of vertebræ, but as it descends it approaches the middle line, and finally, as it passes into the abdomen behind the diaphragm, it lies in front of the body of the last dorsal vertebra. Throughout its course the thoracic aorta is closely related to the œsophagus; at first it lies to the left side of the œsophagus, but as it descends it gets behind it, between it and the vertebral column; below, the œsophagus is placed in front of and to the left of the aorta, the latter (aorta) as it passes into the abdomen being situated upon the front of the spinal column. The thoracic aorta gives off the intercostal branches: one for each intercostal space from the third downward.

The Vena Azygos.—This vein ascends upon the right side of the spinal column; it is made up of branches from the lumbar region and receives the intercostals in its course. About the level of the fourth dorsal vertebra it passes forward over the root of the right lung, and enters the vena cava superior through its posterior wall.

The Vena Hemiazygos.—The origin and course of this vessel are analogous to those of the azygos. It ascends upon the left side of the vertebral column. Opposite the eighth dorsal vertebra the vena hemiazygos passes across the front of the spinal column behind the aorta and thoracic duct, and upon the right side of the vertebral column joins the vena azygos.

The Thoracic Duct passes into the thorax behind the diaphragm in company with the aorta, between this vessel and the front of the spinal column. As it ascends through the thorax it lies upon the bodies of the dorsal vertebræ. In the upper part of the chest it arches forward and outward toward the left, and passes over the first part of the subclavian artery, to enter the left subclavian vein where this vessel joins the left internal jugular, to form the left innominate, just to the inner side of the tendon of the scalenus anticus.

The Innominate Artery has a calibre corresponding to the thickness of the little finger. It springs from the right end of the upper border of the transverse part of the arch of the aorta, and is about 5 cm. long. At its origin it lies in front of the trachea; it terminates by dividing into the subclavian and common carotid behind the right sterno-clavicular joint.

Situated in front of this vessel are the sternal attachments of the sterno-hyoid and sterno-thyroid muscles, the manubrium of the sternum, and the remains of the thymus gland. The left innominate vein passes across the front of the root of the innominate artery, and upon its outer (right) side joins with the right innominate vein to form the vena cava superior. The right inferior thyroid vein, as it descends from the lower part of the thyroid gland to enter the right innominate vein, also passes across the front of the innominate artery. To the outer side of the innominate artery lie the right pneumogastric and the right phrenic nerves and the pleura and apex of the right lung. To the inner side of the innominate is the left common carotid, the distance between the two vessels varying.

The Left Common Carotid and Left Subclavian Arteries arise from the upper border of the transverse part of the arch. They lie deep within the chest, and are, in this region, not subject to surgical interference.

THE PLEURA.

The pleura of each side is a completely closed fibro-serous sac. It lines the entire inner surface of the cavity, within which the lung is contained, and, besides, as a thin, serous layer, invests the whole surface of the lung.

That portion of the pleura which is applied to the surface of the lung is called the visceral layer, and that which lines the whole inner surface of the cavity in which the lung is contained is called the parietal layer. That part of the parietal pleura which lines the inner surface of the wall of the chest, sternum, costal cartilage, ribs, etc., is spoken of as the pleura sterno-costalis; that portion which is spread out upon the surface of the diaphragm, the pleura diaphragmatica; and that which limits the mediastinum on each side, passing from before backward like a partition and separating the mediastinal space from the space which contains the lung, is called the pleura mediastinalis.

The parietal layer, after lining the inner surface of the ribs, intercostal muscles, etc.,—that is, the whole inner aspect of the wall of the thorax,—is found, behind, upon either side of the vertebral column, to leave the posterior wall of the thorax and pass forward, forming the posterior part of the mediastinal pleura; that of the left side, as it passes forward, covers the adjacent wall of the aorta and, lower down, the œsophagus; that of the right side, as it passes forward, covers, below, the side of the vena azygos and, higher up, the side of the œsophagus. Upon reaching the posterior aspect of the root of the lung the pleura is reflected on to the surface of the lung and as the visceral layer completely invests it, being also continued in between the lobes and intimately united with its surface; after thus entirely enveloping the lung it reaches the anterior aspect of the root of the lung, whence it is reflected forward toward the sternum as the anterior portion of the mediastinal pleura; upon reaching the posterior surface of the sternum it becomes continuous with that part of the parietal pleura which lines the inner surface of the wall of the chest: the pleura sterno-costalis. Above and below the level of the root of the lung the mediastinal pleura passes all the way as an uninterrupted layer from behind forward, from either side of the spinal column to the posterior surface of the sternum.

Limits of the Pleura as Indicated by Lines upon the Chest Wall. The Anterior Edge of the Pleura.—The line which indicates the anterior edge of the right pleural sac commences, above, behind the right sterno-clavicular articulation; from this point it passes downward and inward behind the sternum, and at the junction of

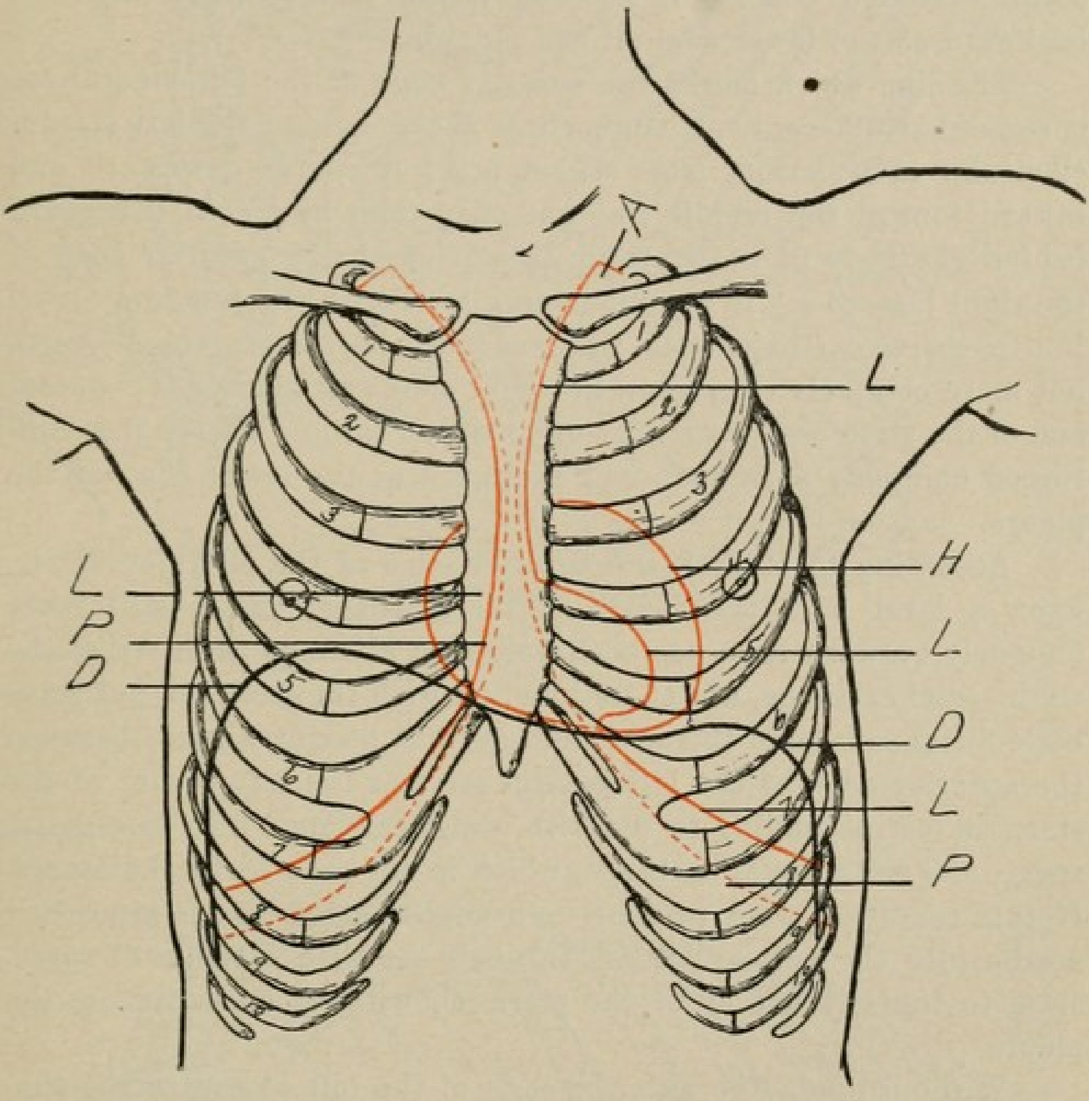

Fig. 146.—Outline of Pleura, etc. Front view. *A*, apex of lung and dome of pleura; *D*, line of diaphragm; *H*, outline of heart; *L*, solid lines show the edges of the lungs; *P*, dotted lines correspond to the edges of the pleura.

the manubrium with the body of the sternum it lies close to the middle line; it is then continued downward behind the middle of the body of the sternum, and opposite the articulation of the fourth costal cartilage it curves outward, as it descends, to reach a point corresponding to the lower border of the sternal end of the sixth costal cartilage, whence it may be traced farther downward and backward as the lower edge of the pleura.

The line which marks the anterior edge of the left pleural sac is somewhat different. It commences above, behind the left sterno-clavicular articulation, from which point it curves downward and inward toward the middle line and may then be traced downward behind the body of the sternum parallel with the anterior edge of the right pleural sac to a point upon a level with the junction of the fourth costal cartilage with the sternum; here it curves outward, but more obliquely than upon the right side, and reaches the sternal end of the sixth costal cartilage at its upper border, whence it is continued obliquely downward and backward as the lower edge of the pleura.

According to Merkel, the anterior edge of the left pleural sac, upon a level with the fourth costal cartilage, passes still more obliquely outward than has been described above so as to strike the sixth costal cartilage, not at its junction with the sternum, but some little distance beyond this articulation, thus leaving a space between the anterior edge of the left pleural sac and the left border of the sternum, corresponding to the fifth costal cartilage, fifth intercostal space, and sixth costal cartilage, which is not covered by the pleura. If this condition were present, one might introduce an aspirating needle into the pericardial sac through the fifth intercostal space, close to the left border of the sternum, without encountering the pleura.

Without doubt the anterior edge of the left pleural sac is subject to considerable variation. I have found the first description to hold for most cases.

The Lower Edge of the Pleura corresponds to a line that commences, in front, behind the junction of the sixth costal cartilage with the sternum; it passes downward and backward, crossing obliquely the cartilage of the seventh rib in the parasternal line and passing into the seventh intercostal space in the mammary line; still continued downward and backward it reaches its deepest point, corresponding to the tenth rib or tenth intercostal space, a little behind

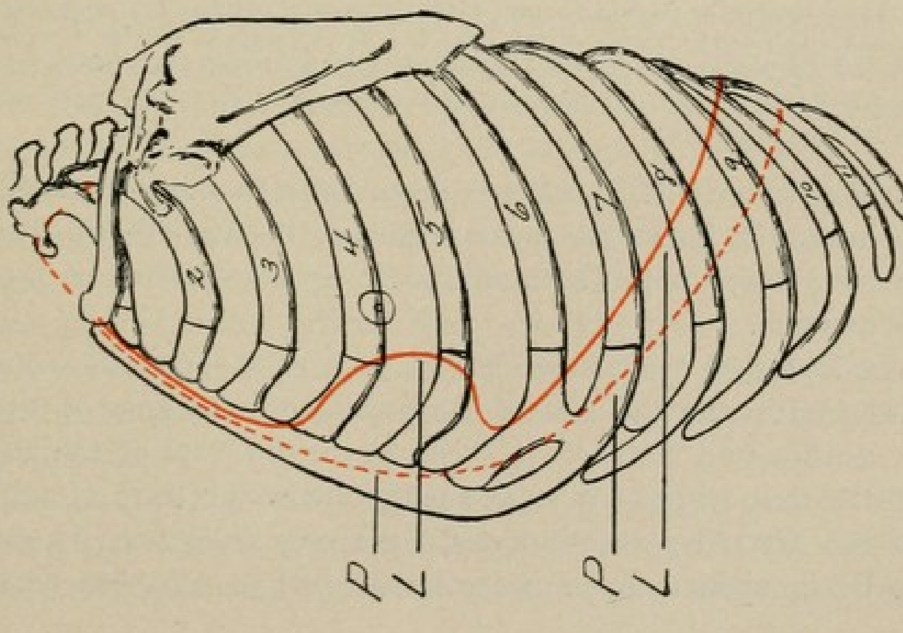

Fig. 147.—Outline of Pleura, etc. Side view. *L*, solid line represents edge of the lung; *P*, dotted line shows the edge of the pleura.

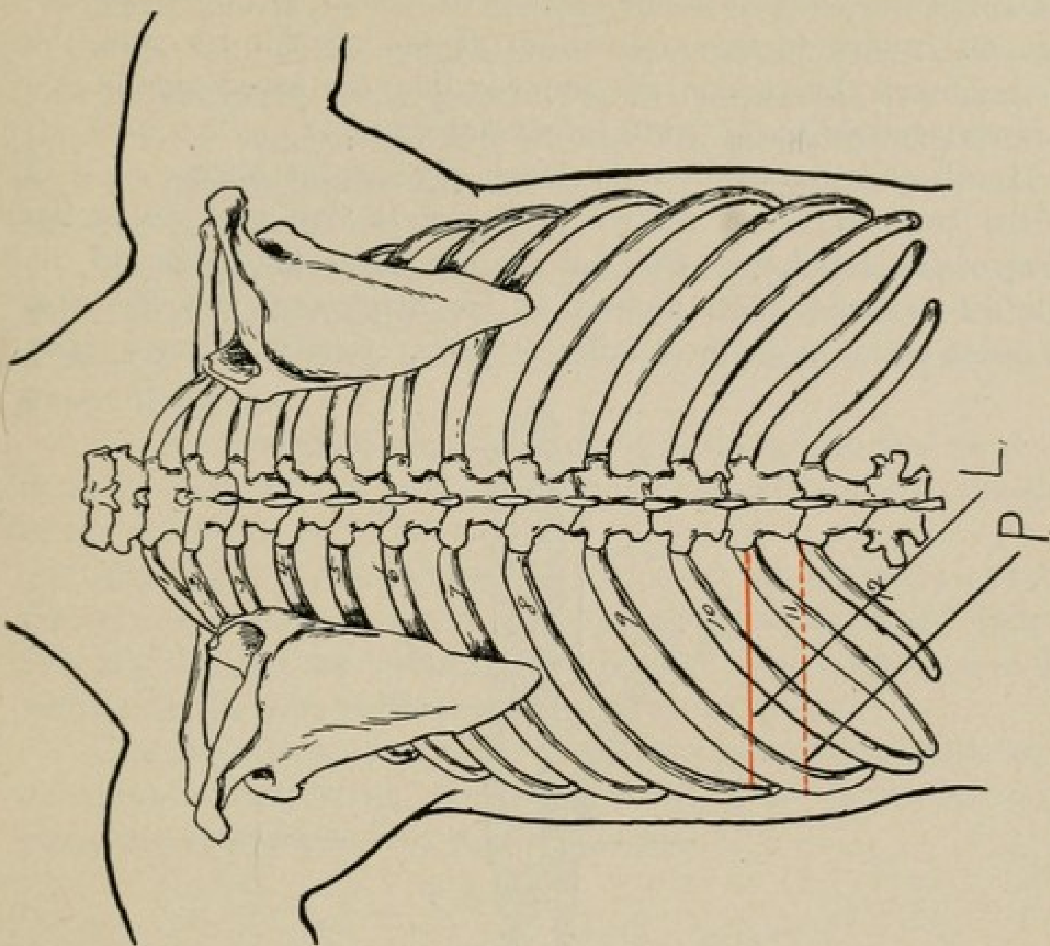

Fig. 148.—Outline of Pleura, etc. Back view. *L*, solid line indicates edge of the lung; *P*, dotted line corresponds to lower limit of the pleura.

the axillary line, whence it may be traced almost horizontally backward and inward to the articulation of the twelfth rib with the spinal column. Behind, in the scapular line, the lower edge of the pleura corresponds to the tenth intercostal space.

It will be observed that the lower edge of the pleura, as it is reflected from the inner surface of the chest wall over on to the surface of the diaphragm, does not dip down into the bottom of the recess between the costal portion of the diaphragm and the ribs. This space varies in depth at different parts. Occasionally the lower

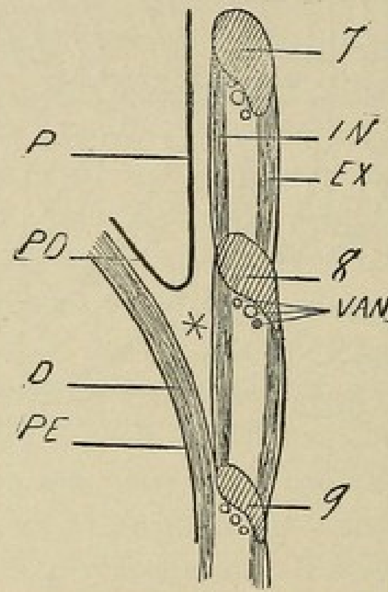

Fig. 149.—Section through Seventh, Eighth, and Ninth Ribs Anterior to the Axillary Line. *D*, diaphragm; *EX*, external intercostal muscle; *IN*, internal intercostal muscle; *P*, pleura covering inner aspect of the chest wall; *PD*, pleura that covers the diaphragm; *PE*, peritoneum that is reflected upon the under surface of the diaphragm; *VAN*, intercostal vein, artery, and nerve situated under lower border of the ribs; 7, 8, 9, cut surface of ribs; * represents the space between the diaphragm and chest wall into which the pleura does not descend, as it is reflected from the chest wall on to the upper surface of the diaphragm.

edge of the pleura, behind, reaches down between the twelfth rib and the diaphragm as far as the lower border of the twelfth rib, or, even beyond this, down to the level of the transverse process of the first lumbar vertebra.

The Dome of the pleura is that part of the pleural sac which projects upward into the root of the neck above the level of the first rib; it reaches to a distance of 5 cm. above the level of the anterior part of the first rib, but does not reach above the level of the back part of the first rib; the first rib is set very obliquely, its anterior portion being upon a much lower level than its posterior part.

The dome of the pleura reaches from 2 to 4 cm. above the level of the clavicle; so that a knife introduced above this bone and passed directly backward would pierce both the pleura and the lung. In front of the dome is the first rib and the posterior surface of the scalenus anticus muscle and the clavicle. Internal to the dome are the trachea and the œsophagus.

The subclavian vessels pass forward and outward across the dome, grooving it and the apex of the lung, which lies beneath. Care is necessary in ligating the subclavian or innominate arteries not to wound the pleura.

As the internal mammary artery dips down into the chest it is crossed by the phrenic nerve and lies in close relation with the dome of the pleura.

The dome of the pleura is re-enforced by the fascia endothoracica, and connected behind, through ligamentous bands, with the first rib and the last cervical and the first dorsal vertebræ and in front with the deep surface of the scaleni muscles.

The mediastinal portion of the pleura and the pericardium are adherent to each other, and between these two serous layers the phrenic nerves descend to the diaphragm.

THE LUNGS.

The Root, or Pedicle, of the Lung.—The root of the lung is located in the back part of the mediastinum behind the ascending part of the arch of the aorta and above the base of the heart. That of each lung is composed of the bronchus, the pulmonary artery, and the pulmonary veins, together with lymphatics (also blood-vessels for the supply of lung tissue proper and plexuses of nerves).

The trachea bifurcates opposite the fifth dorsal vertebra, and its divisions, the bronchi, are directed outward and downward toward the hilum of either lung. The right bronchus is more horizontal, shorter, and of wider caliber than the left, and its lumen is more directly continuous with that of the trachea; so that foreign bodies dropped into the trachea are more apt to enter the right than the left bronchus.

The pulmonary artery springs from the upper part of the right ventricle, and at its origin lies in front of the root of the aorta. It is a short trunk, directed upward and backward, and under the transverse part of the arch of the aorta divides into the right and left pulmonary. These pass outward, in front of the bronchi, to the hilum of either lung. At the hilum the pulmonary arteries are located upon a higher level than the bronchi, and may get to lie partly behind these as they enter the lung.

The pulmonary veins are short trunks which, upon leaving the hilum of the lung, pass transversely inward and enter the corresponding side of the left auricle; they lie some little distance below the level of the bronchi and the pulmonary arteries.

There are numerous lymph nodes irregularly arranged about the root of the lung, but there is always a well-marked group below the bifurcation of the trachea.

Over the root of the left lung, arching from before backward, is the arch of the aorta. The vena azygos passes over the root of the right lung, from behind forward, and enters the vena cava superior, which lies just in front of the root of the right lung, upon its posterior aspect.

The Lung, suspended by its root, occupies the pleural cavity and is entirely enveloped by the visceral layer of the pleura. At the root of the lung this visceral layer of the pleura is continuous with the mediastinal part of the parietal pleura. The base of the lung rests upon the diaphragm; its apex projects into the root of the neck for a distance of 4 or 5 cm. above the front end of the first rib. In the natural sitting position the apex of the lung reaches to a point about 3 cm. above the clavicle.

The right lung consists of three lobes, the left of two. Each lung upon its inner surface shows a depression corresponding to the heart, that upon the left lung being deeper than that upon the right lung.

The lung does not entirely fill the pleural cavity except above, where the apex occupies all the space corresponding to the dome of the pleura.

Limits of the Lungs.—The posterior border of each lung is found alongside the vertebral column. The anterior border of the lung corresponds to the line of the pleura from the sterno-clavicular articulation to the level of the fourth costal cartilage. The anterior border of the right lung continues to be the same as that of the pleura down to the level of the sixth costal cartilage. The anterior border of the left lung, at the junction of the fourth costal cartilage with the sternum, passes almost transversely outward behind the cartilage of the fourth rib, forming the upper border of the incisura cardiaca, and then, midway between the border of the sternum and the nipple, it turns downward behind the fourth intercostal space and fifth costal cartilage, and in the fifth space passes sharply inward, forming the lower border of the incisura cardiaca.

The lower border of either lung is represented by a line which commences at the junction of the sixth costal cartilage with the sternum; it passes downward and backward, behind the sixth costal cartilage, and crosses the seventh rib in the mammary line; from this point the line passes backward, almost transversely, crossing the eighth and ninth ribs in the axillary line, the tenth rib in the scapular line, and reaches the vertebral column upon a level with the articulation of the eleventh rib. Although the line, after crossing the seventh rib in the mammary line, is continued almost transversely backward, it cuts the eighth, ninth, and succeeding lower ribs, owing to the obliquity of the ribs.

The lower edge of the lung does not reach to the bottom of the pleural cavity; so that a space is left which is called the sinus phrenico-costalis. This space commences in front, and gradually becomes deeper; upon the sides it is deepest, and may measure up to two inches. In more forcible inspiration this space is partly obliterated by the increased expansion of the lung.

A similar pleural space, unoccupied by the lung (incisura cardiaca), is found in front of the pericardium and heart, corresponding to the fourth intercostal space and fifth costal cartilage, to the left of the sternum.

In the child the distance between the lower border of the lung and the bottom of the pleural cavity is one-half to one space deeper than described above. In old age the distance between the lower border of the lung and the bottom of the pleural cavity becomes one-half to one space shorter.

Luschka gives the depth of the sinus phrenico-costalis as follows: In the sternal, parasternal, and mammary lines, 2 cm.; in the axillary line, 6 cm.; and near the vertebra, 2.5 cm.

OPERATIONS UPON THE BREAST.

Incisions for Abscess of the Breast.—These should radiate from the region of the nipple toward the periphery of the breast in order to avoid, as far as possible, cutting across the milk-ducts, which all converge toward the nipple. The incisions should be liberal, and should be so placed as to allow the discharge to drain through the lower, dependent part of the breast, and, if necessary in order to accomplish this, one or more counter-openings may be made. Liberal incisions should be made through the skin and fat, and the abscess cavity penetrated with closed artery forceps, which are spread apart as they are withdrawn. In this way hemorrhage, deep, in the substance of the gland and which might be difficult to control, is less likely to occur. The finger is introduced into the incision and any septa which might obstruct the free outflow of pus broken down.

Extirpation of Tumors Out of the Substance of the Mammary Gland (Fibroids, for Example).—An incision is made corresponding in length to the size of the tumor and radiating from the areola toward the periphery of the breast.

These tumors are usually encapsulated and well defined, and can be dissected out with blunt-pointed scissors or may, at times, be enucleated by blunt dissection with the finger.

Amputation of the Breast (Halsted-Meyer).—The breast, together with the pectoralis major and minor muscles and the glands and connective tissue of the axilla, must all be removed in one single mass and without cutting into the diseased tissue. The patient lies upon the back with the arm abducted and supported by an assistant.

An incision is made through the healthy skin and fat, elliptical and circumscribing the tumor; from the upper end of the ellipse the incision should be continued along the edge of the pectoralis major to a point upon the upper part of the arm a little beyond (below) the attachment of the tendon of this muscle to the humerus. Although it is desirable to bring the edges of the wound together with sutures at the end of the operation, yet one should not, on this account, take any chance in leaving suspicious-looking integument, because if we are unable to close the wound with sutures we can cover any remaining raw space with skin grafts.

To this first incision a second is added which runs obliquely from the junction of the middle and outer thirds of the clavicle down into the upper border of the elliptical incision. The corners of the skin-flaps which are thus marked out are seized with the fingers and, including but little of the fat layer, are dissected away from the breast (tumor) and from the underlying surface of the muscles, etc., upward, toward the clavicle; inward, toward the sternum, and outward, toward the axilla. In this way we expose the sternal and clavicular portions and the tendon of the pectoralis major muscle. In the space between the upper border of the pectoralis major and the deltoid the cephalic vein and the descending branch of the acromio-thoracic artery are found. Externally corresponding to the line of reflection of the external flap the edge of the latissimus dorsi is exposed.

The tendon of the pectoralis major is hooked up upon the finger and divided close to its attachment to the humerus, and then, following along the upper border of this muscle, between it and the edge of the

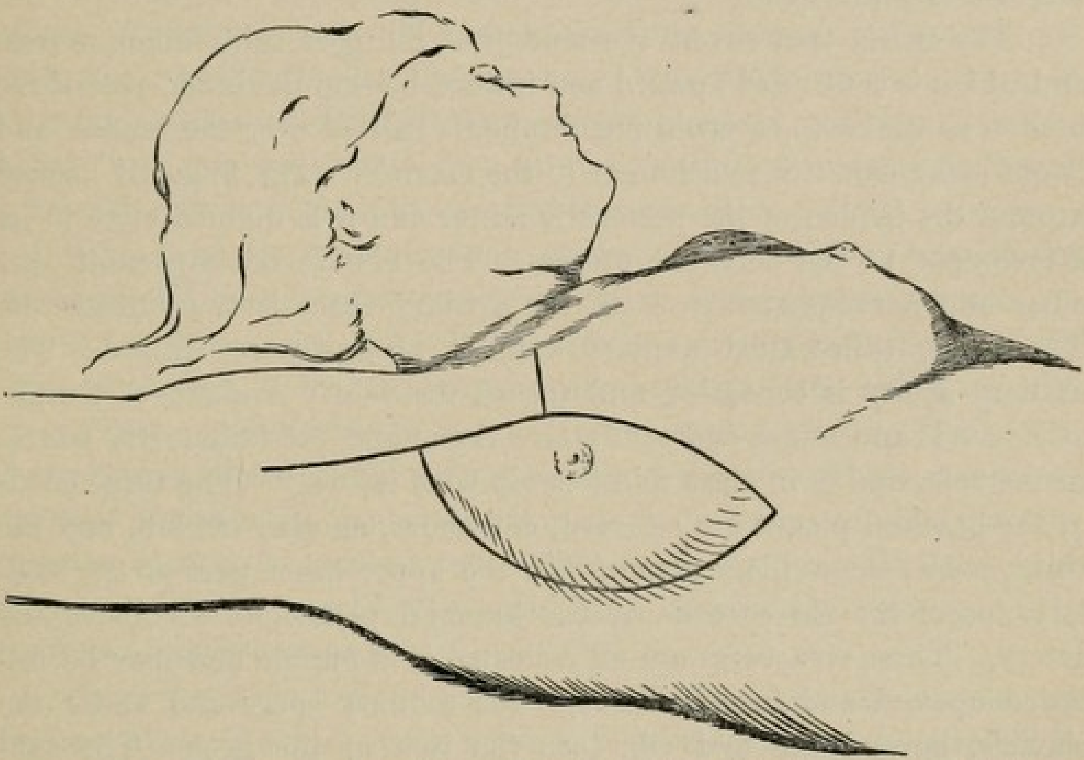

Fig. 150.—Amputation of the Breast. Halsted-Meyer incision for amputation of the breast and to clean out the axilla.

deltoid as far as the clavicle, this muscle (pectoralis major) is cut away from its attachment to the clavicle and reflected downward, thus exposing the next underlying layer, or *"étage,"* which consists of the pectoralis minor muscle covered by its fascia and some loose connective tissue and the costo-coracoid membrane.

Frequently that portion of the pectoralis major which arises from the clavicle can be saved. This will add much to the usefulness of the arm after the operation. A distinct groove is seen between that portion of the pectoralis major which arises from the clavicle and that which arises from the chest-wall. If it is desired to save the clavicular portion of the muscle the finger is introduced into the groove between these two portions and that part of the tendon which corresponds to the pectoral origin of the muscle only is hooked up and divided close to its attachment to the humerus as already described.

The fascia that covers the pectoralis minor is continued upward from the inner border of the muscle as the costo-coracoid membrane and is attached to the first rib and under surface of the clavicle, thus covering in the structures of the infraclavicular region—the axillary vessels, etc. The costo-coracoid membrane is perforated by the cephalic vein, the anterior thoracic nerves which supply the pectoralis major and minor, etc.

The fascia that covers the tendon of the pectoralis minor muscle and which is continued upward and inward beyond the inner edge of the tendon as the costo-coracoid membrane, is incised over the tendon and is cut away from its attachment to the clavicle. The finger is hooked around the tendon of the pectoralis minor and it is divided close to its attachment to the coracoid process. The bundle of important vascular and nervous structures in the axillary space is thus uncovered. The large, thin-walled axillary vein is promptly recognized. The axillary artery is concealed underneath the vein. A chain of lymphatic vessels and nodes and connective tissue and fat follows the course of the vein, and is in close relationship with its wall. The three cords of the brachial plexus are situated, one above, another behind, and the third below, the axillary artery. In the upper inner part of the axillary space, the three cords of the brachial plexus lie all above the artery. These structures are all collected in a bundle and may be followed upward and inward through the axillary space and under the clavicle, beyond the first rib, into the root of the neck. The subscapular vein, the largest and most prominent branch of the axillary vein, accompanied by the corresponding branch of the axillary artery, may also be promptly recognized in the axillary space. These vessels are accompanied by the subscapular nerve, which may be identified by pinching it purposely or accidentally with the forceps. When the nerve is touched or pinched, the latissimus dorsi contracts.

Commencing as high up as possible, the space beneath the clavicle being made more accessible by elevating the shoulder, all the fat and connective tissue are cleaned away from the vessels, ligating all branches as they are met with and working outward and downward along the course of the axillary vein. After the space beneath and above the clavicle has been thoroughly cleared of all fat and connective tissue, the dissection is continued down along the course of the axillary vessels and nerves, working pretty close to the wall of the vein all the time, as far as the attachment of the tendon of the pectoralis major to the humerus. This dissection must be thorough and carried out with great care so as not to wound the axillary vein. If the vein should be accidentally wounded an effort must be made to close the opening. If the opening is small this may be done with a side ligature carefully applied; if larger, the opening may be closed with a continous suture, using the finest silk smeared with vaselin, and the finest straight needle. The method of closure is quite similar to that described on page 28. The circulation must be interrupted during the application of the suture by applying two rubber-sheathed Crile clamps to the vein, one above and the other below the opening. The tissue which is removed from the axilla should not be taken away piecemeal, but should be dissected free from the vessels, etc., in one continuous mass and allowed to remain connected with the general tumor mass.

Now, from the posterior wall of the axilla and from the side of the chest, all the fat and connective tissue and lymphatic tissue are cleared, working from behind forward and laying bare, behind, the anterior surface of the latissimus dorsi, subscapularis, and teres major muscles (posterior wall of the axillary space) and, upon the side of the thorax, the ribs and serratus magnus muscle. Upon the posterior wall of the axilla the subscapular nerve, in company with the subscapular vessels, is encountered. This nerve supplies the latissimus dorsi and should be saved, if possible, and likewise the vessels, if they have not already been cut.

Upon the side of the chest we meet the long thoracic vessels and the long thoracic nerve; if the nerve is recognized it may be possible to avoid cutting it. It supplys the serratus magnus.

The whole mass—which consists of the breast (tumor), pectoral muscles (major and minor), axillary contents, etc.—is now grasped by the operator and lifted away from the chest wall when the attachments of the pectoral muscles to the ribs and sternum are cut, and then, the mass being gradually turned out of the wound, the extirpation is completed and the bare wall of the chest, together with the axillary vessels and the nerves which accompany them, is exposed to view. When the mass is lifted away from the chest wall, the perforating vessels—branches of the intercostals and the internal mammary—may be seen as they enter the posterior surface of the pectoralis major and care should be taken not to tear these or cut them too close to the surface of the chest wall, as it might then be difficult to clamp and tie them. They may often be secured with clamps before they are cut. All hemorrhage must positively be controlled before proceeding to close the wound.

The edges of the wound are brought together by suture, and if too much integument has not been removed the wound may be thus closed entirely. Special care is taken to close in the axillary space by bringing the little triangular flap which corresponds to the outer edge of the incision up to the upper margin of the incision and suturing it in this position. Interrupted sutures of silkworm gut are used for closing the wound. Occasional tension sutures may be necessary. If there is any raw space remaining, it may be covered with skin-grafts applied at once. A cigarette drain is placed in the axilla. A little stab-hole is made for this purpose in the lower part of the little external triangular flap. The drain may be removed on the sixth or seventh day when the first dressing is made. If a portion of the wound has been covered by skin grafting the dressing must be changed on the third day.

One should minimize the loss of blood as much as possible during the course of the operation, clamping vessels before or immediately after they are cut.

Skin Grafting, Thiersch.—Very thin strips of skin, about one inch wide and one to several inches long, are planted upon the surface which is to be covered. If this surface is old, it must be curetted or the granulations rubbed off with a gauze wipe. If the surface is dense and hard, as is sometimes found in old chronic ulcer of the leg, it will be necessary to excise it. It is necessary to have a good vascular surface upon which to place the grafts, but all active hemorrhage and oozing must be checked by ligatures or by pressure with a gauze pad before applying the grafts.

The skin-grafts are usually taken from the anterior surface of the arm or thigh, and preferably from the patient himself. Grafts may also be taken from another person. The part from which the grafts are to be taken is disinfected in the usual manner, washed with soap and water, followed by dilute alcohol, and then washed with normal salt solution and covered with a towel wet in the salt solution. The skin is shaved off in very thin strips. The grafts are cut with a steady back and forward sawing motion, using a very sharp razor for this purpose. The surface from which the grafts are taken must be held taut—upon the stretch—by the operator and his assistant while the grafts are being cut. The skin and the razor are kept moist while the grafts are being cut. This is done by the assistant squeezing a gauze pad wet in salt solution. The salt solution is allowed to fall on the razor-blade drop by drop while the grafts are being cut. Each individual graft is immediately carried upon the razor-blade to the surface where it is to be deposited. The graft is transferred from the razor-blade to the raw surface by fixing the end of the graft upon the wound surface with a probe and then sliding the razor-blade from underneath it. The thin layer of skin is spread out upon the wound surface as it is delivered off the razor-blade, care being taken that the edges are not turned under. The grafts are placed side by side, leaving a narrow interval between them. After the grafts have all been placed upon the raw surface they are covered over with strips of rubber tissue. The rubber-tissue strips are one-half to three-quarters inch wide, and are placed so that they overlap one another slightly like the shingles on a roof. A dry dressing of folded gauze pads is applied. Care is taken not to rub or displace the grafts while the dressings and bandages are being applied.

The raw surface which is left where the grafts have been taken is also covered with strips of rubber tissue and a dry dressing applied.

Ligation of the Intercostal Artery.—Each intercostal artery is situated, together with the intercostal vein and nerve, beneath the lower border of the corresponding rib. These vessels may be injured in stab wounds, etc.

At times it becomes necessary to resect a part of the rib subperiosteally in order to get at the bleeding points. It is necessary to tie both ends of the vessel.

Ligation of the Internal Mammary Artery.—To secure this vessel one must resect the costal cartilage of the second or third rib close to the sternum or the vessel may be ligated through a transverse incision placed midway between the contiguous cartilages and close to the sternum in the third intercostal space. The vessel descends upon the posterior surface of the anterior chest wall, its vein alongside of it; it is accompanied also by a chain of lymphatic nodes.

OPERATIONS UPON THE HEART.

Paracentesis Pericardii.—Tapping the pericardium. This operation may be resorted to when an effusion resists other measures of treatment or when it is causing urgent symptoms of cardiac distress. The puncture is made, as a rule, in the fifth or sixth left intercostal space close to the edge of the sternum. By inserting the needle close to the sternum the internal mammary vessels are avoided; in the sixth interspace there is still less likelihood of meeting the anterior free edge of the pleura than in the fifth; therefore the sixth space is rather preferable except that occasionally it is inconveniently narrow.

A short vertical incision is made through the skin at the left edge of the sternum and corresponding to the fifth or sixth intercostal space.

For the purpose of evacuation a trocar and cannula may be used. If the sixth space is selected the instrument is pushed through the intercostal structures in a direction backward and inward. If the puncture is made in the fifth space the needle is entered close to the edge of the sternum and near the upper border of the sixth costal cartilage and is pushed at first directly backward to a depth of about one-third inch—the thickness of the sternum—and then inward behind and close to the posterior surface of the sternum for a distance of about one-half inch in order to make certain of clearing the edge of the pleura and then, finally, backward and somewhat downward and inward into the distended pericardial sac. While the instrument is being introduced it should be guarded with the finger to prevent its abruptly entering the chest. Fluid may be evacuated with or without aspiration, depending upon the facility with which it escapes. As much as a pint has been withdrawn at a single operation. The small incision in the skin may be closed with a single suture.

Pericardiotomy.—Incision of the pericardial sac in order to establish drainage; for empyema; for the purpose of exploration in cases of suspected wound of the heart. The fifth or sixth costal cartilage, preferably the sixth, is resected.

An incision corresponding to the sixth left costal cartilage is made. It commences at the edge of the sternum and exposes the cartilage for its whole length. The soft parts are detached with the elevator and the cartilage resected with the bone-forceps. The structures corresponding to the posterior surface of the cartilage that has been resected, are divided with the knife and the internal mammary vessels exposed. These vessels are found about one-half inch distant from the border of the sternum. They are ligated double and divided between the ligatures. The triangularis sterni—a flat, muscular layer that is spread out upon the posterior surface of the costal cartilages, etc., between these and the parietal layer of the pleura—is exposed to view. This muscular layer is incised and its edge retracted outward. The lower anterior edge of the pleura is then recognized and is carefully separated from the pericardial sac and also retracted outward.

The line of separation between the edge of the pleura and the pericardial sac is usually indicated by a small pad of fat. Care is exercised not to incise the pleural sac in this step of the operation.

The pericardium is recognized as a dense, whitish, fibrous sac. It is picked up with two toothed forceps and divided between these. If it is desired to keep the sac open for the purpose of drainage the edges of the opening which has been made are sutured to the edges of the deeper layers in the skin incision with several interrupted sutures. A soft-rubber tube or a cigarette drain is introduced. The skin incision is closed in part.

Pericardiorrhaphy.—Suture of the pericardium. After the pericardial sac has been exposed the edges of the opening or wound in it are brought together with silk or catgut sutures in such fashion that the edges are everted and the serous surfaces are apposed. The skin incision should be left open in part and drained.

Cardiorrhaphy.—Suture of wounds of the heart. All wounds of the heart are not necessarily fatal. In many cases the wound may be closed and the hemorrhage checked by suture. Operative interference must, however, be prompt to be effectual. Death ensues in wounds of the heart promptly as a direct result of the great quantity of blood lost or rather more slowly as a result of compression of the heart, especially of the thin-walled auricles and the veins that empty into them, by the blood that has escaped through the wound in the heart filling and distending the pericardial sac—heart tamponade. If the blood cannot escape from the pericardial sac it may collect in such great quantity and under such great pressure that the thin-walled auricles and the veins that enter them are compressed to such a degree that the circulation becomes seriously impeded or entirely interrupted—the blood cannot enter the auricles and is dammed back in the venæ cavæ and pulmonary veins. Under these circumstances, by simply enlarging or making an opening in the pericardial sac, thus giving vent to the blood that is confined within the pericardial sac, the pressure upon the heart is relieved and oftentimes the heart will resume its pulsation even after it had almost or entirely ceased.

Wounds of the heart are usually marked by an extreme degree of shock—the patient is usually unconscious from loss of blood and shock. Blood may be escaping in great quantity from a wound in the chest or there may be but little or no external hemorrhage. The pulse is irregular, rapid, and feeble. If the finger is placed in the wound it may lead down into the pericardial sac, palpate the heart, and its withdrawal may be accompanied with a great gush of blood. If the blood remains imprisoned in the pericardial sac there will be an increased area of cardiac dullness, the heart sounds are distant and indistinct or inaudible, and signs of heart tamponade will be present. These are cyanosis, distension of the superficial veins of the neck, face, etc., prominent bulging of external jugulars, dyspnœa, and labored breathing. These signs are accompanied by a progressive fall in blood-pressure with corresponding rapid, feeble radial pulse, which gradually becomes extinct. If the finger is introduced into the wound it may be followed by a gush of blood which may relieve the symptoms. If the pleural cavity has been opened there will be pneumothorax or the pleural cavity may contain a large quantity of blood. In cases of doubt with a wound in the præcordial region and excessive hemorrhage, or without external hemorrhage and symptoms of heart tamponade, an exploratory pericardiotomy is surely indicated.

Patients with heart wounds are usually in extreme collapse from shock and hemorrhage and in many cases unconscious, so that little or no anæsthetic is required. The operation may be commenced without any anæsthetic, and if an anæsthetic becomes necessary during the progress of the operation, ether, by the drop method, is most satisfactory. The patient must be kept warm.

It may be imperative, on account of symptoms of heart compression, to gain access to the pericardial sac as promptly as possible; and then, after evacuating the blood and according to the conditions that are found, the opening may be enlarged as necessary. If it is apparent that the pleural cavity has not been opened by the original wound, stab, etc., we should employ a method of operating that offers the least chance of opening the pleural cavity. If the pleural cavity has already been opened the necessity for avoiding this accident does not exist and the operation becomes much simpler.

With the Pleura Apparently Unopened.—An incision is made from the level of the third costal cartilage downward a little to the left of the middle line of the sternum as far as the junction of the sixth costal cartilage with the sternum, and from this point another incision is carried downward and outward along the cartilage of the sixth rib. From the upper end of the vertical incision another is carried outward upon the third rib, nearer its upper border. This last incision penetrates through the pectoralis muscle down to the surface of the cartilage. In some cases it will not be necessary to resect higher than the fourth costal cartilage; therefore this upper incision may be left until later, placing it upon the third or fourth costal cartilage as may be required. The soft parts are carefully detached from the sixth cartilage, in front, along the upper and lower borders and behind, with the elevator and the cartilage then resected with the bone forceps. The internal mammary artery and vein are seen about one-half inch from the edge of the sternum. The vessels are surrounded with a ligature, tied double and divided. Beneath the vessels is a thin sheet of muscle, the triangularis sterni. This muscle layer is incised close to the sternum. The edge of the muscle, together with the free edge of the pleura which is usually adherent to the under surface of the muscle, is separated and peeled outward away from the dense whitish, fibrous pericardial sac, leaving the latter thus exposed. The space or line of separation where the free edge of the pleura is in relation with the pericardial sac is usually indicated by a small wad of fat. Blood may be seen issuing from a wound in the pericardial sac or it may be necessary to enlarge or to make an opening in the sac to permit the blood to escape and relieve the heart from compression—heart tamponade.

In some cases sufficient exposure may be obtained with this incision to treat a wound in the heart, especially if the cartilage above, the fifth, is cut away from its attachment to the sternum and tractors are introduced and the edges of the wound—cartilages—pulled strongly apart. As a rule, however, it is necessary to expose the heart more freely. For this purpose the soft parts, pleura and triangularis sterni muscle, are peeled away, in an outward direction, from the under surface of the fifth costal cartilage and this cartilage then cut away with the bone-forceps from its attachment to the edge of the sternum. While the flap is lifted forcibly the soft parts are separated in a similar manner from the under surface of the fourth costal cartilage and the cartilage cut away in like manner from its attachment to the sternum. If necessary the third cartilage may be treated in the same way. The soft parts, intercostal muscles, etc., are detached from the upper border of the third costal cartilage through the upper, transverse, incision that was made along the line of this rib, with the periosteum elevator. As already mentioned, it may not be necessary to resect the cartilages higher than the fourth. The chondroplastic flap which is thus marked out consists of the fifth, fourth, and third costal cartilages—the sixth has been resected—and the corresponding intercostal muscles, integument, etc. According as the flap is lifted, the soft parts, pleura and triangularis sterni muscle, are cautiously peeled away from its under surface and the flap is finally forcibly bent along its outer border, base, breaking the ribs at their chondrocostal junction so that the flap may be reflected and turned down flat upon the chest wall. After the flap has been thus reflected and the pericardial sac exposed and incised, free access may be had to the heart from its base to its apex. The pleura may already have been punctured or it may be torn during the reflection of the flap with a resulting pneumo-

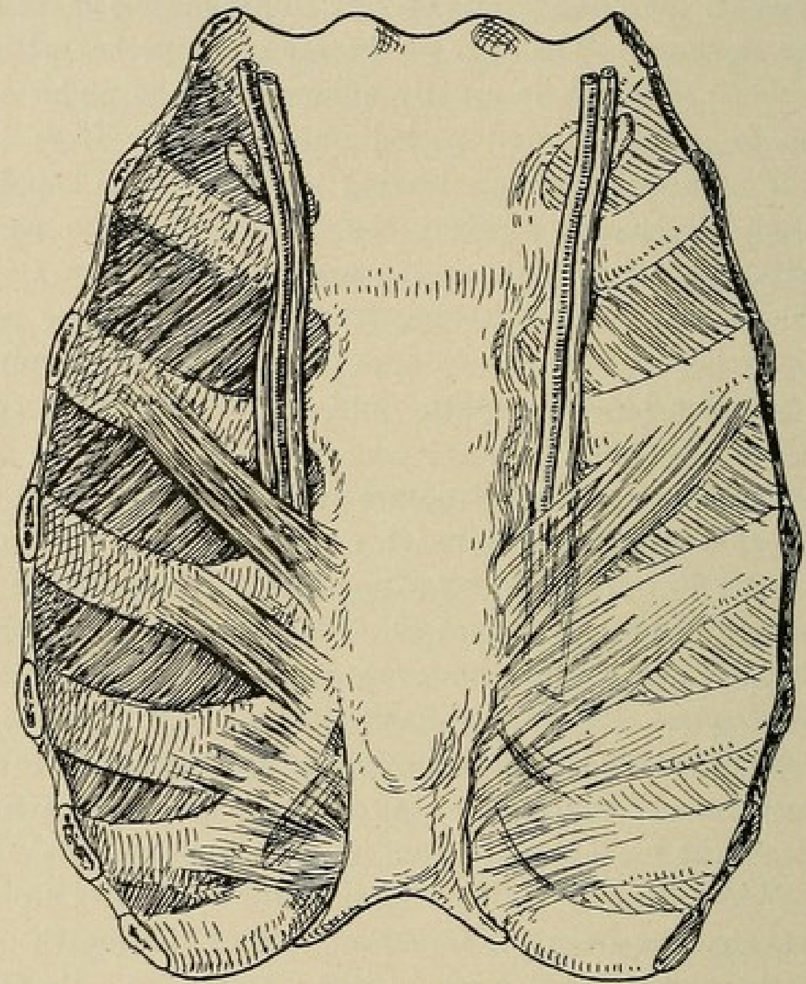

Fig. 151.—Posterior Aspect of Sternum and Ribs; Triangularis Sterni Muscle; Internal Mammary Artery and Vein.

thorax. The edges of a small opening in the pleura may be caught with the artery forceps or the opening may be covered over with a gauze wipe to prevent the entrance and exit of air. A large rent in the pleura with collapse of the lung may be disregarded until the heart wound has been sutured.

It may be necessary occasionally to gain still more room. For this purpose an osteoplastic flap may be taken from the sternum and turned over toward the right side. The soft parts, fascia and pleura, are detached from the under surface of the sternum and the sternum then cut across above and below, with the bone-forceps. The osteoplastic flap is bent over toward the right side, fracturing the ribs and making a hinge at the right chondrosternal border.

The pericardial sac is freely opened and blood and clots cleared out. The heart may be seen beating tumultuously in a pool of frothy blood. The heart is picked up in the hollow of the left hand for ex-

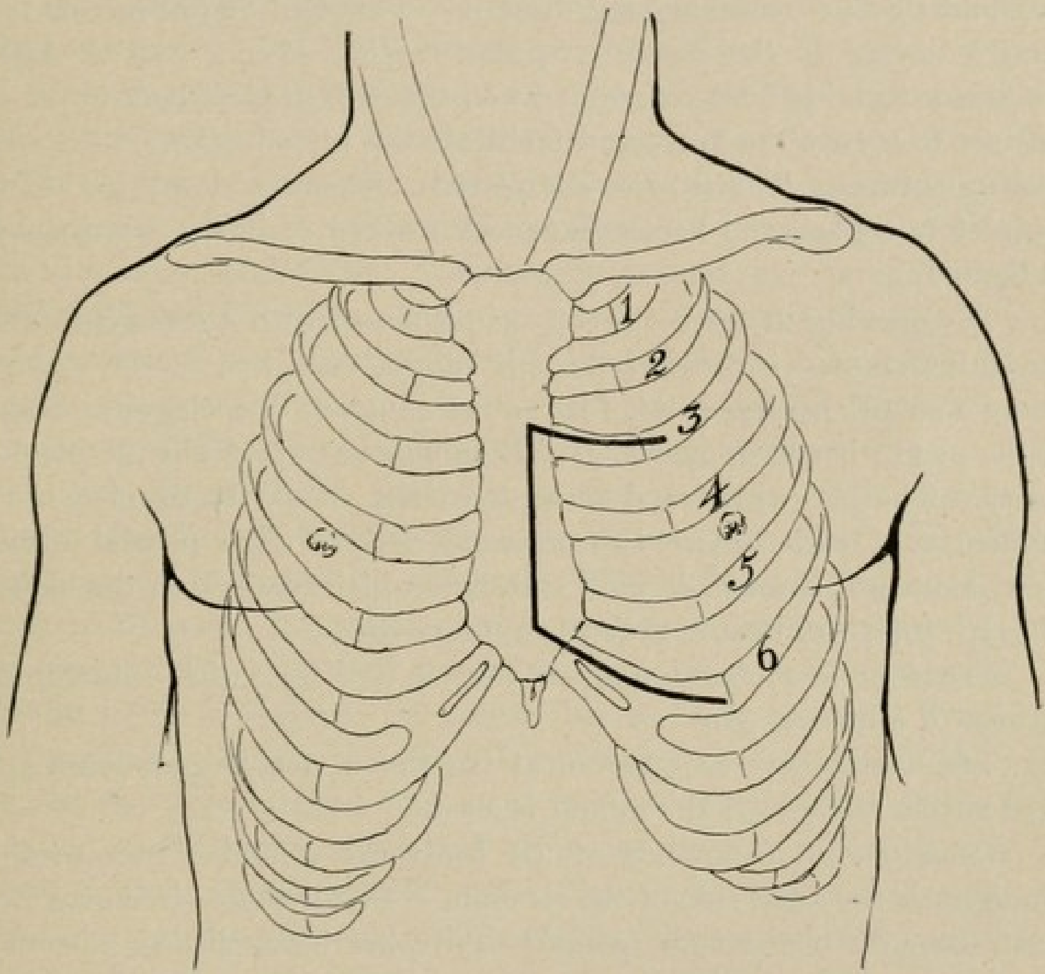

Fig. 152.—Incision in Soft Parts for Exposure of Heart.

amination. The index and middle fingers are inserted behind the heart, which is steadied with the thumb anteriorly. The heart may be lifted partly out of the sac or twisted slightly upon its long axis in order to examine its posterior aspect. Blood may be spurting furiously from the wound in the heart with each beat. The hemorrhage may be controlled momentarily by placing the finger over the wound or into the wound, or it may be necessary to compress the right auricle by grasping it between two fingers of the left hand and making pressure with the thumb anteriorly. This may be continued for a few seconds—long enough to get in one suture to, at least, partly control the hemorrhage. If the heart has stopped beating gentle massage and rhythmic compression may cause it to resume its pulsation. The first suture is passed across the middle of the wound. It takes a good broad bite, but does not penetrate. In wounds of the thin-walled auricle it may be difficult not to penetrate. Fine silk, passed in a thin, smooth curved needle is used for sutures. The effort may be made to pass and tie the sutures during diastole. This will be difficult or impossible owing to the rapid, irregular beating of the heart. After the first suture has been passed and tied the ends are left long to use as tractors to steady the heart and facilitate the introduction of the succeeding sutures. The sutures are placed sufficiently close together to completely control the hemorrhage. A severed coronary artery must be ligated.

The opening in the pericardial sac is closed with a sufficient number of interrupted sutures of chromic catgut, except in the lower part where a small opening is left for the introduction of a cigarette drain. If the pleura has been opened it will be necessary to drain the pleural cavity. The pericardial and pleural cavities should be drained independently of each other—two separate drains. The pleural cavity may be drained through a small stab hole which is made in the eighth or ninth intercostal space near the axillary line.

The flap is replaced and sutured in position with interrupted sutures of silkworm gut.

The drains may be removed at the end of forty-eight hours and need not be replaced if the wound is clean.

Occasionally in wounds of the heart the wound of entrance is found upon the right side of the sternum. Under these circumstances, and especially if the right pleural cavity has been opened, pneumothorax, it would be extremely hazardous to proceed to expose the heart from the left side of the sternum as described above for fear of opening the pleural cavity in this side (where the right pleural cavity has probably or certainly already been opened), with a resulting double pneumothorax and collapse of both lungs. In these cases it would be wise to expose the heart by making an osteoplastic resection of the sternum, turning the flap over toward the left so that the base, hinge, corresponds to the left sternochondral junction.

If the heart is exposed under intratracheal insufflation anæsthesia the lungs can be inflated so as to completely fill the chest cavity before closing by increasing the intrapulmonary pressure. This can be done by compressing the larynx about the intratracheal tube. This plan of anæsthesia would, no doubt, be of the greatest advantage in operations upon the heart if time and conditions would permit the introduction of the intratracheal tube. It would obviate the danger that would result from pneumothorax, especially if both pleural cavities were opened during the course of the operation, and would permit of complete closure of the pleural cavity without drainage in many, if not all, cases.

Spangaro's Incision.—If it is apparent that the pleural cavity has been opened (and this is the fact in the majority of cases of wounds of the heart) and if, therefore, the necessity of avoiding accidental opening of this cavity during the course of the operation does not exist, then assuredly the quickest and most satisfactory way of gaining access to the heart is by means of the incision described by Spangaro—through the fifth intercostal space. The original wound may be utilized, if in the fourth or fifth space, simply enlarging it, inward toward the edge of the sternum and outward toward the mammary line, sufficiently to expose the pericardial sac. As the incision is carried inward toward the sternum the internal mammary vessels are recognized about one-half inch distant from the edge of the sternum. The vessels are ligated double and divided and the incision then continued inward right up to the edge of the sternum. The incision is prolonged in an outward direction toward or even beyond the mammary line. As the incision is carried outward toward the mammary line the edge of the pleural sac is incised and the pleural cavity freely opened. The edges of the incision (costal cartilages) are strongly retracted and the pericardial sac thus exposed. If more room is required the ends of the cartilages of the ribs above and below, as may be necessary, are cut away at their sternal attachments. The wound is held wide open by forcibly retracting the edges. If necessary an osteoplastic resection of the sternum may be added, turning the osteoplastic sternal flap over toward the right side. The pleural cavity is drained either through the outer end of the incision or else a small stab incision may be made in the eighth or ninth intercostal space, near the axillary line, and the drain introduced into the pleural cavity through this opening.

OPERATIONS UPON THE PLEURA.

Thoracentesis.—Puncture through the chest wall into the pleural cavity.

This operation may be performed to show the presence and to determine the nature of fluid in the pleural cavity or to evacuate such fluid. If for diagnosis only, an ordinary hypodermic syringe may be used. If necessary to evacuate a considerable quantity of fluid, a rather good-sized aspirating needle attached to a Dieulafoy syringe may be employed. The patient should be semirecumbent or lying down. The puncture should be made at the point where the physical signs locate the fluid. To anæsthetize the skin a spray of ethyl chloride may be used. Before the needle is introduced, the skin is drawn upward or downward so that the track of the needle through the muscles may not be upon the same level as the puncture in the skin. The needle is thrust into the chest between the two ribs, nearer the lower than the upper one.

If the operator may choose the point at which the needle is to be introduced, either the eighth space, just below the angle of the scapular, or the sixth space,in the middle of the axilla, just in front of the border of the latissimus dorsi, is usually selected.

The fluid should be evacuated slowly, and, if the quantity is great, care should be taken not to remove too much. One should stop if persistent cough occurs or if the pulse changes. At times, the needle becomes plugged with pieces of fibrin, which may be dislodged by introducing a stylet or by pumping some of the fluid back into the pleural cavity. After the fluid has been withdrawn the needle is removed and the small wound in the skin covered with collodion, etc.

It is necessary to remember that the lower limits of the pleural cavity fall short of the free border of the ribs, and, further, that if the needle is inserted straight inward for a considerable distance it may pass through the pleura and diaphragm into the abdominal cavity.

If we find pus in the pleural cavity, in the adult, it is necessary to establish drainage, resecting part of a rib. In the child it often suffices to simply evacuate the pus with the aspirator without providing drainage.

Thoracotomy.—This means cutting through the wall of the chest, usually with the resection of part of a rib, for the purpose of establishing drainage.

The patient lies upon his well side, and should be anæsthetized. The seventh rib, that portion of it which lies anterior to the latissimus dorsi, is usually resected, as this is not covered by muscle and is sufficiently low for proper drainage.

Immediately before proceeding with the operation the exploring needle should be inserted in order to ascertain positively the location of the pus, and there, where the pus is located, should the opening into the pleural cavity be made. As already mentioned, if we have the choice, the seventh rib is the one selected for resection.

The incision, usually about two inches long, corresponds to the course and direction of the rib to be excised; it is carried down through the soft parts, including the periosteum, upon the surface of the rib. With the elevator the periosteum and all the soft parts are peeled off the bone, which is thus laid bare. Care must be exercised, in working around the upper and lower borders of the rib for the purpose of denuding its internal surface, not to perforate the pleura nor wound the vessels that are lodged in the groove along the lower border of the rib. When the length of bone that is to be excised has been denuded of its periosteum it is cut through at either end with the sharp bone-forceps. The opening into the chest cavity is made by incising the pleura with the knife. The opening which is thus made may be enlarged by introducing an artery forceps, the blades of which are spread apart as they are withdrawn so as to make a hole large enough to permit exploration of the interior of the chest with the finger and the introduction of one or two good-sized tubes.

If it is discovered, with the finger in the chest, that the opening is a considerable distance above the bottom of the pus cavity, it may be desirable, in order to facilitate the drainage, to make a second counter-opening at a lower level: through the eighth space, for instance, or even lower, depending upon the part of the chest which is involved (see limits of lower edge of pleura). The drainage tube should be secured to the edge of the incision in the skin with a silk stitch in order to prevent its becoming dislodged. If the skin wound is unnecessarily large, it may be partially closed with one or two silk sutures. The administration of 20 or 30 minims of aromatic spirits of ammonia hypodermically, immediately before the opening is made into the pleural cavity, will often ward off the condition of collapse which sometimes occurs at this time. If a general anæsthetic is used, it is withdrawn before making the opening in the pleura.

In recent cases of empyema where the adhesions are not yet very firm the lung expands after the pus has been evacuated. In this way the cavity is obliterated and a cure of the condition favored.

Thoracotomy, Lloyd.—In cases of empyema of longer duration and in cases that have already been operated and failed to heal the lung will be found contracted and adherent either in the upper part of the pleural cavity or else drawn toward the middle line and adherent to the diaphragm. In these cases, owing to the density of the adhesions, the lung is unable to expand and fill out the pleural cavity, and it will be impossible under these circumstances to achieve a cure.

According to the plan of Lloyd one or two ribs are resected to give sufficient room and the fingers or hand introduced into the thorax and the adhesions that bind the lung to the chest wall, diaphragm, etc., are broken up. The fingers are inserted between the lung and the chest wall and swept around in all directions between the lung and the chest wall and where the lung is adherent to the diaphragm, between the lung and the diaphragm. The anæsthetic is discontinued as soon as the chest has been opened so that, on account of the irritation of the pleura caused by the manipulation of the fingers and tearing of adhesions the patient coughs violently and thus assists materially in expanding the lung. As the separation of the adhesions progresses the lung will be seen to expand more and more until it compeltely fills the pleural space and in this way obliterates the cavity which served as a reservoir for the pus.

The opening in the chest wall is closed with silkworm-gut sutures except for the small space through which the short drainage tube emerges.

Thoracectomy, Resection of the Chest Wall (Estlaender).—This operation is practiced in old chronic cases of empyema—in cases where the lung cannot expand to fill out and obliterate the pleural (pus) cavity. The operation consists in resection of several ribs to permit the chest wall to fall in upon the contracted lung.

An oval or U-shaped flap, consisting of the skin and subcutaneous fat, with its base behind, at the axillary line, is raised from the side of the chest, exposing three or four ribs; or a vertical incision, six inches long, may be made in the axillary line over the fifth, sixth, seventh, and eighth ribs, with two additional incisions along the course of the ribs, the middle of each of these accessory incisions corresponding to the upper and lower ends of the vertical incision. The two flaps which are thus marked out are reflected, one backward and the other forward, exposing four to six inches of three or four ribs.

Each rib is denuded of its periosteum all around, as described in the preceding operation, and resected with the bone pliers. A long incision is then made in the pleura and the thickened pleura excised. The bleeding is controlled by clamps and ligatures. The cavity of the pleura may be curetted if thought necessary. The edges of the skin flap are brought together with several silk sutures and the pleural cavity packed.

Pleurectomy (Fowler).—Detachment and excision of the thickened, diseased pleura, visceral and parietal, entire or in part, in old, intractable cases of empyema.

An incision is made along the course of the ribs corresponding to the site of the fistula, which is always present (since this operation is usually practiced in cases which have already been operated upon unsuccessfully), and the location of the disease; to either end of this incision there may be added accessory incisions, an anterior and a posterior. The flaps that are thus marked out, including all the soft parts, are raised so as to expose two or three ribs for four or five inches of their length. Instead of the incision as described above an elliptical or the double flap incision, as described in the Estlaender operation, may be employed.

The periosteum is stripped off two or three ribs with the elevator, and then from three to five inches of the two or three ribs that have been thus denuded are resected with the bone forceps. All bleeding points are secured with artery clamps and ligated. Cutting from the fistula, the parietal (costal) pleura, which is now exposed, is opened up with a free incision, and entrance thus gained into the suppurating pleural cavity. The pleura which invests the lung (visceral) is incised, and by blunt dissection with the finger or with the blunt-pointed scissors this is peeled off the lung; here and there it will be necessary to cut a band with the scissors. In many cases the pleura may be separated from the lung with comparative ease, and this should be done with care, so as not to tear into the lung tissue proper.

As the decortication of the lung progresses there may be considerable oozing from the denuded lung surface, but this may be controlled by compression with gauze pads, which are applied to the bleeding surface following up the fingers of the operator or the blunt scissors, according as the pleura is detached.

After the pleura has been peeled off the lung the parietal pleura is stripped off the chest wall and then off the diaphragm. In separating the pleura from the contiguous portion of the pericardial sac care must be exercised to avoid any undue pulling or tearing. As a rule, the pleura is fairly easily separated and removed.

At times it will be found more convenient to commence the detachment of the pleura by stripping it away from the chest wall; it is then peeled off the diaphragm and finally from the surface of the lung.

Occasionally the conditions that exist preclude the possibility of excising all of the diseased pleura, and under these circumstances the operator must content himself with the excision of the visceral or parietal (costal and diaphragmatic) pleura in part, or else simply incise the visceral pleura and strip it away from the surface of the lung without removing it.

After the pleura has been removed, either entire or in part, the cavity in the chest is loosely tamponed with gauze and the edges of the skin approximated with silkworm-gut sutures, except for a part of its extent, where the tampon emerges.

As a rule, as the detachment of the pleura from the lung progresses, the lung will be seen gradually to expand more and more.

This operation has the advantage of removing the pathological suppurating membrane, and besides eliminates an obstacle to the expansion of the lung. The operation is not advisable in cases of diagnosable pulmonary tuberculosis. The discovery, during the course of the operation, of tuberculous deposits in the lung would warrant the surgeon in discontinuing the operation.

PART V.

THE ABDOMEN AND BACK.

THE ABDOMEN.

THE abdomen corresponds to the lower part of the trunk, and consists of a cavity with elastic muscular walls.

Within the cavity are contained the chief part of the alimentary canal and the organs of digestion and the kidneys, etc. These organs are all more or less movable, and are provided with a more or less complete investment of peritoneum.

Externally the abdomen is limited above by the free border of the costal cartilages and below by the crest of the iliac bone of either side and Poupart's ligaments. The walls consist almost entirely of soft parts, and may be conveniently considered as the posterior and the antero-lateral. The capacity of the abdominal cavity is greater than is indicated by its external limitations.

The roof of the abdominal cavity is formed by the diaphragm; below, the abdominal cavity includes, on either side, the iliac fossa and communicates through a wide, heart-shaped opening with the cavity of the true pelvis. The margin of the inlet into the pelvic cavity is called the pelvic brim.

The interior of the cavity of the abdomen is lined by the parietal layer of the peritoneum, and is entirely shut off from communication with the exterior of the body except in the female, where a communication exists through the vagina, uterus, and Fallopian tubes, and this is frequently the channel through which infection is carried to the peritoneum from without.

The Diaphragm, which forms the roof of the abdominal cavity, is a musculo-aponeurotic structure that separates the cavity of the chest from that of the abdomen. It is dome-shaped, bulging into the cavity of the thorax and presenting its lower concave surface to the abdominal cavity. It arises by muscular fibers, which vary in length, from the inner surface of the ensiform process of the sternum and from the inner surface of the cartilages of the lower ribs. Behind, it arises from the ligamentum arcuatum externum and ligamentum arcuatum internum and by its two crura from the anterior surface of the bodies of the three upper lumbar vertebræ. From these points of origin the muscular fibers converge and are continued into a three-leafed aponeurotic structure: the central tendon of the diaphragm. Behind the diaphragm there is an opening, the aortic, through which the aorta passes from the thoracic into the abdominal cavity; the posterior boundary of this opening corresponds to the body of the twelfth dorsal vertebra. In the back part of the diaphragm, a little to the left of the middle line, there is an opening which is surrounded by muscular fibers and through which the œsophagus passes to the cardiac end of the stomach. To the right of the middle line, toward the front, at the junction of the right and middle segments of the central tendon, there is an opening for the passage of the inferior vena cava; the edges of this opening are formed of aponeurotic fibers. The heart, wrapped in its pericardial sac, rests upon the upper surface of the central tendon of the diaphragm.

In front, close to the sternum, on either side of the bundle of fibers which arises from the ensiform process, there is a space where the muscular fibers of the diaphragm are absent; so that, in this situation, an opening exists through which the contents of one cavity may be forced into the other, giving rise to a so-called diaphragmatic hernia.

On the right side, owing to the presence of the liver, the diaphragm reaches higher into the chest than on the left. The thoracic surface of the diaphragm is covered by a thin fascia, the fascia endothoracica; the abdominal surface is likewise covered by a fascia which is very thin, the fascia transversalis.

The Posterior Wall of the Abdomen, the lumbar region of the back, corresponds to the five lumbar vertebræ and to the several muscles which fill in the space between the last rib and the crest of the ilium on either side of the spinal column. Externally we find the skin and beneath this the subcutaneous fatty layer. Between the muscles of the lumbar region there are interposed strong layers of fascia which serve to strengthen this region very much. The internal or abdominal aspect of the posterior wall of the abdomen is lined by that part of the transversalis fascia which covers the psoas and quadratus lumborum muscles.

The kidney, inclosed within its fatty capsule, is located in the lumbar region between the transversalis fascia—*i.e.,* the anterior layer of the lumbar fascia—and the parietal peritoneum, its anterior surface only being covered by the peritoneum; so that the organ is thus excluded from the peritoneal cavity.

The Antero-Lateral Wall of the Abdomen is made up of several layers of soft parts. It consists of the skin with its underlying fatty layer; several broad, flat muscles, the oblique, the transversalis, and the recti; and the aponeuroses which correspond to these muscles. The fascia transversalis is found beneath the muscles, and beneath the fascia transversalis the subperitoneal fat is encountered, and, finally, deepest, most internal of all, is the parietal peritoneum.

In the female the abdomen is more rounded and contains a considerable pad of fat; in the male, especially in athletes, the fatty layer is less marked or almost entirely absent; so that the markings of the muscles show through the skin and give the characteristic appearance to the abdomen.

In the middle line, about midway between the ensiform process and the symphysis pubis, there is a well-marked depression, the navel; this is an important landmark, although its position may vary somewhat in different individuals, and marks the place where the fœtal umbilical vessels and fœtal channels enter and pass out of the abdomen. Above, in the middle line, is the ensiform process of the sternum, and passing downward from this there is a furrow which corresponds to the space between the rectus muscles, but which does not reach downward as far as the symphysis. On either side of the middle line, corresponding to the outer border of the rectus, is the location of the linea semilunaris. Below, on either side, the anterior superior iliac spines—important surgical landmarks—may be seen, and upon the pubic bones, on either side of and close to the symphysis, the spinous processes of the pubes may be felt.

Corresponding to Poupart's ligament, which reaches from the anterior superior spine to the spine of the pubes, there is a linear crease in the skin which separates the abdomen from the front of the thigh.

The whole abdomen is covered by the skin, underneath which is the subcutaneous fat; the abdomen is a favorite site for the accumulation of fat in the obese, and this layer varies much in thickness in different individuals; it is continuous with the corresponding fatty layer upon the breast and below with the fat of the thighs. At the navel the fat is absent, the skin being depressed and fixed to the aponeurosis beneath, so that the depth of the navel corresponds to the thickness of the abdominal pad of fat. The subcutaneous fatty layer may be readily separated from the underlying muscle and aponeurosis, leaving these structures covered by a thin, loose, cellular fascia, the so-called deep layer of the superficial fascia, but which is really a part of the subcutaneous connective-tissue layer. This fascia is more intimately attached to the linea alba and Poupart's ligament and to the pillars of the external inguinal ring than elsewhere. From the pillars of the ring it is prolonged downward around the spermatic cord and into the scrotum, where it is continuous with the dartos.

The Superficial Vessels of the Abdominal Wall.—In the subcutaneous fatty layer the superficial arteries and veins ramify.

Above, branches of the superior epigastric, which perforate the rectus and the anterior layer of its sheath, are distributed to the integument and subcutaneous tissue. Below, the superficial epigastric artery, which is derived from the femoral, curves obliquely upward across Poupart's ligament toward the umbilicus and supplies the skin and fat in this region. Upon the sides of the abdomen branches that are given off from the lumbar arteries pierce the muscles and ramify in the subcutaneous tissue. These vessels are all accompanied by their corresponding veins. Underneath the skin of the abdomen are seen many large veins which communicate with those within the abdomen, and therefore when the blood-current is obstructed in the portal vein or the vena cava these superficial abdominal veins become swollen and prominent and are readily recognized beneath the skin.

After the skin and subcutaneous fatty layer, including the thin, deep layer of the superficial fascia, have been removed from the front and sides of the abdomen, the broad, strong aponeurosis of the external oblique upon the front of the abdomen and the fleshy portion of this same muscle upon the side of the abdomen are exposed.

The Muscles of the Antero-Lateral Wall. The External Oblique is a broad, flat muscle, the most superficial of the abdominal muscles, and occupies the side of the abdomen. The muscle arises by fleshy slips from the external surface of the eight lower ribs, interdigitating with the processes of origin of the pectoralis major and the latissimus dorsi. The fibers of this muscle have a general oblique direction, downward, forward, and inward, terminating in the broad, strong aponeurosis which occupies the front of the abdomen. Those fibers which arise from the lowest ribs pass almost directly downward and are attached to the anterior half of the outer lip of the crest of the ilium. The posterior free border of the external oblique muscle forms the anterior border of the triangle of Pettit. The posterior border of this triangle is formed by the outer free edge of the latissimus dorsi, its base by the crest of the iliac bone, its floor by the internal oblique muscle.

The aponeurosis of the external oblique is a broad, strong, pearly white, glistening, fibrous structure which occupies the front of the abdomen and is exposed after the integument and underlying fatty layer (superficial fascia) have been removed. The fibers of the aponeurosis are, for the most part, directed downward and inward, covering in the recti and joining in the middle line, between these muscles, to form the linea alba.

The linea alba is a strong, fibrous band which reaches from the ensiform cartilage above to the symphysis pubis below; it marks the union of the aponeuroses of either side and separates the recti from each other. The linea alba is interrupted by the navel. Above the navel the linea alba is broad: in the epigastric region it is .1 to 2 cm. wide, and below, toward the navel, becomes still broader. Below the navel, however, it is not so broad, owing to the closer approximation of the edges of the recti. Above, where it is broad, it is thin from before backward, and below, where it is narrow, it is thick from before backward. Below, at its attachment to the symphysis pubis, it spreads out and is known as the adminiculum lineæ albæ.

Those fibers of the aponeurosis of the external oblique, that pass from the anterior superior spine of the ilium downward and inward to the spine of the pubes, form Poupart's ligament; where this ligament is attached to the pubic spine, the aponeurosis of the external oblique splits and leaves a triangular opening which is called the external inguinal ring, and through this the spermatic cord in the male, and the round ligament in the female, emerge. Below Poupart's, the aponeurosis is continuous with the fascia lata of the front of the thigh.

Along the outer edge of the rectus, at the linea semilunaris, the aponeurosis of the external oblique is blended with the aponeuroses of the underlying muscles; from the linea semilunaris the aponeurosis is continued inward, forming the anterior layer of the sheath of the rectus, and in the middle line joins with that of the opposite side to form the linea alba.

The Internal Oblique Muscle lies beneath the external oblique upon the side of the abdomen, a thin, loose, cellular connective tissue being interposed between them. The fibers of this muscle have a direction the opposite to those of the external oblique.

This muscle arises below from the anterior two-thirds of the middle lip of the crest of the ilium and from the outer half of Poupart's ligament. From this origin the fibers pass in a general direction upward and forward, some being attached to the lower border of the cartilages of the four lower ribs, the others terminating in the anterior aponeurosis, at the outer border of the rectus, the linea semilunaris. The lowermost fibers, which arise from Poupart's ligament, pass inward and then, curving downward, join with a similar process from the transversalis to form the conjoined tendon, which is attached to the crest of the os pubis.

The Transversalis is the deepest of the three broad abdominal muscles. It occupies the side of the abdomen lying next beneath the internal oblique, a thin, loose, cellular connective tissue intervening between them. Its fibers have a transverse direction. This muscle arises behind, through the lumbar fascia, from the transverse processes and spines of the lumbar vertebræ; above, from the inner surface of the six lower ribs; below, from the crest of the ilium and the outer one-third of Poupart's ligament. The fibers pass forward and inward, and, at the outer border of the rectus, terminate in the anterior aponeurosis. Those fibers of the transversalis which arise from Poupart's ligament pass inward, and curving downward join with a similar process from the internal oblique to form the conjoined tendon, which is attached to the crest of the pubes behind the external inguinal ring. Beneath the transversalis muscle, the transversalis fascia, which lines the whole inner surface of the abdomen, is found.

The Rectus is a long, flat muscle occupying the front of the abdomen, one on either side of the middle line, the linea alba being interposed between them.

Above, the rectus muscles are broad and attached to the cartilages of the fifth, sixth, seventh, and eighth ribs and to the sides of the ensiform cartilage. Below, they become narrow and are attached to the symphysis and crest of the pubes. The recti are marked by several transverse fibrous intersections, which are united to the anterior layer of the sheath of this muscle, but not to the posterior; they are usually three in number, two above the umbilicus and one below.

The Aponeuroses of the external and internal oblique and transversalis are blended with each other along the outer border of

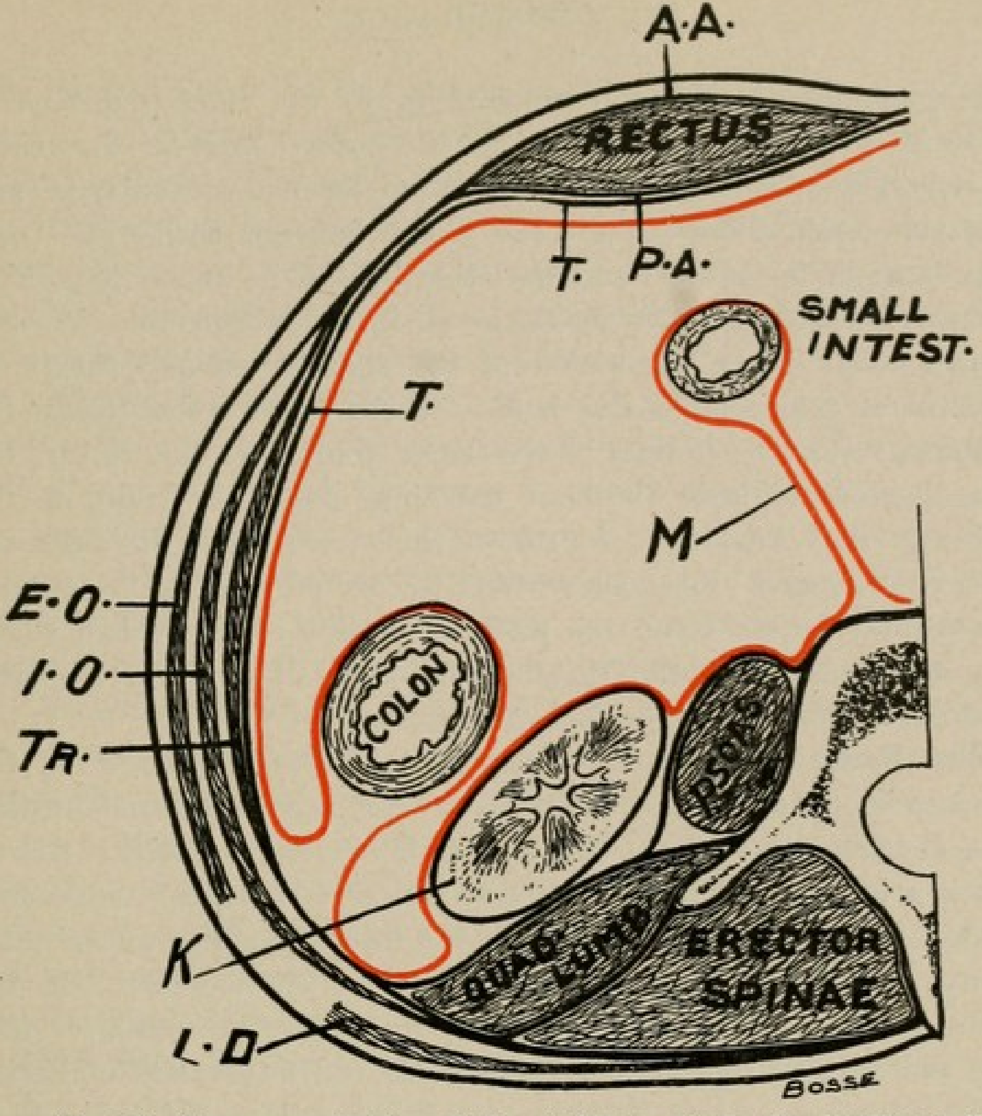

Fig. 153.—Transverse Section of the Abdomen Above the Semilunar Fold of Douglas. *AA*, anterior layer of the split aponeurosis of the oblique and transversalis muscles—anterior layer of sheath of the rectus; *EO*, external oblique muscle; *IO*, internal oblique muscle; *K*, kidney; *LD*, latissimus dorsi muscle; *M*, mesentery (suspends small intestine to vertebral column); *PA*, posterior layer of split aponeurosis of the oblique and transverse muscles—posterior layer of sheath of rectus; *T*, *T*, transversalis fascia; *TR*, transversalis muscle; red line represents the peritoneum.

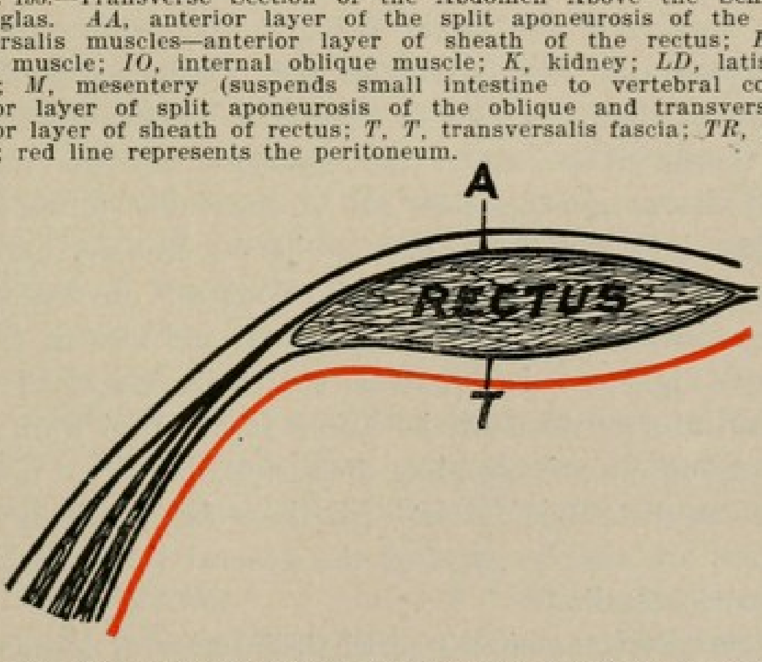

Fig. 154.—Transverse Section of the Abdomen Below the Semilunar Fold of Douglas, Showing the Entire Aponeurosis Passing in Front of the Rectus Muscle. *A*, aponeurosis of the abdominal muscles (oblique and transversalis) passing undivided in front of the rectus.

the rectus muscle. Here, corresponding to the linea semilunaris, they form one aponeurotic layer. At the outer border of the rectus the conjoined aponeurosis splits into two layers,—an anterior and a posterior,—and these include the rectus between them, one passing in front of the muscle and the other behind it, and both joining again with each other, between the recti, in the middle line, to form the linea alba. This disposition of the aponeurosis and sheath of the rectus is very simple and holds for the upper three-fourths of the muscle. Corresponding to the lower fourth of the rectus, the whole aponeurotic layer, without splitting, passes in front of the muscle; so that this lower fourth of the rectus, upon its posterior aspect, is without a proper sheath and is covered only by the general fascia transversalis. Upon the posterior aspect of the rectus, where the posterior layer of the sheath terminates, it presents a sharp, curved edge: the semilunar fold of Douglas.

The Fascia Transversalis.—Lining the inner surface of the transversalis muscle and continued over the whole internal surface of the abdomen is a strong fascia, the fascia transversalis. Above, this fascia is thin and lines the abdominal surface of the diaphragm. In front and upon the sides it lines the internal aspect of the muscles, etc., that form the antero-lateral wall of the abdomen. In the inguinal region it is rather thicker. Behind, upon the posterior wall of the abdomen the fascia covers the psoas and quadratus lumborum muscles, forming in this situation the anterior layer of the lumbar fascia. This portion of the fascia, being traced downward, is seen to invest the psoas and iliacus muscles and is attached to the inner lip of the crest of the ilium and to Poupart's ligament except where the femoral vessels escape, under the ligament, into the thigh. As the psoas and iliacus muscles pass out of the abdomen, under Poupart's ligament, into the thigh, the fascia accompanies and invests them. That portion of the fascia which covers and invests the psoas and iliacus muscles, both within the abdomen and also in the thigh, under Poupart's ligament, is known as the fascia iliaca. The fascia also dips down into the true pelvis, lining its internal wall, muscles, etc., providing more or less complete sheaths to the pelvic viscera and is here known as the pelvic fascia. All these fasciæ, though having different names, are simply parts of the general transversalis fascia or fascia endoabdominalis.

The Parietal Peritoneum.—The whole interior of the abdominal cavity is lined by the parietal layer of the peritoneum. Between this parietal layer of the peritoneum and the transversalis fascia there is a layer of loose connective tissue which contains a variable quantity of fat. This is the subperitoneal connective tissue.

Through an incision in the anterior abdominal wall placed just to the left of the middle line, we may study the round ligament of the liver. This structure is the remains of the fœtal umbilical vein and reaches from the posterior aspect of the navel upward and to the right as far as the under surface of the liver. A fold of the parietal peritoneum, which is reflected from the anterior abdominal wall around the round ligament, is called the falciform ligament.

Accompanying the round ligament of the liver from the region of the umbilicus are several veins; one, the largest, enters the portal system, and thus establishes a communication between the veins of the wall of the abdomen and the portal circulation.

Reaching downward, in the middle line from the umbilicus to the summit of the bladder, is the urachus. This is a musculo-fibrous cord,—the remains of the fœtal allantois,—and may be found more or less pervious in the child or adult; so that a communication may thus exist between the umbilicus and the bladder. As the parietal peritoneum which lines the posterior surface of the anterior abdominal wall passes over the urachus, it is raised in the form of a distinct longitudinal fold: the plica vesico-umbilicalis media.

The Deep Vessels of the Abdominal Wall.—Between the layers of the muscles of the abdomen the deep vessels of the abdominal wall ramify. Above are found the terminal branches of the internal mammary, the superior epigastric, and the musculo-phrenic. The superior epigastric is continued from the thorax, through the opening in the diaphragm, between its costal and sternal portions; it pierces the posterior layer of the sheath of the rectus, supplies this muscle and gives off branches which perforate the muscle and the anterior layer of its sheath to supply the subcutaneous tissue and skin of the abdomen. It anastomoses with branches of the superficial epigastric and deep (inferior) epigastric.

Below, the deep epigastric and deep circumflex iliac, which are derived from the external iliac, are encountered; these are given off just before this vessel passes under Poupart's ligament to become the femoral.

The deep epigastric is directed upward and inward toward the umbilicus, resting upon the posterior surface of the rectus, between the transversalis fascia and the parietal peritoneum, and enters the substance of this muscle below the semilunar fold of Douglas, supplying it and anastomosing with the end branches of the superior epigastric. Some branches from this vessel pierce the anterior layer of the sheath of the rectus muscle and ramify in the fatty layer beneath the skin.

The deep circumflex iliac passes upward and outward beneath and parallel with Poupart's ligament toward the anterior superior iliac spine; it then runs along the crest of the ilium and after piercing the transversalis fascia is distributed to the muscles of the abdomen.

From behind come the abdominal branches of the lumbar arteries: usually four. They pass forward between the muscles and anastomose with the branches of the musculo-phrenic, superior epigastric, the deep epigastric, and the deep circumflex iliac. These arteries are all accompanied by their corresponding veins.

The Regions of the Abdomen.—The surface of the abdomen may be marked off into areas by several imaginary lines which intersect each other. Two of these are transverse, the upper passing through the tips of the tenth ribs, the lower through the highest points of the iliac crests. These are crossed by two lines which pass from the tip of the tenth rib of either side downward and inward to the pubic spine.

Above the upper transverse line is the

(*a*) Regio epigastrica;

between the two transverse lines is the

(*b*) Regio mesogastrica;

and below the lower transverse line is the

(*c*) Regio hypogastrica.

The regio epigastrica is subdivided into three portions:—

1. Regio epigastrica proper.
2. Regio hypochondriaca dextra.
3. Regio hypochondriaca sinistra.

The regio mesogastrica is subdivided into three portions:—

1. Regio umbilicalis.
2. Regio abdominis lateralis dextra.
3. Regio abdominis lateralis sinistra.

The regio hypogastrica is subdivided into three portions:—

1. Regio pubica.
2. Regio inguinalis dextra.
3. Regio inguinalis sinistra.

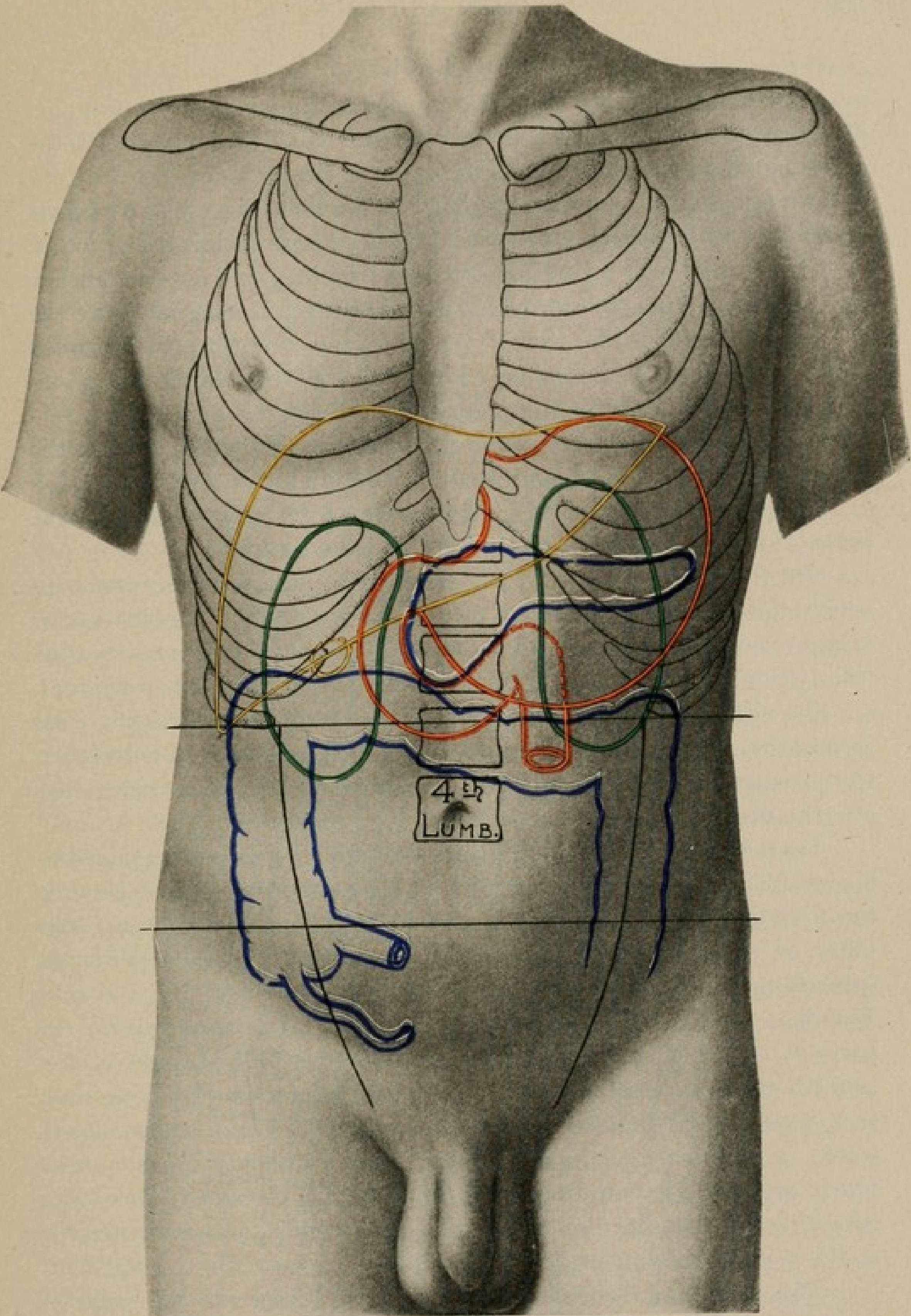

Fig. 155.—The Regions of the Abdomen as Indicated by Two Transverse Lines drawn through the Tips of the Cartilages of the Tenth Ribs and the Anterior Superior Iliac Spines and Two Oblique Lines drawn from the Tips of the same Cartilages down to the Pubic Spines. The liver and gall-bladder are indicated in orange, stomach and duodenum in red (dotted lines represent that part of the duodenum which lies behind the stomach). The pancreas and colon are indicated in blue, the kidneys in green.

THE BACK.

When we speak of the back we mean the whole posterior part of the trunk. The back may be divided into three regions: the dorsal, the lumbar, and the sacral.

It is better to consider the back as a whole, since these regions merge directly into each other without any definite dividing line.

Above the back is limited by the vertebra prominens and below by the tip of the coccyx. The dorsal portion corresponds to the chest, and includes the dorsal vertebræ and the ribs, the scapulæ and the muscles of this region. The lumbar portion forms the posterior wall of the abdominal cavity, and includes the five lumbar vertebræ and the thick mass of muscle on either side which fills in the space between the last rib and crest of the ilium.

The sacral region corresponds to the posterior wall of the true pelvic cavity and includes the sacrum and the coccyx.

In the middle of the back there is a longitudinal furrow in which the spinous processes of the vertebræ, from the seventh cervical, vertebra prominens, above, to the sacrum below, may be distinctly felt; those which correspond to the sacrum are less prominent.

To either side of this median furrow there is a prominent mass formed by the longitudinal muscles of the back. These masses extend from the sacrum to the occiput, and, the more pronounced they are, the deeper is the median groove.

In the dorsal region, on either side, are the scapulæ—shoulder-blades. These bones are triangular in shape and are located between the first and eighth ribs toward the outer part of the thorax. The inner or vertebral border of the scapula is nearly parallel with the spinous processes of the vertebræ when the arm hangs by the side. This bone is freely movable and its position varies according to the position of the upper extremity. The spine of the scapula is felt beneath the skin and may be traced outward and upward; its outer end, which is prolonged outward and flattened from above downward, is called the acromion process and overhangs the shoulder-joint, articulating with the outer end of the clavicle. The lower extremity of the scapula, the angle, corresponds to the eighth rib, and is a surgical landmark of some value.

The skin and subcutaneous connective tissue of the back is continuous with the corresponding layers of the adjoining parts of the trunk. The subcutaneous tissue is rather firm and fibrous and contains a varying amount of fatty tissue. The deep fascia of the back is a strong, dense, fibrous layer which covers in the superficial muscles; it is attached in the middle line to the spinous processes of the vertebræ and may be traced upward, upon the trapezius muscle, as far as the occipital bone, to which it is attached. In the dorsal region it is attached to the subcutaneous surface of the spine of the scapula. Below it is attached to the crest of the ilium and to the sacrum.

The Muscles of the Back are numerous and may be divided into several layers.

First Layer of Muscles.—Trapezius and latissimus dorsi.

The Trapezius is a broad, flat muscle, one on either side; together they are lozenge-shaped and occupy the dorsal and cervical regions. Each muscle arises from the superior curved line of the occipital bone, from the ligamentum nuchæ, which corresponds to the spinous processes of the cervical vertebræ, and from the spinous processes of all the dorsal vertebræ. From this extensive origin the muscle of each side is attached as follows: Those fibers which arise from the occipital bone pass downward, outward, and forward, and are attached to the upper surface of the outer one-third of the clavicle; those from the dorsal and cervical vertebræ converge and are attached to the whole length of the upper border of the spine of the scapula. That portion of the muscle which corresponds to the lower cervical and upper dorsal vertebræ shows an aponeurotic origin, which, together with that of the opposite side, is oval in shape.

The Latissimus Dorsi is broad, triangle-shaped, and flat, and occupies the lumbar and lower dorsal regions, being partly overlapped by the trapezius.

It arises by aponeurotic fibers from the spinous processes of the five or six lower dorsal and the lumbar vertebræ. Below the aponeurotic origin of the latissimus dorsi is intimately blended with the aponeurosis that covers the erector spinæ; the muscle also arises from the back part of the outer lip of the crest of the ilium and by three or four slips from the external surface of the lower ribs. From this extensive origin the fibers all converge, and at the angle of the scapula they form a thick, flat, fleshy muscle, which, making a half-turn upon itself, passes upward, in front of the teres major, and is attached by a narrow, flat, aponeurotic tendon to the inner lip of the bicipital groove of the humerus. The tendon of the latissimus dorsi and the teres major form the lower border of the posterior walls of the axilla.

SECOND LAYER OF MUSCLES:

Levator anguli scapulæ.

Rhomboideus $\begin{cases}\text{Major.}\\ \text{Minor.}\end{cases}$

The Levator Anguli Scapulæ is located in the side of the neck and the upper dorsal region. It arises by tendinous slips from the tubercles on the transverse processes of the four upper cervical vertebræ; passing down the side of the neck, it is attached to the upper part of the inner, or vertebral, border of the scapulæ.

The Rhomboids are two flat muscles placed one above the other, both lying upon the same plane and really forming one broad, flat muscle. Internally they are attached to the spinous processes of the last cervical and four or five upper dorsal vertebræ, and externally to the vertebral border of the scapula.

THIRD LAYER OF MUSCLES.—Splenius; serratus posticus, superior and inferior.

The Splenius is located in the back of the neck and upper dorsal region, reaching from the occiput downward as far as the sixth dorsal vertebræ below.

The Serratus Posticus.—The superior and inferior are two thin, flat muscles, the superior being located in the upper dorsal region, the inferior in the lower dorsal and lumbar regions.

THE MUSCLES OF THE FOURTH LAYER are numerous and have a longitudinal direction, reaching upward, alongside of the spinal column, from the sacrum as far as the occiput. The muscles of this group, except the erector spinæ, are of but little importance surgically.

The Erector Spinæ below, in the lumbar region, forms a large musculo-tendinous mass, which fills in the space on either side of the lumbar part of the spinal column, being superimposed upon the quadratus lumborum in this region. From the lumbar region the erector spinæ is continued upward into the dorsal region. In the dorsal region this muscle divides into a number of processes, each of which receives a different name and is described as a separate muscle. The erector spinæ below, in the lumbar region, is covered by a dense aponeurotic structure: the posterior layer of the lumbar fascia. The muscle arises from the back part of the iliac crest and, through its aponeurosis, from the posterior surface of the sacrum and from the spinous processes of the lumbar and two or three lower dorsal vertebræ. The erector spinæ is included between the posterior and middle layers of the lumbar fascia. The quadratus lumborum lies beneath the erector spinæ.

In the lumbar region the erector spinæ forms a well-marked muscular mass, and its outer edge is an important guide in cutting down upon the kidney.

THE MUSCLES OF THE FIFTH LAYER are numerous, and are made up, for the most part, of longitudinal strips that connect adjoining vertebræ to each other. They are all more or less continuous with each other, but receive different names in different regions. They are lodged in the groove upon either side of the spinous processes, and extend from the sacrum to the occiput.

The Quadratus Lumborum is really a muscle of the abdomen, forming part of its posterior wall; it is quadrilateral in shape, broad, and thick. It fills in the space on either side of the spinal column from the last rib to the crest of the ilium. It is broader below at its attachment to the crest of the ilium than above at its insertion into the last rib. Its outer border is free and lies more external than that of the erector spinæ, and forms an important surgical guide.

The muscle arises by aponeurotic fibers from the upper part of the ilio-lumbar ligament and from the adjacent part of the crest of the ilium for a distance of about two inches. From this origin the muscle passes upward and is inserted into the inner half of the lower border of the last rib and, by fleshy slips, to the transverse processes of the four upper lumbar vertebræ.

The muscle is inclosed between the middle and anterior layers of the lumbar fascia, and lies directly beneath the erector spinæ, from which it is separated by the middle layer of the lumbar fascia.

The Lumbar Fascia.—In the lumbar region there is a strong aponeurotic structure called the lumbar fascia; it is through this fascia that the transversalis muscle is connected with the spine. The lumbar fascia is usually described as consisting of three layers (see Fig. 89). The anterior layer is rather thin, covers the front surface of the quadratus lumborum muscle, and is attached internally to the anterior aspect of the transverse processes of the lumbar vertebræ; above, this layer of the fascia is attached to the lower border of the last rib, where it constitutes the ligamentum arcuatum externum. The middle layer of the lumbar fascia is strong, is attached to the apices of the transverse processes of the lumbar vertebræ, and is placed between the quadratus lumborum and erector spinæ muscles. The posterior layer of the lumbar fascia is attached to the apices of the spinous processes of the lumbar vertebræ; it forms the posterior aponeurotic covering of the erector spinæ, and is blended with the aponeurosis of origin of the latissimus dorsi. At the outer border of the quadratus lumborum the three layers of the lumbar fascia unite to form a single aponeurotic layer, through which the transversalis muscle is connected with the spinal column.

The Psoas and Iliacus Muscles.—In the back of the abdomen, lying one upon either side of the spinal column, is the psoas muscle. It arises by slips from the transverse processes and bodies of the last dorsal and the lumbar vertebræ, and passing downward joins with the iliacus.

The iliacus muscle occupies the iliac fossa, taking its origin there, and, together with the psoas, passes out of the abdomen under Poupart's ligament to be attached to the lesser trochanter of the femur and to the surface of the bone immediately below this.

The psoas and iliacus are covered by a fascia, the iliac fascia. This is simply a part of the general transversalis fascia of the abdomen. That part which covers the psoas muscle is thickened above, where it is known as the ligamentum arcuatum internum; laterally, beyond the edge of the psoas muscle, this fascia is continuous with that which covers the quadratus lumborum: the anterior layer of the lumbar fascia. The iliac fascia covers the iliacus muscle also, and is attached to the crest of the ilium and the brim of the pelvis, and to Poupart's ligament except where the femoral vessels pass down into the thigh. In this situation the fascia is continued downward, under Poupart's ligament, behind the vessels into the thigh, covering the anterior surface of the psoas-iliacus muscle.

The parietal peritoneum is spread out over the inner surface of the posterior wall of the abdomen. The kidney, incased in its capsule of fat, lies between this layer of the peritoneum and the fascia which covers the quadratus lumborum muscle.

The Spinal Column, etc.—The spinal column is made up of the vertebræ and intervertebral pads, the sacrum, and the coccyx; it is located at a considerable depth from the surface of the body. The spinal column gives solidity, combined with flexibility, to the trunk, and furnishes a canal to contain and protect the spinal cord.

We may palpate the body of the first cervical vertebra, the atlas, through the mouth, its anterior tubercle lying just behind the soft palate; those vertebræ which lie below this down as far as the fifth cervical may also be palpated through the mouth. Lower in the neck and in the dorsal region palpation of the bodies of the vertebræ is impossible. The bodies of the lumbar vertebræ can be felt through the abdomen, especially in thin persons. The sacrum and coccyx may be palpated through the rectum.

The laminæ meet behind, in the middle line, to form the spinous processes and to complete the canal which contains the spinal cord.

In the cervical and lumbar regions the spaces between the laminæ are broad, and a knife-blade might easily be introduced through these into the spinal canal. This could not be so readily done in the dorsal region, however, where the laminæ and spines overlap each other like the shingles on a roof.

The spaces between the laminæ are occupied by the ligamenta subflava, which serve to complete the canal and even it out upon its inner aspect.

The bodies of the vertebræ are joined to each other by the anterior and posterior common ligaments; the posterior common ligament, besides connecting the bodies of the vertebræ with each other, also serves to even out the irregularities upon the internal aspect of the canal. The spines of the vertebræ are connected with each other by ligaments: the interspinous and the supraspinous.

The spinal column presents three curves in the sagittal direction, antero-posterior, and one lateral with the concavity toward the left (aorta).

Fractures of the spine usually involve the fifth and sixth cervical, last dorsal, and first lumbar vertebræ, and are usually caused by indirect violence, the curved parts of the spine being bent beyond the limit of their elasticity.

The spinal canal is widest in the neck and triangular upon section; narrower in the dorsal region and circular upon section. It is narrowest at the level of the ninth dorsal. From the eleventh dorsal it becomes wider again. In the sacrum it is flattened from before backward and terminates upon the posterior surface of this bone.

The spinal canal shows a series of openings—intervertebral—upon either side, just behind the bodies, for the passage of nerves and vessels to and from the canal. The contents of the canal are well protected. It is an uncommon accident for an instrument to penetrate into the canal, and unusual force is required to injure the cord inclosed within these bony walls.

Contained within the canal is the spinal cord, which is much smaller and shorter than the canal; the spinal cord commences at the upper border of the posterior arch of the atlas, where it is continuous with the medulla, and terminates below in the conus terminalis on a level with the lower border of the first lumbar vertebra. From the conus terminalis the cord is prolonged still farther downward as the filum terminale.

The spinal cord, as it lies within the canal, is inclosed by the dura and pia mater. The dura mater of the spinal canal is continuous with the dura mater that lines the interior of the skull, and is adherent to the margin of the foramen magnum. Here it splits into two layers, the external of which is applied to the inner aspect of the spinal canal as a lining membrane, periosteum, whereas the other, the inner layer, forms a loose, sack-like envelope for the cord, the dura mater proper, and is continued all the way down to the coccyx, where it is blended with the periosteum of that bone. Between these two layers there is a space in which veins and arteries ramify and into which hemorrhage may take place. Each nerve, at its exit from the spinal canal, has prolonged upon it a tubular process, which is derived from the dura and pia mater.

Beneath this dura mater sheath is the pia mater, a reticular structure like that which invests the brain; the outer surface of the pia is known as the arachnoid, and the inner, which is applied directly to the surface of the cord, is known as the pia mater proper and carries the vessels which penetrate into the substance of the cord to supply it.

Between the two surfaces of the pia there is a space, which is called the subarachnoid space, and which is subdivided, cut up, by numerous trabeculæ into a net-work of small spaces. In the subarachnoid space, between the two layers of the pia, the cerebrospinal fluid is found. From the pia mater laterally, between the roots of the nerves, there arises a longitudinal septum which is attached to the inner surface of the dura mater by a number of processes. The line of origin from the pia is continuous. The line of attachment to the dura mater is interrupted. This is known as the ligamentum dentatum.

The surfaces of the dura and the pia mater (arachnoid) are not joined to each other except for occasional strands of connective tissue that unite them here and there. The space between the dura and pia mater is known as the subdural space.

Each nerve-root is provided with an envelope consisting of a process of the pia and dura.

Arteries that supply the cord consist of branches from the vertebral, intercostals, lumbar, and lateral sacral; all along the spinal column these vessels pass through the intervertebral foramina to supply the coverings and the cord.

Veins, in the form of plexuses, are found on the front and back of the cord, within the canal, between the two layers of the dura, or, better, between the dura proper and the periosteum.

OPERATIONS UPON THE ABDOMEN.

Laparotomy.—Incision into the abdomen. This operation is undertaken for the purpose of relieving some condition previously diagnosticated or of exploration in conditions of doubtful diagnosis. Abdominal incision is, in almost all instances, more or less exploratory, since it is rarely possible to be positive as to the exact nature of the conditions that exist within the abdomen. In most cases, however, an approximate diagnosis will have been made and the incision is placed, and the preliminary preparations made accordingly.

Preparation of the Patient.—The preparation of the patient is important. The evening before operation the patient, if the conditions permit, is given a warm tub-bath. He is then put to bed and his abdomen is shaved and scrubbed with a soft, flesh brush or a square of gauze, using tincture of green soap and water. This scrubbing process should be thorough, devoting special attention to folds in the skin and to the umbilicus, but it should not be too vigorous nor should it be done with a harsh brush. It is desirable that the skin be not scratched or abraded. After the scrubbing process has been completed the abdomen is wiped dry with gauze pads. The abdomen is then wiped successively with sterile gauze pads, first wet with ether, and then wet with alcohol. Finally the abdomen is swabbed with a gauze wipe wet with bichloride solution, 1 in 2000, and a towel wrung out in the same solution is applied to the abdomen and held in place with an abdominal bandage, and left thus until the patient is transferred to the operating table. After the patient has been placed upon the table and anæsthetized, the abdominal bandage and towel are removed and the abdomen is again scrubbed and washed with ether, alcohol, and bichloride solution. The stomach, bowels, and bladder should be empty at the time of operation. If conditions permit, the bowels should be emptied by the administration of laxatives given on one or on several evenings preceding the operation. A satisfactory plan is to give a dose of castor oil, half to one ounce, the evening before the operation. A soapsuds enema is given about three hours before the time set for the operation, and is repeated until the return is clear. The bladder is emptied either voluntarily or by catheter before the patient is carried to the operating room. The stomach will be empty if the patient has been fasting for ten or twelve hours previous to the time of operation. If the operation contemplates opening the stomach the teeth should be carefully brushed twice or three times daily, and an antiseptic mouth-wash used frequently for several days prior to the operation. In these stomach cases the patients should commence the systematic cleansing of the teeth and mouth several days before the operation, and during this period only fluid foods, and none but those that have been boiled and pure water are allowed. The stomach is washed out finally just before the patient is anæsthetized.

Occasionally in exceptional and emergency cases, as, for example, when operating for perforated gastric or intestinal ulcer; suspected acute gangrenous appendicitis, gun-shot wounds and rupture of the intestine, etc., it will be unwise or impossible to carry out some of the preparations described above. The operator will have to be content with shaving and thorough scrubbing and disinfection of the abdomen immediately before proceeding with the operation or the field of operation may be very satisfactorily prepared by thorough rubbing with benzin and painting with a 5 per cent. iodine. In these cases neither laxative nor enema should be given before the operation.

Incision.—The position of the incision varies according to the location of the organ that is to be exposed. It is placed most commonly in the middle line, above or below the umbilicus, but it may be more convenient to place it elsewhere if it is desired to reach certain of the abdominal organs, as, for example, the gall-bladder, appendix, etc. Where possible the abdomen should be opened without dividing any of the fleshy fibers of muscles, using the blunt method of penetrating the muscle, splitting between the fibers with the handle of the knife or with the fingers, so that nerve branches that ramify in the substance of the muscle will be pushed upward or downward out of the way and not cut. It is important to avoid division of the nerves that supply the abdominal muscles. In those cases where the incision is purely exploratory, it is placed in or near the middle line, either above or below the umbilicus. In the beginning the incision should not be any longer than is required to permit the introduction of the fingers and the necessary intra-abdominal examination. The incision can be extended subsequently as may be indicated, and to a sufficient degree to permit of the necessary operative work. In very fat patients the incision in the skin and fat layers is made longer, so as to give better access to the deeper layers of the abdominal wall.

Median Incision.—The incision in the middle line is carried through the skin and fat down to the aponeurosis, linea alba, with one or two sweeps of the knife. Arterial and venous branches, which are severed, are clamped, but need not be ligatured at once. Usually the hemorrhage from these small branches will have ceased when the clamps are removed later on in the course of the operation, and it will not be necessary to tie them. The aponeurotic layer, linea alba, is divided with the knife or sharp-pointed angular scissors cutting between the edges of the recti. Below the umbilicus, where the edges of the recti lie close together, the edges of the muscles are usually exposed and recognized. Above the umbilicus the edges of the recti are more widely separated, and we may cut through the linea alba between the muscles without exposing their edges.

After the aponeurosis, linea alba, has been divided, the fascia transversalis is exposed to view. When this layer is incised we enter the loose connective tissue and fat layer, the so-called pre-peritoneal fat layer. This layer is scraped or torn through with the finger or handle of the knife, or snipped with the knife, and the peritoneal layer proper is exposed. The peritoneal layer is picked up with two mouse-tooth forceps and incised between these. Care is exercised, in picking up the peritoneal layer, not to include the underlying gut in the grip of the forceps. Even if the gut is not adherent it often floats up so close to the peritoneum that there is danger of catching it up with the forceps and dividing it. At times, especially in thin patients, the pre-peritoneal fat layer is very thin or almost absent, and the fascia transversalis and peritoneal layer may, under these circumstances, be divided as a single layer. The edges of the small opening which has been made in the peritoneum are seized with artery clamps, one on each side, and the finger is introduced and the incision enlarged, cutting upon the finger as a guide with the blunt-pointed scissors. If the incision is below the umbilicus, it is well to incise the peritoneal layer in the upper part of the incision, so as to avoid the bladder in case it may have been drawn up into the abdomen by a tumor which rises out of the pelvis above the level of the symphysis. If it becomes necessary to prolong the incision in the middle line, upward or downward, beyond the umbilicus, this is done by carrying it to the left of the umbilicus rather than to the right, in order to avoid the round ligament of the liver and its falciform fold of peritoneum.

LATERAL VERTICAL INCISIONS are preferred to those that pass through the middle line, linea alba. They are made parallel with the linea alba, above or below the level of the umbilicus. These incisions are sometimes made quite close to the middle line, exposing the inner edge of the rectus muscle. The edge of the muscle is drawn outward away from the middle line to permit of the incision being made through the posterior layer of the rectus sheath, fascia transversalis, and peritoneum. This incision is preferred by many surgeons and has several distinct advantages, chief among which is the fact that the rectus muscle is not injured nor is its nerve supply interfered with, and the linea alba is not cut through. When the incision is closed the several aponeurotic layers can be sutured separately, and the edge of the muscle returns into place and forms a strong buttress against subsequent hernia.

Incisions are frequently employed which run parallel with, but more or less distant from, the middle line, penetrating between the fleshy fibers of the rectus muscle. In the lower part of the abdomen this incision is employed in order to reach the appendix, uterus and appendages, colon, sigmoid flexure, etc., and affords very satisfactory access to these organs. After the fascia transversalis has been divided the deep epigastric artery and vein are exposed in the bottom of the incision, and must be avoided or ligated. In the upper part of the abdomen the incision through the middle or through the outer part of the rectus, is employed to expose the gall-bladder, liver, pylorus, spleen, etc. In penetrating between the fibers of the rectus, it is desirable to tear bluntly up and down with the handle of the knife or with the fingers, so as not to divide any of the nerve branches that supply the portion of the muscle that lies to the inner side of the incision. If the nerve branches are divided, the portion of the muscle to the inner side of the incision is likely to atrophy, and thus the development of a ventral hernia is invited.

THE OBLIQUE INCISION BELOW AND PARALLEL WITH THE FREE BORDER OF THE RIBS is used by some operators for the purpose of exposing the gall-bladder, liver, and stomach. When this incision is employed in gastrostomy, it is carried down through the muscle layers, separating bluntly between the fibers of the internal oblique and the transversalis, gridiron incision.

THE GRIDIRON INCISION OF MCBURNEY is employed whenever possible in operations upon the appendix, and may be used upon the left side for colostomy. In this incision the aponeurosis and muscle layers are not cut; they are separated bluntly between the fibers along the course of their direction with the fingers or with the handle of the knife. (See page 477.)

THE BATTLE INCISION is vertical and placed in the lower part of the abdomen, to the inner side of the linea semilunaris. It is employed to expose the appendix, and sometimes the tubes and ovaries. After the anterior layer of the rectus sheath has been incised the rectus muscle is exposed. The rectus is not cut through, but is drawn over toward the middle line, so as to expose the posterior layer of the sheath of the muscle. The posterior layer of the rectus sheath is incised along a line external to that of the incision in the anterior layer of the sheath. In closing this incision the several layers are sutured separately, and the uninjured muscle returns to its original place and forms a strong bulwark between the lines of incision in the anterior and posterior layers of its sheath. The deep epigastric vessels are seen crossing the incision, after the posterior layer of the rectus sheath and transversalis fascia have been incised. The vessels may be clamped and ligated before they are cut, or they may be pulled over to one side and not divided.

TRANSVERSE INCISION of the abdominal wall, entailing cross-division of the muscles, should be avoided whenever possible. This incision reaches from near the tip of the twelfth rib forward, around the side of the abdomen toward the umbilicus. It is employed for removal of large tumors of the kidney and spleen, and for gaining access to the pancreas.

KÜSTNER AND PFANNENSTIEL INCISION may be occasionally employed with advantage, where much room is not required, for gynæcological operations, suspension of uterus, operations upon ovaries, etc. It is not practical where large tumors are to be removed. The incision passes across the lower part of the abdomen, reaching from the outer edge of one rectus to the outer edge of the other. The incision is slightly curved, with the convexity downward, just above the symphysis. The incision penetrates the skin and fat, and exposes the aponeurosis covering the rectus muscles. The aponeurosis is divided in a transverse direction, and detached upward and downward from the surface of the recti. Penetrating between the edges of the rectus muscles through the linea alba, the fascia transversalis and peritoneum are incised in the usual way, and the abdomen entered. The incision is closed layer by layer. First the edges of the peritoneum and transversalis fascia are united with a continuous suture of plain catgut, then the edges of the recti are approximated with several interrupted sutures of plain catgut. The edges of the aponeurosis are united with a continuous suture of chromic catgut, and finally the skin. The scar is not conspicuous, and is partly hidden by the hair growth above the pubes. The chief advantage of the incision is the absence of a prominent abdominal cicatrix.

Examination of Abdominal Organs, Etc.—After the abdomen has been opened, the fingers, or the hand, are introduced for the purpose of exploration. It is necessary to be systematic in examination and gentle in manipulation. Care must be exercised in separating adhesions. Much unnecessary hemorrhage, and maybe tearing of hollow organs, may result from violence in this regard. In very young children it is easy to tear the gut away from its delicate mesentery.

The organ, which is the object of operation, is drawn into the incision or out upon the abdomen if possible. Access to the various abdominal organs is assisted very materially by position. The pelvic organs, by Trendelenburg; the gall-bladder, ducts, etc., by the use of the Robson cushion under the lower dorsal region and by raising the head end of the table, etc. Gauze pads of large size are tucked into the incision and about the organ which is to be operated upon to protect the peritoneal cavity against the entrance of blood and various discharges. These abdominal pads should be provided with tapes and artery clamps attached and carefully accounted for. Smaller pads employed as intra-abdominal wipes should not be used loose; they are less likely to be overlooked and left in the abdomen if used on holders. Gauze wipes and laparotomy pads, artery clamps and parts of broken artery clamps, have been left in the peritoneal cavity. Operations that involve resection of bowel, etc., should be done, as far as possible, with the parts outside upon the abdomen, and after the operation has been completed, and before returning the sutured organs into the abdominal cavity, they should be thoroughly cleansed by swabbing them with a gauze wipe wet with very hot saline solution.

Before proceeding to closure of the incision, the operator should assure himself that all hemorrhage has ceased or has been controlled, and that the abdominal cavity has been wiped dry of blood and other fluids.

Closure of the Incision.—It is desirable to obtain primary union—union which is firm and secure from the danger of subsequent hernia. The incision should be dry and free from oozing before proceeding to close. There are several methods of closure.

Through-and-Through Suture.—The incision is closed by a number of interrupted sutures of heavy silk or silk-worm gut. These sutures pierce all the layers of the abdominal wall. This method of closure has many disadvantages, and should not be used except in cases where great haste in completing the operation is indicated. Where this plan is employed the edges of the corresponding layers are not brought into sufficiently accurate apposition, and even when primary union results there is more likelihood of a subsequent yielding of the cicatrix and consequent ventral hernia. There is frequently failure to obtain primary union. The sutures penetrate the skin and are therefore more apt to become infected. Each suture in its course pierces all of the layers of the abdominal wall, including the peritoneum, and thus presents a loop upon the inner surface of the peritoneum, within the abdominal cavity. If the sutures become infected the process readily extends along the course of the sutures into the abdominal cavity.

Many of the disadvantages of the through-and-through suture may be obviated by first suturing the peritoneum and the fascia transversalis with a separate continuous suture of plain catgut, and then introducing the interrupted mass-sutures of silk, silk-worm gut, etc., which penetrate the skin, aponeurosis, and muscle layers only. By this method closure may be effected quickly and without the disadvantages of the through-and-through suture. As a result of the separate suture of the peritoneum and fascia transversalis, there is obtained an accurate, smooth union of the peritoneal layer. The mass-sutures that secure the skin, aponeurosis, and muscle may be applied so as to oppose the edges of the corresponding layers fairly accurately, and they have not the great fault of penetrating the peritoneal layer and presenting inside within the peritoneal cavity.

Layer-by-Layer Suture.—The most satisfactory method of closing the abdominal incision is layer by layer. The edges of the peritoneum are sewed together with a continuous suture of plain catgut. The edges of the fascia transversalis (and posterior layer of the sheath of the rectus in some parts of the abdomen) are included with the peritoneum in this suture on account of the strength which is added by this strong layer. The edges of the muscle are brought together with several interrupted sutures of plain catgut, and finally the edges of the aponeurosis are united with a continuous suture of chromic catgut. Some surgeons advise overlapping the edges of the aponeurosis, one over the other. The edges of the skin are sutured with plain catgut. It is desirable to use the intra-cuticular suture for approximating the edges of the skin. The stitches do not pierce the skin, and therefore there is much less likelihood of infection, stitch abscesses, etc., and greater probability of primary union. With this suture the resulting scar is very much diminished.

Drainage.—Where it is necessary to employ drainage, the incision must be left open in part. Even in these cases the through-and-through method of suture should be avoided. The several layers can be sutured separately, as described in the layer-by-layer method, leaving the lower end of the incision where the drains emerge unsutured or the edges of the peritoneum and fascia transversalis may be first sewed together as a single layer with a continuous suture of plain catgut, and the other layers, skin, aponeurosis, and muscle then approximated with a sufficient number of interrupted sutures of silk or silk-worm gut. These sutures include all the layers of the abdominal wall, except the peritoneum and fascia transversalis (and posterior layer of the sheath of the rectus in certain parts of the abdominal wall).

If it is necessary to leave the incision partly open for the purpose of drainage, the probability of subsequent yielding of the cicatrix and development of hernia is greatly increased. The employment of drainage should be limited as much as possible. Drainage is frequently employed unnecessarily. The peritoneum will itself take care and dispose of a limited amount of infectious matter. Drains, when used, should not be unnecessarily bulky, and should be made to emerge at the lower end of the incision. The rest of the incision can be carefully sutured. The drains should be removed as early as possible. They will, as a rule, have served their purpose at the end of forty-eight hours, when they can be removed and replaced, if necessary, by a narrow strip of gauze.

OPERATIONS FOR UMBILICAL AND VENTRAL HERNIA, ETC.

Umbilical Hernia.—By umbilical hernia is meant a protrusion of the abdominal contents through the umbilical ring. The umbilical ring is an aperture which is present in the fœtus. Through it the fœtal channels (vitelline duct and pedicle of the allantois) and the umbilical arteries and vein pass to and from the placenta. At birth, under normal conditions, the abdominal walls will have grown together tightly around the root of the umbilical cord, and the fœtal umbilical ring is thus reduced to a size which is just sufficient to accommodate the structures that comprise the umbilical cord. If the cord is examined at birth it will be observed that the skin is continued from the abdomen upward around the root of the cord for a short distance to become continuous with the amniotic layer which forms the outer envelope or sheath of the cord. Where the skin joins the amniotic layer upon the root of the cord, there is a well marked, irregular line of demarcation.

The subject of umbilical hernia is considered in detail under three headings, as follows:—

1. Congenital Umbilical Hernia.
2. Infantile Hernia.
3. Umbilical Hernia in Adults.

Congenital Umbilical Hernia.—Hernia funiculi umbilicalis; hernia into the root of the umbilical cord. This is a congenital hernia in the strict sense. It has its origin during the fœtal period, and it is present at birth.

The condition is rare—seen once in three or four thousand births. It is due to non-closure of the fœtal umbilical ring. The plates that are destined to become the abdominal wall, fail to close in tightly around the root of the umbilical cord, and thus an aperture is left (patent umbilical ring) which allows the abdominal organs to escape and find their way into the root of the umbilical cord.

These herniæ vary from the size of a nut to that of a fœtal head. They may contain but a single coil of intestine or a diverticulum from the ileum (Meckel's diverticulum), or they may contain the entire length of the intestinal canal and the liver, spleen, and heart. In the extreme cases the condition amounts practically to complete eventration. This variety of hernia is frequently associated with other congenital malformations, as extrophy of the bladder, spina bifida, etc.

The abdominal contents which have escaped through the patent umbilical ring are found in the root of the umbilical cord, which is dilated to accommodate them. The smaller herniæ may be overlooked at birth, and a loop of intestine contained within the root of the cord may be included in the ligature which is applied around the cord, and an umbilical intestinal fistula results.

The intestine can be seen through the thin transparent layers that form the coverings of the hernia. The coverings are, externally, that portion of the amnion which forms the envelope or sheath of the umbilical cord, and which is continuous around the base of the hernia with the skin that covers the abdomen; internally, lining the interior of the hernia and forming the sac proper of the hernia, is the peritoneum. Between these two thin layers are found the umbilical vessels and a certain amount of Wharton's jelly. An umbilical cord with a funnel-shaped root, and with a broad base corresponding to its attachment at the navel, should excite suspicion that a congenital hernia exists. The children with large herniæ usually die; the smaller herniæ may oftentimes be remedied by timely surgical operation.

Operation for the cure of congenital hernia should be undertaken soon after birth. An incision is made through the skin close to the root of the umbilical cord and exposing the sac of the hernia-peritoneum. The umbilical vessels are ligated and cut short. The sac is incised and the contents reduced. The sac is ligated and resected, and the edges of the ring approximated with several sutures of fine kangaroo tendon. The edges of the skin are united with several sutures of catgut.

Infantile Hernia.—The umbilical hernia of young children. This variety of hernia is of frequent occurrence. It is acquired after birth, and should not be confounded with congenital hernia.

After birth the stump of the umbilical cord cicatrizes, and the umbilical ring gradually contracts, becoming smaller and smaller. After the lapse of several months the ring has become completely obliterated, being filled in with a plug of dense connective tissue, and surrounds and grips the remains of the umbilical vessels very closely. The sooner after birth an infantile hernia makes its appearance, the larger the ring will be and the weaker the cicatrix; hence the larger the hernia is apt to be.

This variety of hernia is more frequently seen in male than female children, and among the poorly nourished. It is caused by the straining, crying, coughing that accompany gastro-enteritis, bronchitis, phimosis, etc., during the first weeks and months after birth, and before the umbilical ring has had time to become obliterated to a degree sufficient to offer adequate resistance.

The opening corresponds to the umbilical ring, is usually small, oval, and transverse in direction, or it may be round. The coverings consist of the skin, a layer of connective tissue representing the stretched out umbilical cicatrix, and, internally, lining the protrusion, the peritoneum which forms the sac proper of the hernia.

These herniæ rarely become strangulated, and in growing children have a natural tendency to spontaneous cure. Operation is rarely, if ever, indicated. It suffices to relieve the cause: bronchitis, phimosis, etc., and to apply a belly-band with a flat pad which is larger than the umbilical opening, so that it covers the opening and extends well beyond its margin.

Umbilical Hernia in Adults.—This condition is more frequently seen in women, and especially those who have borne many children, than in men, and more in stout people and those with pendulous bellies. These herniæ vary in size; some are very large, large as a child's head or larger. As a rule they are partly or completely irreducible. The contents, which consist of intestine (commonly the transverse colon) and great omentum, are frequently adherent to the interior of the sac, and thus render the hernia partially or completely irreducible. At times portions of the intestine or processes of fat from the intestine or omentum work their way through the sac and become intimately united with the subcutaneous fat layer. At operation under these conditions the contents may be encountered directly underneath the skin. The contents escape from the abdominal cavity through the umbilical ring which, in some cases, is considerably enlarged. The coverings of this variety of hernia consist of the skin, which may be very thin and presenting the umbilicus oftentimes flattened out and nearly obliterated; the subcutaneous fat layer; a thin fibrous layer corresponding to the stretched-out, attenuated umbilical cicatrix, and the peritoneum which lines the interior of the hernia and forms the sac proper. The subcutaneous fat layer varies much in thickness; sometimes it is very thick or it may be very thin, especially over the summit of the hernia; maybe so thin that the sac of the hernia is encountered almost directly under the skin. The sac may be perforated by the intestine and by processes of fat that grow from the intestine and omentum. These structures, after penetrating the sac, become fused with the fat in the subcutaneous layer, and may be intimately adherent to the skin. At times, especially in large herniæ and in the neighborhood of the navel, the coverings of the hernia, skin, and fatty layers, are so thin that an incision made over this part of the hernia would come down abruptly upon, and maybe injure, the contents (gut); hence an elliptical incision corresponding to the base of the hernia is used, rather than one over the summit of the hernia, for the purpose of exposing the sac.

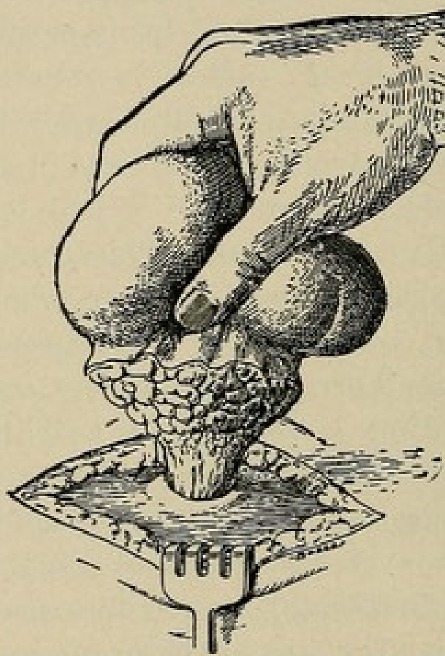

Fig. 156.—Umbilical Hernia. The entire hernia mass has been dissected free around its base exposing the aponeurosis of the external oblique and the edge of the umbilical ring. Pedicle of the mass corresponds to the neck of the sac as it emerges through ring.

Mayo's Operation.—An elliptical incision with the long diameter transversely, is made into the fatty layer, some distance from and surrounding the umbilicus. This incision corresponds to the base of the hernia mass. The neck of the sac is sought and reognized, and the abdominal aponeurotic layer, for a distance of two or three inches beyond the neck of the sac, is dissected clean and plainly exposed to view. The sharp, well-defined aponeurotic edge of the opening through which the hernia protrudes, may be distinctly made out with the finger.

The sac of the hernia is incised in a circular manner around the neck, thus exposing the contents. Intestine that is present and adherent within the sac is carefully separated and returned into the abdomen. Omentum is ligated and divided, the ligated stump being allowed to slip back into the abdomen. The sac, which has already been divided by the incision around its neck, and the omentum, which has been resected and which is usually adherent to the sac, may be thus removed in one mass. The finger is introduced through the mouth of the sac and swept all around to make certain that there are no adhesions to the margin of the ring.

An incision is made through the aponeurotic and peritoneal layers of the ring extending for a distance of one inch or less, transversely, on each side. The peritoneal layer is detached with

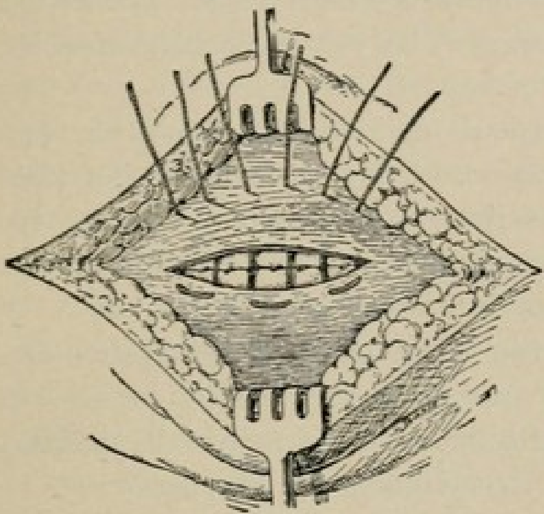

Fig. 157.—Umbilical Hernia. The edges of the peritoneum corresponding to the stump of the sac have been sutured. Three mattress sutures have been introduced through the upper and lower aponeurotic flaps.

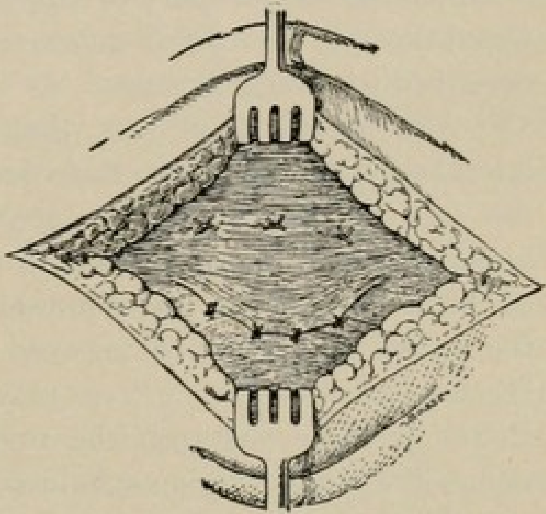

Fig. 158.—Umbilical Hernia. Mattress sutures have been tied. The upper aponeurotic flap overlaps the lower. The edge of the upper flap is secured to the lower with several additional sutures.

the finger from the under surface of the upper of the two aponeurotic flaps, which are thus made. Three or four mattress sutures of heavy silk or of kangaroo tendon are introduced in the aponeurotic flaps in such a manner that, when drawn tight and tied, they cause the upper flap to overlap the lower one. These sutures pierce the upper flap two to two and one-half inches away from its margin, but secure the lower flap fairly close to its margin; the sutures are left untied temporarily. The edges of the peritoneum are united with a continuous suture of plain catgut. After the edges of the peritoneum have been united, the mattress sutures are drawn tight and tied, with the result that they draw the entire lower aponeurotic flap upward, under the upper aponeurotic flap, into the space previously made to receive it between the peritoneum and the upper aponeurotic flap. The free edge of the upper overlapping flap is secured with several additional sutures of chromic catgut to the surface of the aponeurosis which lies beneath it.

The incision in the skin is closed in the usual manner.

Ventral Hernia.—By ventral hernia is meant a protrusion of the abdominal contents through some opening in the abdominal wall other than the natural orifices, umbilical, inguinal, femoral rings, etc., or a protrusion or bulging of the abdominal contents due to yielding of a cicatrix or of a portion of the abdominal wall which has been weakened by degeneration of the muscle or by loss of resistance on the part of the aponeurosis (linea alba), permitting separation of the rectus muscles, etc. The ventral herniæ may be described in several groups.

Abdominal Herniæ.—Sometimes divided into anterior and lateral—depending upon their location. They present in the middle line, through openings in the linea alba, above or below the umbilicus, or through transverse openings (foramina for the transit of blood-vessels) in the tendinous intersections of the sheath of the rectus, or, laterally, between the outer edge of the rectus and the oblique muscles, or they may appear in the lumbar region—in Petit's triangle—between the twelfth rib and the crista ilei. Herniæ in the lumbar region should not be mistaken for cold abscess.

These herniæ often reach considerable size, and may have a fairly large orifice. They may become irreducible or strangulated, and may call for surgical interference. They are treated along the same general lines as described in the operation for umbilical hernia: exposure and incision of the sac and reduction of the contents. The sac is ligated and resected, and the orifice closed by overlapping the edges of the aponeurosis, usually in a transverse direction, and securing them thus with several sutures of kangaroo tendon. Closure of skin incision.

Epigastric Hernia.—Occasionally we meet with small hernia, usually not larger than a hazel nut, that protrude through little, well-defined, transverse openings in the tendinous intersections—lineæ transversæ—in the upper part of the recti or in the linea alba above the umbilicus. These herniæ really form a group by themselves, and are characterized by their small size and location, and the peculiar gastric and intestinal symptoms with which they are associated. They appear in the upper part of the abdomen—in the epigastric region.

These herniæ are caused by the penetration of little processes of fat which grow from the subperitoneal layer forward through little foramina (for the transit of blood-vessels) in the linea alba, or in the tendinous intersections of the sheath of the rectus. As they grow they draw a little process or pouch of the peritoneum after them, and this forms the hernia sac. These herniæ are too small to contain gut. They usually contain a process of fat which may be attached to the omentum, colon or stomach. They may be irreducible, owing to the fact that the mouth of the sac is too narrow or because the contents of the hernia have become adherent within the sac. In this way we may account for the gastric and intestinal pain, and symptoms of digestive disturbance which are so frequently associated with this condition. Treatment of these herniæ consists of incision and opening into the sac, and reduction of contents. The little sac is ligated and cut away, and the edges of the orifice approximated in a transverse direction, or, better, overlapped and secured with several sutures of kangaroo tendon.

Diastase of the Recti.—Another not uncommon variety of so-called ventral hernia is that seen in women who have borne children, and in individuals who have suffered from ascites or who have had large intra-abdominal tumors. There is a bulging in the middle line due to stretching or weakening and yielding of the linea alba, and a separation of the edges of the recti. The line of separation may reach from the ensiform cartilage all the way down to the symphysis, or may involve only the lower part of the linea alba from the umbilicus downward.

When the patient makes the effort to raise herself from the recumbent to the upright position through the contraction of the recti, the edges of the cleft between the muscles can be distinctly felt. When the patient stands or strains there is a bulging corresponding to the site of the hernia.

The coverings of this variety of hernia are the peritoneum and transversalis fascia, an aponeurotic layer corresponding to the stretched-out linea alba and the skin. The passage from the abdominal cavity into the hernia is a wide, open space, and there is no danger of the hernia becoming strangulated.

Fortunately in most cases after parturition, relief from ascites, etc., the walls of the abdomen are sufficiently lax to permit of the edges of the recti being approximated and held in close apposition with sutures. In this manner these herniæ are cured.

An incision is made in the middle line and the skin and fat dissected outward, on either side, away from the middle line, until the aponeurosis is clearly exposed. The inner edge of either rectus muscle is exposed by incising the aponeurosis along the edge of each muscle. The layers that stretch across the space between the recti are the attenuated fibrous layer that corresponds to the stretched linea alba, the transversalis fascia, and the peritoneum. It is not necessary to incise these layers; they may be infolded into the abdomen as the edges of the recti are approximated. The umbilicus is excised, the opening which results being closed with several catgut sutures. The edges of the recti are brought together in the middle line with a number of mattress sutures of kangaroo tendon. The edges of the aponeurosis, corresponding to the anterior sheath of the rectus, are overlapped, one over the other, across the middle line, and secured thus with a sufficient number of mattress sutures of kangaroo tendon placed fairly close together. The edge of the overlapping aponeurotic layer is sutured to the surface of the overlapped layer with a continuous suture of chromic catgut in order to fix it still more securely. Finally the edges of the skin, which is more than abundant, are trimmed away and sutured together.

Post-operative Ventral Hernia.—A common variety of ventral hernia is that which follows incision in the abdominal wall, wounds, etc. Hernia is less likely to follow careful suturing, and where healing by first intention results. The condition is due to failure of the edges of the aponeurosis to unite securely, and to weakening and yielding of the cicatrix and to degeneration of the muscle. In those cases where the healing process has been accompanied by intra-peritoneal suppuration and drainage has been necessary, we find the intestine and omentum adherent to the interior of the sac (peritoneum) along the line of the cicatrix.

This variety of hernia is seen in the middle line and laterally; in the usual sites of incision for operations on the uterus, tubes, etc.; for gall-stones, appendicitis, colostomy.

These herniæ are sometimes very large. The contents bulge into the hernia through a large, roomy passage corresponding to the location in the fascia, muscle, and aponeurosis, where the parts have failed to unite. There is but slight danger of strangulation. The coverings consist of the skin, which presents the cicatrix; maybe or maybe not the transversalis fascia, and the peritoneum which lines the interior of the protrusion and forms the sac of the hernia. The contents, intestine, omentum, etc., are usually adherent to the sac (peritoneum) along the line of the cicatrix.

An elliptical incision which surrounds the cicatrix is made, the long axis of the ellipse corresponding to the line of the cicatrix. The incision penetrates the skin down into the fat layer. Search is made around the base of the hernia for the aponeurosis, which should be exposed all around for an inch or more. The edges of the aponeurosis are recognized and dissected clean. Underneath the aponeurosis the edges of the muscle are sought for and exposed. The peritoneal layer is incised, and the abdominal cavity is entered. Care must be exercised when the peritoneum is incised and the abdomen entered not to injure adherent gut and omentum. Omentum, which is adherent to the (sac) peritoneum, is ligated and divided. Adherent gut is carefully detached from the peritoneum surface along the line of the cicatrix. If the gut is accidentally torn the opening must be closed with a Lembert suture. After the omentum has been separated or ligated and divided, and adherent gut separated and returned to the abdomen, we proceed to close the abdominal incision. The edges of the peritoneum, and including the transversalis fascia in order to secure a better hold, are sutured together with a continuous catgut stitch. The edges of the muscle are next approximated with several chromic catgut sutures. The edges of the aponeurosis should be overlapped, if possible, and joined securely with a sufficient number of sutures of kangaroo tendon in a manner similar to that employed for the cure of diastase of the recti, as described above. The edges of the skin are brought together in the usual manner.

THE STOMACH.

The Surgical Anatomy of the Stomach.—The stomach is a pear-shaped, pouched portion of the alimentary canal with a capacity of from three to four pints. It is suspended obliquely in the upper part of the abdomen, upon the left side, extending from the œsophagus to the duodenum. Its walls are thick, and consist of a serous, a muscular, a submucous and a mucous membrane coat.

The larger end of the stomach, the cardiac, is above and toward the left side; the smaller end, the pyloric, is below and toward the right side.

The œsophageal opening is called the cardiac, and the opening into the duodenum, the pyloric orifice. The dilated left end of the stomach—*i.e.*, that part to the left of the œsophageal opening—is called the fundus; the middle part, the body; and the right, rather constricted portion, the pylorus.

The stomach presents an upper or right border, the lesser curvature, and a lower or left border, the greater curvature. The lesser curvature is about four inches long, and continuous with the line of the œsophagus, almost perpendicular, straight up and down. The greater curvature is about three times as long as the lesser curvature. The stomach has an anterior wall which is directed forward and upward, and a posterior wall which is directed backward and downward.

The adult stomach, moderately distended, measures in its longest diameter from ten to twelve inches; from the greater to the lesser curvature, four to five inches; and from the anterior to the posterior wall about three and one-half inches. When the stomach is empty the first and second diameters are diminished and the third disappears, as the walls come into contact with each other. In this condition the mucosa is thrown into numerous folds and rugæ.

The opening between the pylorus and the duodenum is indicated by a well-marked thickening of the wall of the stomach. It is made up of circular muscular fibers, which act as a sphincter and which serve to shut off the cavity of the stomach from that of the duodenum.

The stomach is situated in the left hypochondriac and the epigastric regions; about five-sixths part of the organ lies to the left of the middle line, the pyloric end lying to the right of the middle line. The cardiac orifice is located one inch below the diaphragm, to the left of the body of the eleventh dorsal vertebra, and at a depth of 11 cm. from the front wall of the abdomen, on a line directly behind the articulation of the seventh left costal cartilage with the sternum. The pyloric orifice lies to the right and a little below the ensiform cartilage and nearer the anterior wall of the abdomen. The direction of a line drawn from the cardiac orifice to the pyloric orifice would be downward and to the right. The fundus of the stomach reaches upward as high as the level of the fifth costal cartilage, and is separated from the base of the left lung by the diaphragm.

The anterior surface of the stomach, toward the left, is in relation with the seventh, eighth, and ninth ribs, the diaphragm being interposed; the pyloric end and upper part of the anterior surface of the stomach are covered by the left lobe of the liver.

Corresponding to the lower border of the stomach, along its great curvature and attached to it by the so-called gastro-colic ligament, is the transverse colon.

A triangular area of the anterior wall of the stomach—near the left free border of the ribs—is in direct relation with the anterior abdominal wall, and is here accessible for operation. The base of this triangular space is indicated upon the surface of the abdomen by a transverse line, which corresponds to the transverse colon and greater curvature of the stomach, and which is drawn through the tip of the tenth rib (costal cartilage) of either side. The other lines of the triangle are, upon the left, the free border of the ribs, and, upon the right side, a line corresponding to the anterior thin edge of the left lobe of the liver, which is drawn from the tip of the tenth right costal cartilage to the tip of the eighth left costal cartilage.

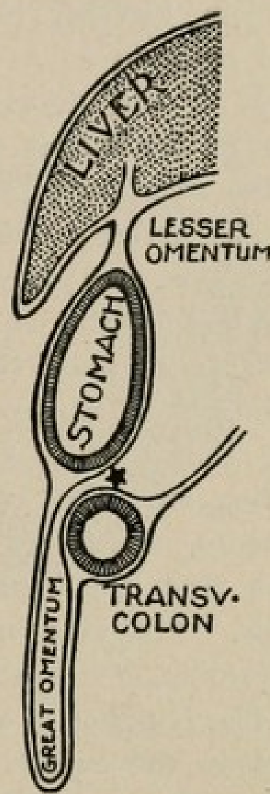

Fig. 159.—Sagittal Section to Show the Arrangement of the Great and Lesser Omenta, etc. *, indicates situation where the layers of the great omentum become fused to that portion of the peritoneum which invests the transverse colon, thus joining the latter to the lower border of the stomach.

Behind the stomach lie the pancreas, with the splenic vessels passing along its upper border, the commencement of the jejunum, the upper part of the left kidney and suprarenal capsule, and, toward the left, the spleen.

Behind the pyloric end of the stomach are the duodenum, portal vein and common bile-duct, head of the pancreas and first lumbar vertebra, crura of the diaphragm, aorta with the cœliac axis, solar sympathetic plexus, thoracic duct, vena cava inferior, etc.

The spleen lies to the left of the stomach and rather behind it. The gall-bladder is in relation with the pyloric end of the stomach.

The stomach is entirely enveloped by the peritoneum, which forms its serous coat; above, extending between the transverse fissure of the liver and the lesser curvature of the stomach, the two layers of the peritoneum join to form the lesser omentum, gastro-hepatic ligament, between the layers of which, toward its right edge, the hepatic artery, portal vein, and common bile-duct are located.

Below, at the greater curvature, the two layers of peritoneum, after enveloping the stomach, again join to form the great omentum through which the transverse colon is attached to the greater curvature of the stomach. That portion of the great omentum which joins the stomach to the transverse colon is called the gastro-colic ligament. Toward the left, the two layers of peritoneum which cover the anterior and posterior surfaces of the stomach also join together to form the gastro-splenic omentum, but they again separate so as to invest the spleen and connect it with the fundus of the stomach. Between the layers of the gastro-splenic omentum the arteria epiploica sinistra, a large branch of the splenic, and the vasa brevia pass to the fundus of the stomach.

The arteries which supply the stomach are derived from the cœliac axis, and consist of large branches which course along the lesser and greater curvatures; these vessels give off large branches, which ramify upon the anterior and posterior walls of the stomach, coursing from the periphery toward the middle of each surface; along the lesser curvature, the pyloric artery, a branch of the hepatic, and the gastric artery anastomose; along the greater curvature, anastomosing with each other, are the gastro-epiploica dextra from the hepatic and the gastro-epiploica sinistra from the splenic. The vasa brevia, from the splenic, ramify upon the left end, fundus, of the stomach.

The lymphatics of the stomach form a plexus of dilated lymph-spaces in the submucous layer. From these spaces the lymphatic vessels run toward the upper and lower borders and toward the left end of the stomach, where they terminate in a number of lymphatic nodes that are located between the layers of the lesser and greater omenta and the gastro-splenic omentum.

According to the direction taken by the lymphatics that drain it, the stomach may be divided into three areas: the region adjoining the lesser curvature, the region adjoining the greater curvature, and that corresponding to the fundus.

First.—The lymphatic vessels that drain that portion of the stomach adjacent to the lesser curvature terminate in a chain of nodes that are situated between the folds of the lesser omentum, along the course of the gastric artery, reaching from the pylorus upward and toward the left as far as the point where the gastric artery strikes the stomach. Here they leave the stomach and may

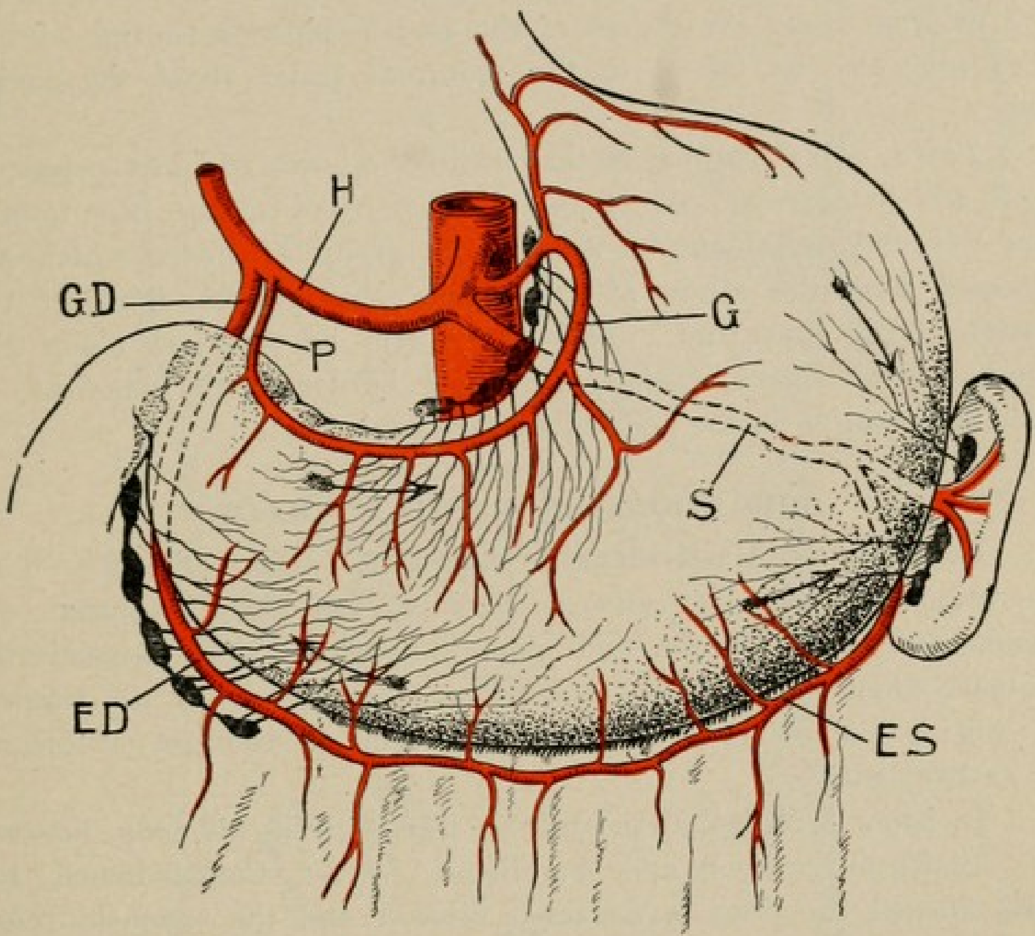

Fig. 160.—Stomach, showing Arteries that Supply it, its Lymphatics and Adjacent Lymph Nodes. Corresponding to the lesser curvature, the lymphatics run in a direction away from the pylorus to terminate in the nodes along this border of the stomach. Corresponding to the greater curvature, they run toward the pylorus to communicate with the nodes below and behind the pyloric end of the stomach. The lymphatics of the fundus terminate in the nodes at the hilum of the spleen. *ED*, epiploica dextra; *ES* epiploica sinistra; *G*, gastric; *GD*, gastro-duodenalis; *H*, hepatic; *P*, pyloric; *S*, splenic. Arrows indicate direction of the lymph current.

then be traced backward behind the pancreas to the nodes that are found adjacent to the cœliac axis.

Second.—The lymphatics that drain the lower part of the body of the stomach, parts adjacent to the greater curvature, run from the left downward and toward the right, to terminate in a chain of nodes spread along the greater curvature, and below and behind the pylorus, along the course of the gastro-epiploica dextra, whence they may also be traced to the group of nodes about the cœliac axis.

Third.—The lymphatics that drain the lower end of the œsophagus and the cardiac end of the stomach, fundus, etc., pass toward the left and terminate in the splenic group of nodes which are situated near the hilum of the spleen, between the folds of the gastro-splenic omentum. These may also be followed along the course of the splenic vessels, the upper border of the pancreas, to their termination in the nodes about the cœliac axis.

OPERATIONS UPON THE STOMACH.

Plication of Gastro-hepatic Ligaments, etc. (Beyea).—This operation consists practically in "reefing" the lesser omentum, the ligaments—gastro-hepatic and gastro-phrenic—which suspend the stomach from the liver and diaphragm. It is done for the purpose of raising the stomach up into its normal position in conditions of gastroptosis.

Incision is placed in the middle line, four inches long, between the ensiform process and umbilicus. After the abdomen has been opened the liver is retracted upward and the stomach drawn downward. In this way the gastro-hepatic ligaments (the fold of peritoneum that attaches the stomach to the liver) and the gastro-phrenic ligament (a portion of the same fold that attaches the cardiac end of the stomach to the diaphragm) are exposed to view and put upon the stretch and their increased length can be readily appreciated. Three rows of interrupted silk sutures are placed in the ligaments.

Those of the first row are placed about one inch or less apart and each takes a bite of from one-half to one inch, the bites being made progressively smaller as the cardiac end of the stomach is approached. The ends of all the sutures of this first row are seized and held with an artery forceps. The sutures of the second row are then introduced and take bites beyond those of the first, and those of the third row beyond those of second (Fig. 162). Finally

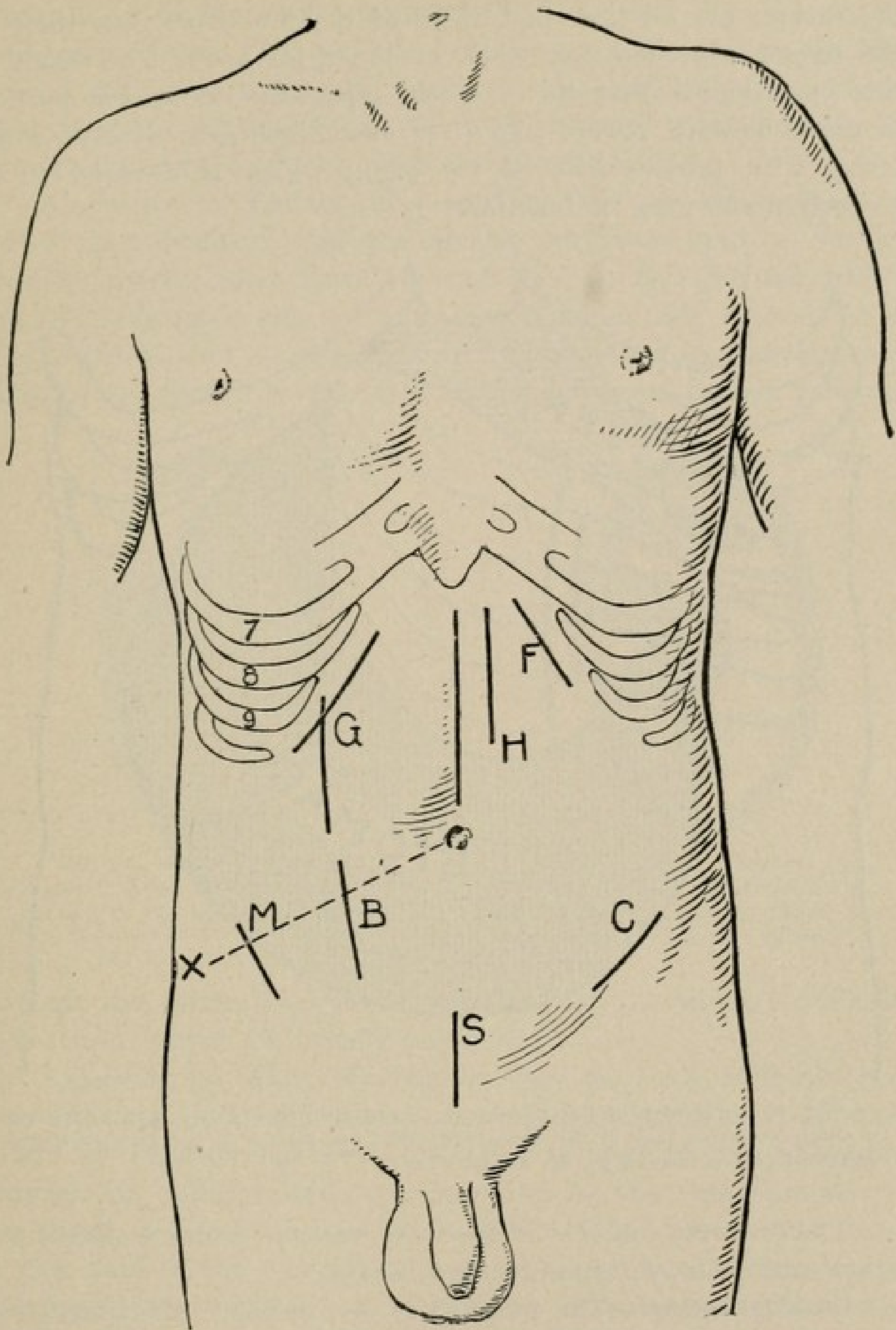

Fig. 161.—Various Abdominal Incisions. *B*, mid-rectus incision; *C*, incision for left inguinal colostomy; *F*, Fenger incision for stomach; *G*, vertical and oblique incisions for gall-bladder, etc.; *H*, von Hacker's incision for gastrostomy; *M*, McBurney incision for appendicectomy; *S*, incision for suprapubic cystotomy. In middle line above umbilicus is linea alba incision for operations upon stomach. × indicates location of anterior superior iliac spine. Dotted line drawn from spine to the umbilicus.

the sutures are all tied, first those of the first row, then those of the second row, and last those of the third row. The result of this operation is that the stomach, especially its pyloric portion, is raised upward toward the liver and diaphragm without interfering with the mobility of the organ which is essential to its properly performing its functions.

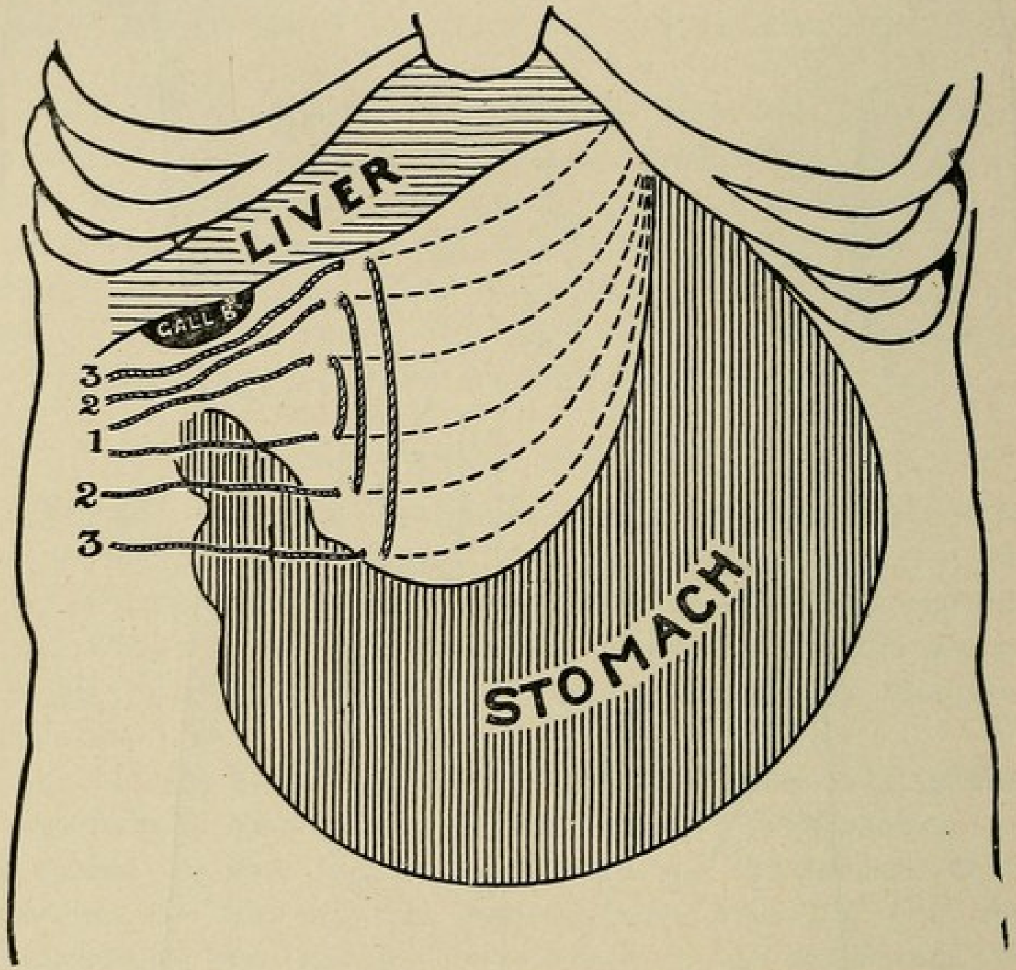

Fig. 162.—Plication of Gastro-hepatic Ligament (*Beyea*). 1, 2, and 3 indicate a single stitch of each of the three rows that are placed in the gastro-hepatic ligament as represented by the dotted lines.

The sutures are of the mattress variety, and are introduced with a small, curved, round-pointed needle.

Gastroplication.—The folding in, or "reefing," of a portion of the wall of the stomach in order to diminish the size of the organ. This operation was first performed by Bircher, and is applicable to cases of dilatation without stenosis of the pyloric orifice.

The abdominal incision, five to six inches in length, may be placed a finger's breadth distant from and parallel with the left free border of the ribs, commencing above near the tip of the ensiform process, or it may be located in the linea alba, reaching from a point one inch below the tip of the ensiform process downward as far as the umbilicus. Through either of these incisions the stomach may be brought out upon the abdominal wall.

According to Bircher, the anterior wall of the stomach is folded upon itself so that the greater curvature may be brought up close to the lesser curvature and fixed in this position with a row of interrupted silk sutures; these should take a good, broad bite in the wall of the stomach, including its serous and muscular coats. Care should be exercised that the sutures do not penetrate

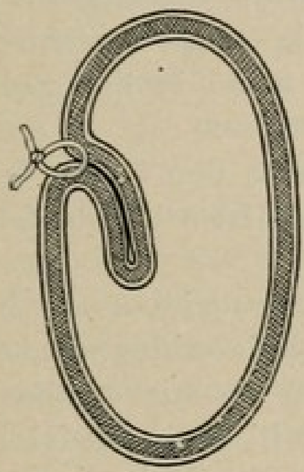

Fig. 163.—Cross Section of the Stomach After Gastroplication according to the Method of Bircher.

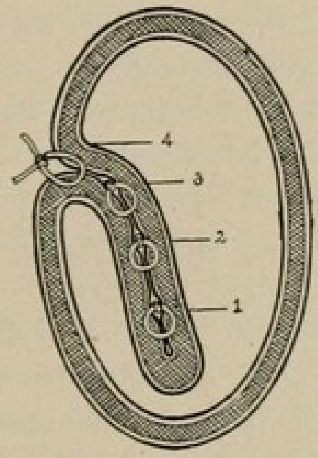

Fig. 164.—Cross Section of Stomach After Gastroplication; the Turned-Up Portion Fixed by Four Rows of Sutures. (*Weir.*)

through the entire thickness of the wall of the stomach. Twelve to fourteen sutures are usually required.

According to Weir, the fixation may be made with three or four separate tiers of sutures, one superimposed upon the other. After the stomach has been brought out through the abdominal incision, its anterior wall, corresponding to the long diameter of the organ, is inverted, and the edges of the furrow thus made in the wall of the stomach united with a row of continuous or interrupted silk sutures. A second row of sutures is then introduced parallel with and about one inch distant from the first. A third and finally a fourth row may be introduced, the last row joining the greater curvature to the upper part of the anterior wall of the stomach near the lesser curvature. In this way six or eight inches of the stomach wall may be reefed in and the organ materially reduced in size. No doubt the folding of the stomach wall is made more secure when several rows of sutures are used.

Infolding of the Wall of the Stomach for Ulcer.—This plan was suggested by Mitchell and answers well, provided the ulcerated area is limited and accessible, especially if the anterior wall is the portion involved. The stomach is exposed through an incision in the middle line commencing near the tip of the ensiform process and carried downward toward the umbilicus. The ulcerated portion of the stomach wall is infolded or inverted into the lumen of the organ and fixed thus with two rows of non-penetrating, Lembert sutures of silk. If the posterior wall of the stomach is the portion affected the operator may attempt to gain access to this part of the organ through an opening which is made in the gastro-colic ligament, or, better, in the transverse mesocolon.

The beneficial result of the operation is due to the fact that the diseased portion is placed at rest—free from peristalsis, etc.—and it gradually atrophies.

It might be advisable to perform a gastro-jejunostomy in addition because in some of these cases the pyloric orifice will be found to be more or less stenosed. Even if no stenosis of the pyloric orifice is present the gastro-jejunostomy will be beneficial in that it permits easy and quick evacuation of the stomach.

Gastrotomy.—This operation consists in making an incision into the stomach for the purpose of extracting a foreign body lodged in the stomach or impacted low down in the œsophagus; for exploration of the interior of the stomach, ulcer, hemorrhage, etc., and to treat strictures in the lower part of the œsophagus.

Immediately preceding any operation upon the stomach the organ should be emptied and irrigated, if the conditions permit, with the stomach tube. This is best done just before the patient is anæsthetized. It is desirable that the stomach be empty when it is opened during the course of the operation.

The incision may be made in the middle line through the linea alba, three to five inches long, commencing above about one inch below the ensiform process, and extending downward toward the umbilicus; or an incision may be made just to the left of the linea alba, passing through the inner margin of the left rectus muscle; or the Fenger incision, parallel with the free border of the left ribs, may be employed. This last incision (Fenger) is probably the best if the ultimate object is to reach the œsophagus (see Fig. 161).

Having carried the incision down to the parietal layer of the peritoneum, this is picked up with two toothed forceps and a small incision made between them with the knife; through this incision the finger is introduced, and upon the finger, with a blunt-pointed scissors, the opening in the peritoneum is enlarged so as to correspond in length with the incision in the abdominal wall. Two fingers are then introduced into the abdomen and the stomach searched for. If there is a foreign body in the stomach, this may oftentimes be felt and serves as a guide to the stomach. The thin anterior edge of the left lobe of the liver may be always readily recognized, and this is a good guide to the stomach, as the stomach lies directly underneath this organ, being partly covered by it; that part of the anterior surface of the stomach which is not covered by the liver is accessible for operation; it is seized with two fingers and drawn out of the abdominal incision. If the stomach is diminished in size there may be some difficulty in drawing it out through the incision upon the abdomen.

One should not mistake the transverse colon for the stomach. The transverse colon lies below and close to the greater curvature, being connected with the greater curvature by the great omentum (gastro-colic ligament); the great omentum is suspended free, apron-like, from the transverse colon, and when this part of the intestine is drawn out upon the abdomen the great omentum is drawn out with it; the colon can be further identified by its sacculation, by the litle fatty appendices attached to it, and by the striæ which run along its length. The wall of the stomach is smooth, and the blood-vessels ramifying upon its surface have a characteristic course, converging from the periphery toward the center; the gastro-epiploica dextra and sinistra run along the greater curvature from either end of the stomach, anastomosing with each other.

The stomach may be examined by inspection and palpation before it is opened. The posterior wall of the stomach may be palpated through an opening torn in the gastro-colic ligament. If the stomach has not been previously emptied, stricture of the œsophagus, etc., the attempt should now be made by the operator to express the contents onward into the duodenum before it is opened.

A portion of the stomach wall is drawn out through the abdominal incision and after gauze pads have been properly arranged to protect the peritoneal cavity the stomach is incised. When the incision is made care should be taken to prevent any stomach contents from entering or soiling the peritoneal cavity. If there is any fluid present in the stomach when it is opened this should be swabbed out or removed with a siphon. The stomach is best incised in its long diameter and the incision may vary from one to three inches. Bleeding vessels may be secured with artery forceps. Venous hemorrhage stops after the artery forceps have been applied for a short time, but spurting arterial branches should be clamped and tied with fine catgut.

After the removal of the foreign body or examination of the interior of the stomach or treatment of ulcer, etc., the opening in the stomach may be closed.

The closure of the incision in the stomach is best effected with a continuous Lembert suture of fine silk, which is applied with a fine, curved, surgeon's needle. This suture includes the serous and muscular coats and takes a good bite, each loop being drawn fairly tight. This line of suture may be reinforced by a second similar row of Lembert sutures which bury the first row.

The incision in the abdomen is closed first by a continuous catgut stitch which approximates the edges of the parietal peritoneum and transversalis fascia, and then a sufficient number of interrupted silkworm-gut sutures—each including the skin, aponeurosis, and muscle—are introduced or the incision may be closed layer by layer.

For Bleeding Ulcer.—Operation is indicated in this condition when medical treatment, rest, etc., fail to control it or if the hemorrhage recurs and is profuse. Owing to the risk of increasing the hemorrhage the stomach should not be washed out before operating. Loss of body heat must be prevented as much as possible during the operation. When the stomach is exposed it should be emptied by expressing the contents onward into the duodenum. Before opening the stomach its surface should be carefully examined by inspection and palpation in an effort to locate the ulcer; a puckering of the surface, thickening of the wall, or difference in color may indicate its site. If unable to obtain a clue to the location of the ulcer by these means, then the stomach must be incised and its inner surface systematically explored, first the anterior wall and then the posterior, and finally the cardiac and pyloric ends. This examination may be made with the naked eye, bringing different areas of the stomach wall into the incision, one after the other,

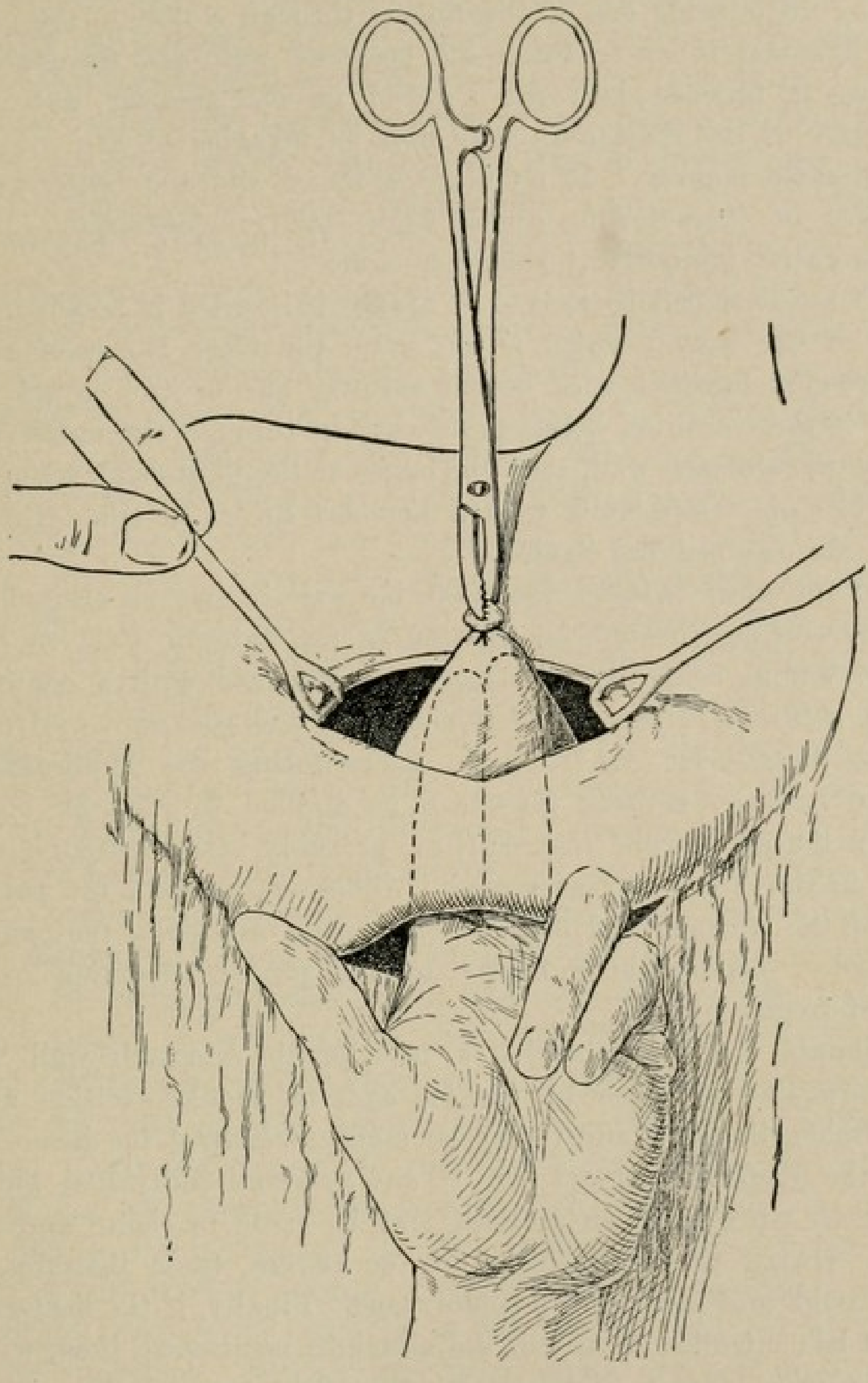

Fig. 165.—Posterior Wall of Stomach Pushed out through Incision in Anterior Wall by Fingers Passed into Space behind Stomach through Opening in Gastrocolic Ligament. Clamp applied to bleeding point.

or assisted by the introduction of a speculum and the use of a reflector. The posterior wall of the stomach may be brought into view by introducing one or two fingers through a rent in the gastro-colic ligament so as to reach the posterior wall and invaginate it, pushing it forward into the incision in the anterior wall. The first part of the duodenum may also be invaginated and examined in the same manner. If no ulcer is found and the hemorrhage is capillary in character or comes from small, indiscoverable ulcers, then a gastro-jejunostomy should be done.

If an ulcer can be located it should be excised if possible. The edges of the wound which is left after the ulcer has been excised are brought together with catgut sutures, one or two layers being used; if the condition necessitated cutting through the entire thickness of the stomach wall, then the edges of the peritoneal, serous coat must be united separately with a Lembert suture of silk. Bleeding points are clamped and ligated.

If the ulcer involves the posterior wall it may be excised from within, working through an incision in the anterior wall, the edges of the wound being brought together afterward with a continuous catgut suture. If the entire thickness of the posterior wall of the stomach has been cut through, necessitating the application of outside Lembert sutures, these can be applied through an opening torn in the gastro-colic ligament, or, probably better, through a rent made in the transverse mesocolon. Adhesions between the posterior wall of the stomach and neighboring organs, especially the pancreas, may add considerable difficulty to the proper execution of this plan of treatment.

Should the ulcer involve a part of the stomach wall which is inaccessible for excision, cardiac end, or should excision appear inadvisable, then the effort may be made to control the hemorrhage with the Paquelin cautery, or, if one or more individual bleeding points are discovered, an attempt may be made to clamp and ligate them. Owing to the friability of the tissues, these ligatures may cut through and increase the hemorrhage. Finally, if the hemorrhage cannot be controlled by any of the measures mentioned, then, without further delay, a gastro-jejunostomy should be performed.

If the ulcer involves the pylorus, a pyloroplasty according to the method of Finney may be done, excising the diseased area at the same time, or a typical pylorectomy may be performed if time and the patient's condition permit; or instead of either of these radical measures and without further regard as to the exact source of the bleeding or condition of the pylorus, a gastro-jejunostomy may be performed. Time is an important consideration in operations for the control of hemorrhage, and the patient's condition may preclude prolonged or complicated operative procedures.

For Treatment of Stricture of the Œsophagus.—An abdominal incision parallel with the left free border of ribs, according to Fenger, is the most satisfactory. After the stomach has been incised, as described in the preceding paragraphs, the finger is introduced through the opening in the stomach and into the œsophageal orifice; at times it is necessary to make a little steady pressure with the finger before this opening yields so as to allow the finger to enter. Conical rubber bougies of increasing calibre are then introduced, one after another, into the œsophagus and up beyond the site of the stricture. If the stricture is dense and unyielding, the operator may, according to the method of Abbe, pass a thin bougie, carrying a strand of braided silk, up into the œsophagus, through and beyond the stricture, so that the end carrying the silk cord may be felt in the pharynx. The silk cord is seized either in the back of the pharynx, through the mouth, or else through an incision which is made for that purpose in the side of the neck and upper part of the œsophagus; the bougie is then withdrawn, leaving the silk thread behind it in the œsophagus. A conical bougie is now again introduced into the œsophagus from below through the opening in the stomach; this bougie should be large enough to become tightly engaged in the stricture; the ends of the silk string are then seized and it is drawn back and forth several times; it will then be observed that the bougie can be passed farther and farther into the stricture; bougies of increasing calibre are used in this manner until the stricture is sufficiently relieved. The incision of the stricture which is made by the friction of the silk string is accomplished with but little hemorrhage. The bougie and string are finally withdrawn and a rubber tube which is permitted to remain is passed into the œsophagus, its end projecting through the opening in the stomach and out of the abdominal incision. Besides this tube which reaches up into the œsophagus, a second one may be introduced into the stomach and left there for the purpose of feeding.

In the abdominal incision the edges of the parietal peritoneum are fixed to the corresponding margins of the skin with several catgut sutures and the edges of the opening in the stomach then united to the edges of the abdominal incision with a sufficient number of interrupted silk sutures, the ends of the sutures being left long in order to facilitate their removal later. The abdominal incision, except for that portion to which the stomach has been sutured, should be closed with interrupted silkworm-gut sutures.

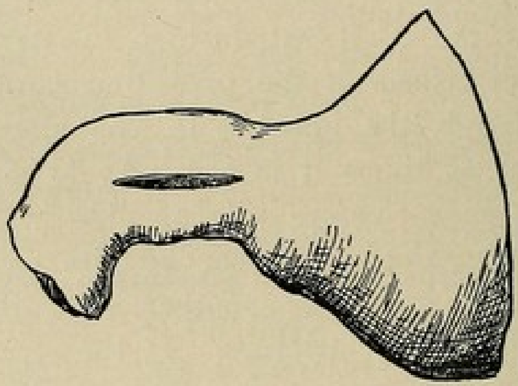

Fig. 166.—Pyloroplasty. Horizontal incision into the pylorus.

This is practically a gastrostomy, and through the opening in the stomach the effort to relieve the stricture of the œsophagus may be repeated if necessary after an interval of several days. The gastric fistula that remains closes spontaneously or may be closed by a secondary plastic operation.

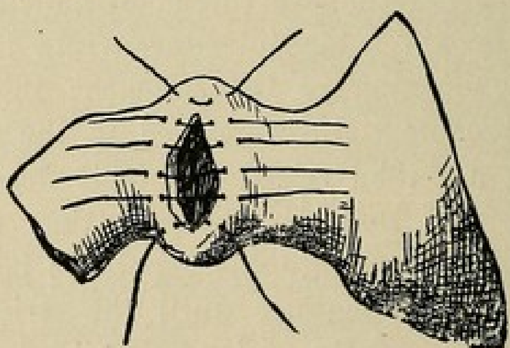

Fig. 167.—Pyloroplasty. Horizontal converted into a vertical incision and sutures placed.

Pyloroplasty.—For the relief of cicatricial stricture of the pylorus causing obstruction to the emptying of the stomach.

Heinecke-Mikulicz Method.—The results obtained from this operation are not entirely satisfactory. In many cases the symptoms of pyloric obstruction return after a brief period of relief. The operation should not be performed in cases where a condition of active ulceration exists. Under such conditions a pylorectomy is the preferable operation.

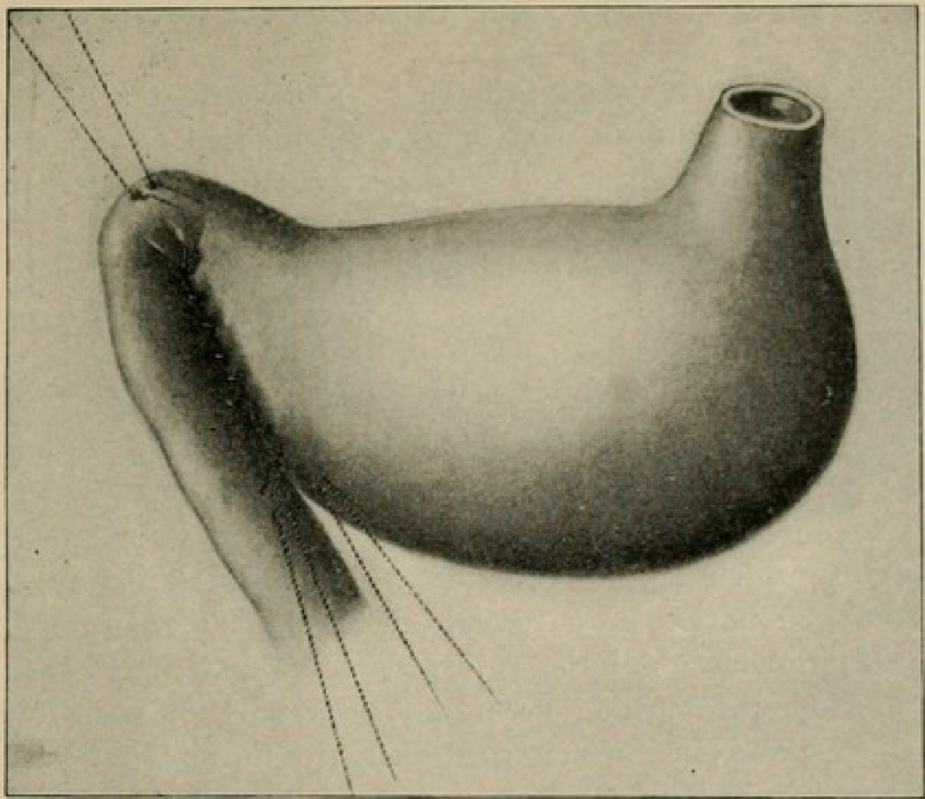

Fig. 168.—Pyloroplasty (*Finney*). Tractor stitches have been placed and the posterior line of suture joining duodenum to stomach has been inserted.

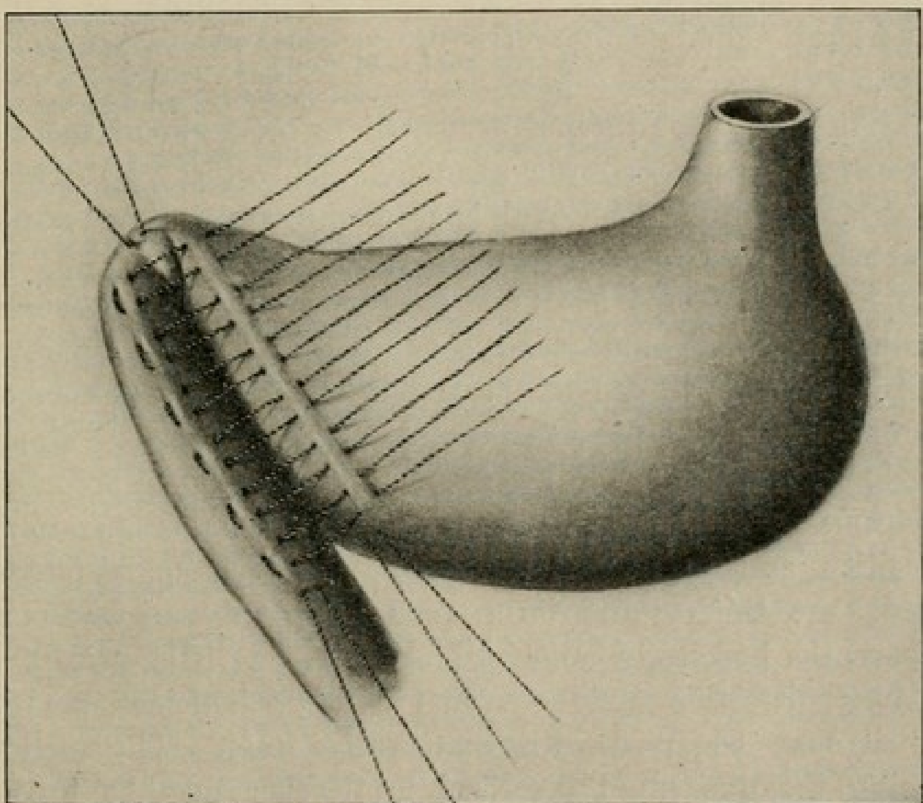

Fig. 169.—Pyloroplasty (*Finney*). The anterior row of mattress sutures has been introduced, but not tied.

The stomach is exposed through an incision in the middle line and its pyloric end drawn out through the incision. Pads are then properly placed to protect the peritoneal cavity during the rest of the operation.

The pylorus is incised in its long axis, a clean cut being made through all its coats; this incision should be liberal, from 4 to 6 cm. long, reaching crosswise from the stomach through the pylorus into the duodenum. The edges of the incision are drawn widely apart by tenacula hooked in the middle of each edge, and in this way the transverse incision becomes converted into a vertical one. In this position, the opening is closed by a row of interrupted Lembert sutures which take a good, deep, and broad bite, these being reinforced and buried by a second row of Lembert sutures, which may be continuous. All the sutures are of silk. Care should be taken to close the opening accurately, especially in the middle of each edge,—the points which correspond to the extremities of the original incision. The result is a marked widening of the pyloric orifice. The incision in the abdomen is closed according to any of the usual methods.

Finney Method.—The result of this operation is a gastro-duodenostomy. For benign stricture of the pylorus, for chronic ulcer, etc.

The incision, longitudinal, is placed to the right of the median line, penetrating between the fibers of the rectus. It commences near the ensiform cartilage and is carried downward for a distance of from six to eight inches.

After the abdomen has been opened the pylorus is sought for and adhesions that bind it to the adjacent organs separated or divided. The pyloric end of the stomach and the first part of the duodenum should be freed as completely as possible. Upon the thoroughness with which this step of the operation is accomplished will depend in a large measure the success of the operation and the facility and rapidity with which the subsequent steps are executed. At times the pylorus and duodenum will be found to be apparently hopelessly adherent, but after a little patient effort with blunt dissection and occasional careful, judicious use of the scalpel it may be freed with comparative ease. The method of mobilizing the duodenum described by Kocher may be used with excellent effect. See mobilization of the duodenum, "Gastro-duodenostomy," page 438.

After the duodenum and pylorus have been mobilized, a silk

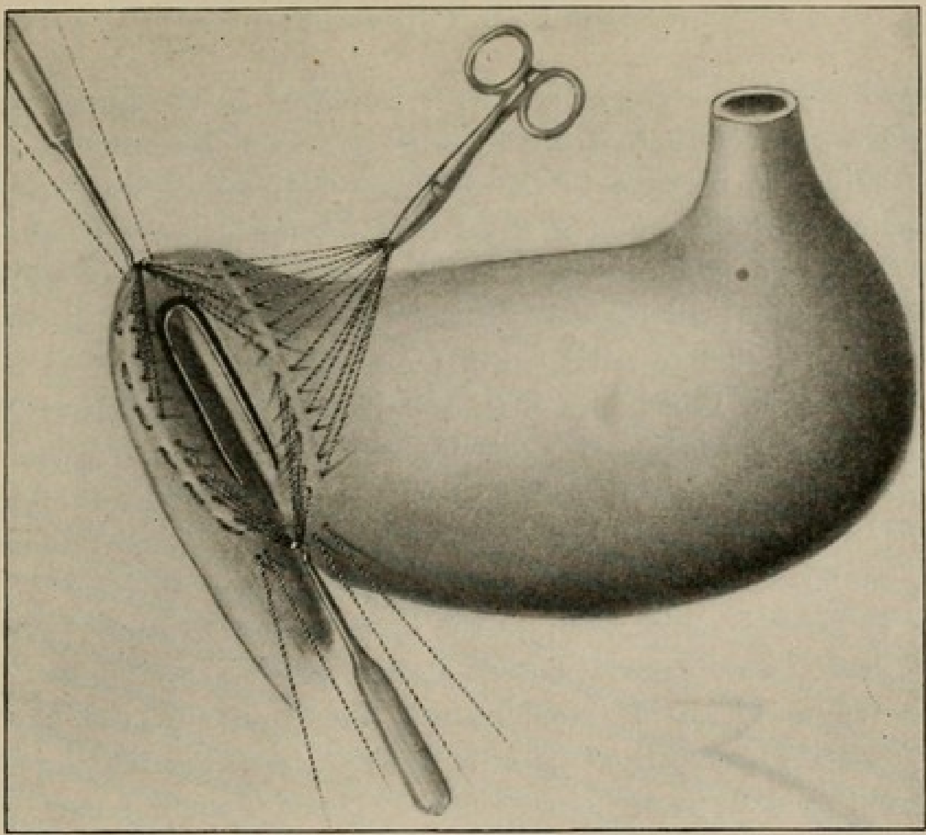

Fig. 170.—Pyloroplasty (*Finney*). Anterior mattress sutures retracted upward and downward and horseshoe-shaped incision made, one arm cutting into duodenum and the other into stomach.

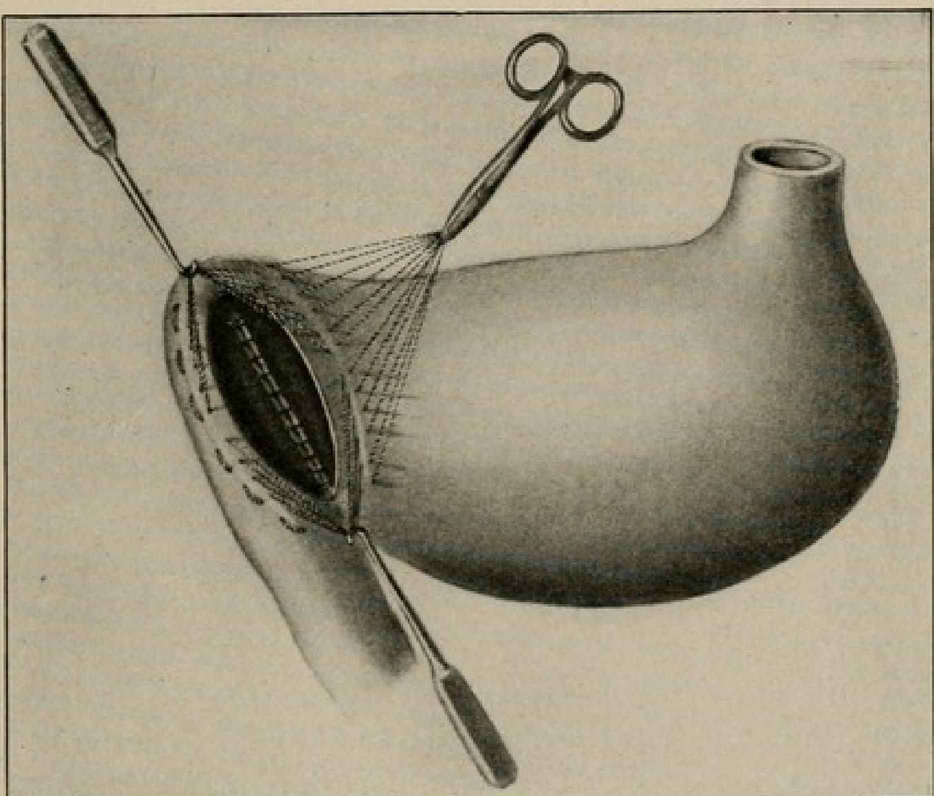

Fig. 171.—Pyloroplasty (*Finney*). Posterior raw edges of incisions in duodenum and stomach have been united with a continuous suture. It remains now, to complete the operation, to release the anterior mattress sutures, draw them tight, and tie.

suture which is to serve as a tractor is placed in the upper part of the pylorus, and with this the pylorus is drawn upward. A second tractor suture is inserted in the anterior wall of the stomach, near the greater curvature, and a third in the anterior wall of the duodenum. The second and third tractors should be placed at points equidistant—about 12 cm.—from the tractor that has been applied to the pylorus. These sutures are temporary and should be of silk and take a good, broad bite in the walls of the organs, but should not penetrate through their entire thickness. The second and third serve to indicate the lower ends of the incisions that are to be made in the stomach and duodenum respectively, and should be placed as low as possible in order that the new pyloric opening may be sufficiently large. While the upper, pyloric, tractor is drawn upward, the lower, gastric and duodenal, tractors are pulled downward so as to make the stomach and duodenal surfaces taut and bring them into apposition in order to facilitate the placing of the line of suture that is to join them together. The first part of the duodenum and the corresponding part of the stomach, along its greater curvature, are united from above downward as far as the lower, gastric and duodenal, tractors with a continuous non-penetrating Lembert suture of silk. After this row of sutures has been applied, a second row of sutures, mattress variety, is introduced along a line anterior to the first row of sutures. Ample space should be left between the first, posterior, row of sutures and this second, anterior, row of mattress sutures in order to permit of making the incisions in the stomach and duodenum between them. The anterior mattress sutures should take a good bite in the serous and muscular coats of the stomach and duodenum, but they should not penetrate the entire thickness of the walls of the organs.

The anterior row of mattress sutures are not tied but are left long and loose, their ends caught with artery forceps and their loops drawn upward and downward with blunt hooks. While the mattress sutures are thus held out of the way the incision into the stomach and duodenum is made. The incision is horseshoe-shaped. The gastric arm of the incision is made in the stomach wall commencing just above the lowest point of the line of suture; it is carried up to and through the pylorus and around into the attached portion of the duodenum to a point opposite where it commenced in the stomach. Hemorrhage from the edges of the incisions in the stomach and duodenum is then controlled; for this purpose clamps may be applied temporarily; but, as a rule, it is unnecessary to employ any ligatures because the bleeding usually ceases when the edges of the incisions are sutured together. It is desirable to resect as much as possible of the cicatricial tissue present upon either side of the incision in order to limit subsequent contraction. The redundant edges of the mucous membrane may be trimmed away so as to make the opening of the new pylorus as large and free as possible.

The contiguous edges of the horseshoe opening for the posterior part of their extent are united to each other with a continuous, through-and-through suture of catgut. The anterior row of mattress sutures are then drawn tight and tied and the operation is thus complete. Several additional Lembert sutures of silk may be placed in front of the line of mattress sutures, burying them, so as to secure the parts still more firmly; this is, however, probably unnecessary.

The incision in the abdomen is closed either layer by layer or else with a sufficient number of interrupted sutures of silk that penetrate all the layers of the abdomen, special care being taken to include the peritoneum in each stitch.

With Clamps.—According to the method of Gould, the Finney operation may be done in a manner analogous to that described in "Gastro-jejunostomy, Clamp Method." A fold of the wall of the stomach and a fold of the wall of the duodenum are secured with the holding forceps, the blades sheathed with rubber tubing. The folds grasped with the forceps are about four inches in length. The blades of the forceps are placed side by side, and the folds of stomach and duodenum united with a non-penetrating continuous suture of silk in a manner similar to that described in gastro-jejunostomy. The needle still carrying the thread is then laid aside until needed later to complete the operation. The folds of stomach and duodenum are incised and the corresponding edges of the openings joined to each other with a continuous, through-and-through suture of chromic catgut. The clamps are removed and the needle carrying the silk thread with which the stomach and duodenum were originally joined is again taken in hand and the operation completed by applying the anterior half of the non-penetrating stitch which joins the stomach and duodenum together.

Gastrostomy.—The formation of a permanent gastric fistula for the purpose of feeding in cases of simple or malignant stricture of the œsophagus. The fistula should permit the introduction of nutriment and at the same time prevent the escape of stomach contents.

Method of Ssabanajew and Franck.—A very satisfactory operation. The incision is placed parallel with the left free border of the ribs and should be not more than two inches long, commencing above to the side of ensiform process. The upper end of the incision is opposite the tip of the cartilage of the eighth rib. The incision is continued down through the muscles and parietal peritoneum. The margins of the peritoneum and fascia transversalis are fixed to the edges of the muscles in the abdominal incision with one or two catgut stitches on either side, near the middle. The anterior wall of the stomach, near the fundus, is seized with two fingers, and drawn out of the wound in a cone-shaped process one and one-half to two inches long and a silk sling suture passed through its apex to serve as a tractor. The base of this process of the stomach wall is fixed all around to the edges of the incision in the abdomen with a continuous chromic catgut suture. This suture includes the serous and muscular coats of the stomach and the edges of the parietal peritoneum and transversalis fascia and deep muscular layer in the abdominal incision. They do not pass through the skin nor should they pass through the entire thickness of the stomach wall. After this step of the operation has been completed a second short incision about three-fourths inch long is made through the integument, one and one-half inches above and parallel with the first incision and well above the free border of the ribs. The bridge of integument that intervenes between this and the first incision is raised bluntly with the handle of the knife and, using the silk sling as a tractor, the apex of the cone-shaped process of the stomach wall is drawn through into the second small incision, where it is fixed with four to six interrupted chromic catgut sutures. The edges of the skin corresponding to the first incision are approximated with several interrupted silkworm-gut sutures. The conical process of the stomach wall is thus buried underneath the bridge of tissue between the two incisions. After the apex of the cone-shaped process of the stomach has been sutured to the second small incision, it may be opened and a tube introduced for the purpose of feeding. A fistulous tract about two inches long which is bent around the free border of the ribs and leads into the stomach is the result.

Witzel's Method is a most satisfactory operation. An incision is made below and parallel with the free border of the ribs. The incision commences about one and one-half inches below the tip of the costal cartilage of the ninth rib and is carried obliquely downward and outward for a distance of two or three inches. The integument and aponeurosis are divided. The fleshy fibers of the internal oblique

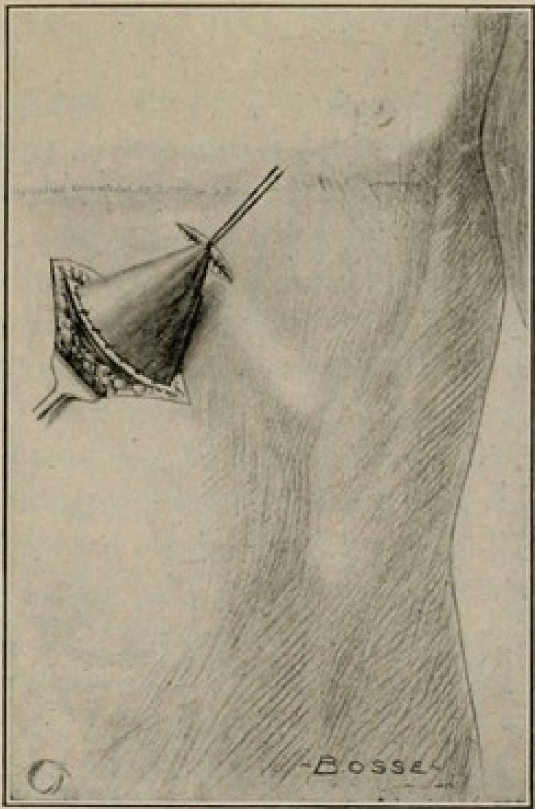

Fig. 172.—Gastrostomy (*Ssabanajew-Franck*). A cone-shaped process of the anterior wall of the stomach drawn out through the abdominal incision by a silk tractor passed through its apex; the base of the process is sutured all around to the edges of the parietal peritoneum and transversalis fascia, etc., in the abdominal incision.

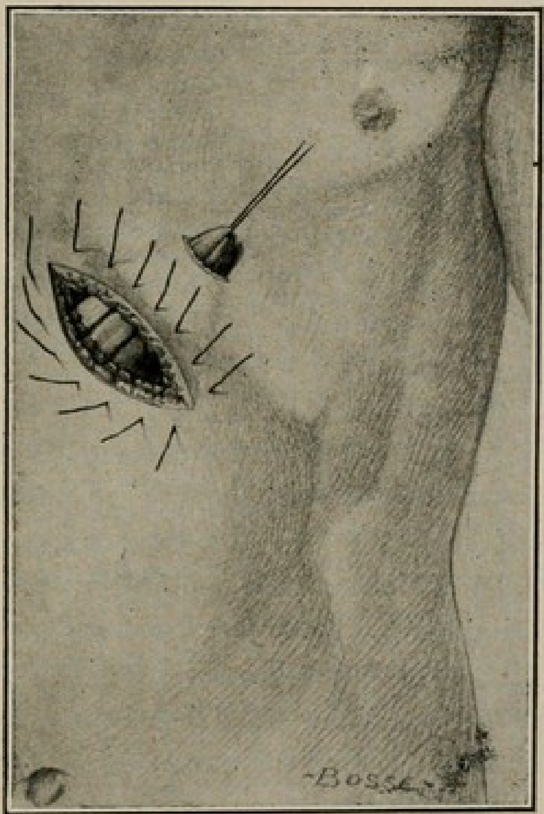

Fig. 173.—Gastrostomy (*Ssabanajew-Franck*). Apex of process of stomach drawn through the second incision ready for suture. Sutures have been introduced for the purpose of closing the first incision.

are exposed and the fibers separated bluntly with the handle of the knife; the fleshy fibers of the transversalis are exposed and split in the same manner in a transverse direction corresponding to their course. Thus no muscle fibers are cut. The edges of the incision are drawn apart with blunt retractors and the fascia transversalis and peritoneum incised. The peritoneal layer is picked up with two toothed forceps and carefully incised and the anterior wall of the stomach seized and drawn out through the incision.

A No. 25 F. soft-rubber catheter is placed upon the surface of the stomach so that it is directed obliquely downward and toward the

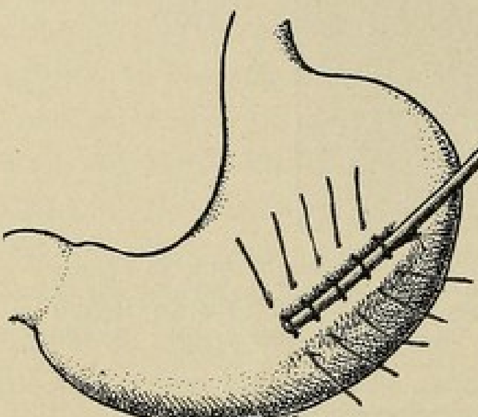

Fig. 174. — Gastrostomy (*Witzel*). Sutures that infold the tube in the wall of the stomach have been introduced. The end of the tube projects into the stomach through a small incision in the wall of the stomach.

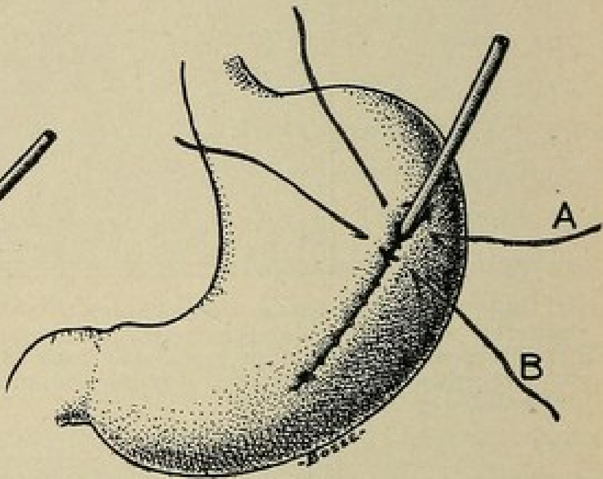

Fig. 175. — Gastrostomy (*Witzel*). The first row of sutures have been tied and the tube thus buried between the folds of the stomach wall which have been raised up about it. A second row of continuous sutures have been applied. Two suspension sutures, *A* and *B*, have been introduced, one above and the other below the point where the end of the tube emerges.

right, and in this position it is fixed with four or five interrupted chromic catgut sutures which pick up the wall of the stomach on either side of the catheter, each taking a good, broad bite, but not penetrating through the entire thickness of the wall of the stomach. In this way the stomach wall is raised in a fold, or plait, upon each side of the tube so that when the sutures are tied the two folds meet and completely bury the tube. Corresponding to the end of the catheter a very small opening is made in the stomach wall with the point of the knife, and through this the end of the catheter is pushed so that about three inches of its length is within the stomach. The opening in the stomach should be so small that the tube will be a tight fit. The end of the tube is secured near the edge of the incision in the stomach with a single fine chromic catgut stitch so that the tube cannot become displaced. The free end of the tube is closed with a ligature or forceps to prevent the escape of stomach contents. The four or five sutures which have been introduced across the tube into the stomach wall are tied and thus the tube is imbedded between the two folds of the stomach wall which form a canal about the tube. An additional line of suture is introduced to secure the accurate coaptation of the two folds of the stomach wall over the tube, and at the point where the end of the tube penetrates the stomach the sutures are extended a sufficient distance beyond to insure against leakage from the stomach around the tube. This line of suture is continuous, non-penetrating, of fine catgut. That part of the stomach wall which is immediately adjacent to the end of the catheter as it emerges from the canal formed by the folding of the wall of the stomach is secured with two non-penetrating sutures of chromic catgut. These sutures are used to fix the stomach to the edges of the parietal peritoneum and transversalis fascia in the abdominal incision. Each of these sutures takes several good, broad bites in the wall of the stomach, but should not pass through its entire thickness. One of the sutures is placed above the point where the tube emerges and the other below. They serve to suspend that part of the wall of the stomach which is immediately adjacent to the tube, to the parietal peritoneum.

The abdominal incision is closed except where the tube emerges. The edges of the peritoneum and transversalis fascia are sewed together with several sutures of plain catgut. These are introduced before the suspension sutures are tied. The edges of the split muscles return into close approximation. The edges of the aponeurosis are united with a chromic catgut suture and finally the skin with several sutures of silk-worm gut.

Kader Method.—An excellent procedure. The incision is made about one inch below and parallel with the left free border of the ribs, about three inches long, the upper end of the incision opposite the tip of the eighth costal cartilage. Instead of cutting the muscular layers, the operator may penetrate bluntly, separating between their fibers. The transversalis fascia and parietal peritoneum are incised in an oblique direction, along the same line as the integument. Some operators prefer the vertical incision, made over the middle of the left rectus, commencing above about one inch below the free border of the costal cartilage, carried downward for about three inches.

A portion of the anterior wall of the stomach is seized with the fingers and brought out through the abdominal incision. Pads are placed to protect the parts and a very small opening is made in this part of the stomach with the knife. A soft-rubber catheter about as big around as a lead-pencil is introduced through this incision, into the stomach for about two inches and fixed to the edge of the incision with a single catgut suture.

Four sutures are then introduced in the wall of the stomach, two above the catheter and two below. These sutures are of chromic catgut, of the non-penetrating, Lembert variety. They are placed about one-third of an inch apart and take a good broad bite penetrating through the serous and muscular coats. When these sutures are tied they serve to raise the wall of the stomach up around the catheter in the shape of two folds which have the effect of infolding the catheter into the lumen of the stomach for a depth of about one-half inch. A second tier of four sutures is introduced in a similar manner, picking up the wall of the stomach about one-half inch beyond the first row upon each side, burying these and at the same time still further infolding the catheter into the cavity of the stomach. A third tier of sutures may be employed, but these are usually unnecessary.

The stomach, the portion immediately adjacent to the catheter as it emerges from the canal formed by the infolded portion of the wall of the stomach, is fixed to the edges of the parietal peritoneum and transversalis fascia in the abdominal incision with two suspension sutures, one above and the other below the point where the tube emerges. These sutures are of chromic catgut and do not penetrate the entire thickness of the wall of the stomach, but the serous and muscular coats only.

The abdominal incision is closed except for the small space through which the catheter emerges in a manner similar to that described in the preceding operation.

Gastrorrhaphy.—Suture of the wall of the stomach for perforation due to ulcer or stab or gunshot wounds. The surgeon should remember, in connection with stab and gunshot wounds, that the pancreas from its position is especially liable to be injured also.

Ulcer more commonly affects the posterior wall of the stomach than the anterior wall. Perforation due to ulcer, however, is more frequently met with in the anterior wall. There may be more than one perforation. The stomach should not be washed out before operating if perforation is suspected. An incision is made in the middle line through the linea alba from a point just below the ensiform process to the umbilicus and the stomach exposed.

The entire stomach should be carefully explored, first the anterior wall and then the posterior. In order to explore the posterior wall an opening may be torn, not cut, in the gastro-colic ligament or preferably in some cases in the transverse mesocolon. Through the opening thus made access may be had to the posterior wall of the stomach.

If the wound in the stomach is small, it may be closed with a non-penetrating purse-string suture or with a single row of Lembert sutures of silk. These sutures take a good, broad bite in the wall of the stomach, and should include the serous and muscular coats only; they do not pierce the entire thickness of the wall of the stomach or enter the mucous membrane layer. It is well to reinforce the first row of Lembert sutures with a second row. If the wound in the stomach is large, for example, after excision of a portion of the wall of the stomach for ulcer, etc., the opening may be closed with a continuous, through-and-through suture of chromic catgut and then in addition to this a row of continuous Lembert sutures of silk are applied. These bury the through-and-through catgut stitch and bring the serous edges into accurate apposition.

If there is difficulty in closing the perforation by suture, owing to dense adhesions, etc., it might be plugged up by applying a piece of omentum or a coil of intestine against it and fixing it by suture to the stomach.

If the peritoneum has become soiled by escaping stomach contents, it is well to thoroughly flush out the abdominal cavity with salt solution after the opening in the stomach has been closed.

Gastroplasty.—The steps of this operation are quite analogous to those described in the pyloroplasty of Heinecke and Mikulicz. For hour-glass contraction of the stomach due to cicatrization, etc., dependent upon chronic ulcer.

The stomach should be emptied before the operation is commenced, just before the patient is anæsthetized, with the stomach tube. The stomach is reached through an incision in the middle line, commencing just below the ensiform cartilage and reaching down to the umbilicus.

A transverse incision is made in the constricted part of the stomach, penetrating through the entire thickness of the stomach wall and reaching from one pouch into the other. Bleeding points are clamped and ligated with catgut. The edges of the incision are then drawn apart with two tenacula which are hooked in the edges of the incision, about the middle, so that the transverse incision becomes converted into a vertical one. The edges of the incision while they are held thus are sutured together: first with a sufficient number of interrupted, through-and-through stitches of chromic catgut which close the opening, and then with one or two rows of Lembert sutures of silk. The latter may be interrupted or continuous and should take a good, broad bite in the stomach wall.

This operation is probably not so satisfactory where chronic ulcer exists as the operation of gastro-gastrostomy combined with gastro-jejunostomy as described in the next paragraphs.

Gastro-gastrostomy.—The establishment of an artificial communication between parts of the stomach. The operation is done for the relief of symptoms due to hour-glass contraction, the result of cicatrization, etc., of ulcer affecting the body of the stomach. In exaggerated cases the stomach may be found separated into two distinct pouches communicating with one another through an opening so constricted as barely to admit the end of the finger. The object of the operation is to provide a liberal opening between both pouches which will readily permit the discharge of the stomach contents from the proximal into the distal pouch and at the same time avoid the passage of the foodstuffs over the ulcerated area. Under these favorable conditions ulcers will often heal rapidly.

The stomach (proximal pouch) should be emptied with the stomach tube immediately before operating and after the patient has been anæsthetized or, if this has not been done, then, when the stomach is exposed, the contents may be expressed from the stomach into the duodenum. The incision is placed in the middle line, commencing about one inch below the tip of the ensiform process and reaching downward to the umbilicus; it can be still further lengthened if necessary.

After the abdomen has been opened the stomach is sought. It may be found separated into two pouches of nearly equal size or the upper, cardiac pouch may be quite small and concealed above, underneath the ribs. Care must be exercised in dealing with adhesions. The stomach may be adherent to the anterior abdominal wall, and the breaking down of these adhesions may show a perforation leading into the stomach; this may be closed by infolding all of the ulcerated area and the application of one or two rows of Lembert sutures. The operator should not be precipitate in breaking down adhesions between the stomach and the adjacent organs, especially the pancreas and liver; it is well in most cases not to disturb these adhesions, as at times they serve to close up an opening into the stomach, the result of deep ulceration.

The two pouches of stomach are drawn into the abdominal incision or, if possible, outside upon the abdomen and after pads

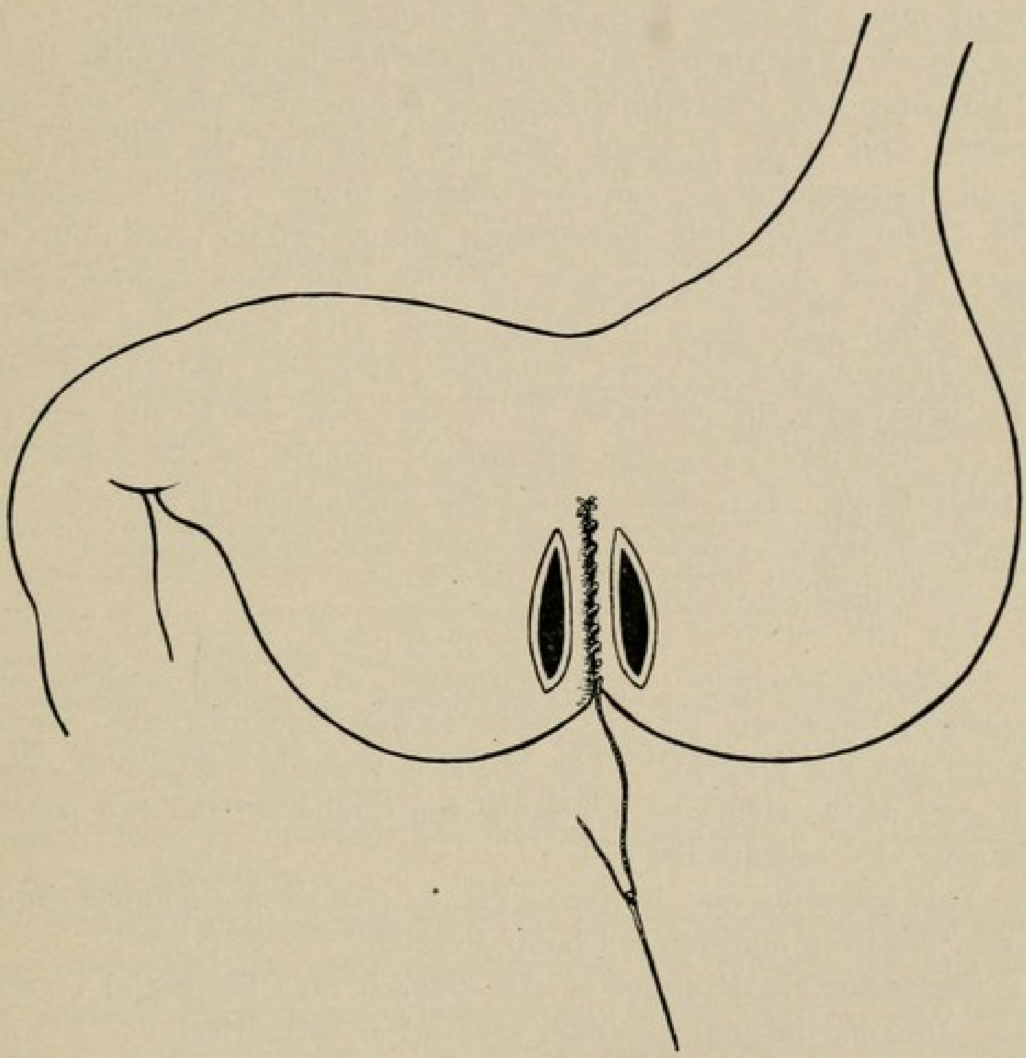

Fig. 176.—Gastro-gastrostomy. The two stomach pouches have been joined together with a row of continuous Lembert sutures and each has been incised.

have been properly arranged to protect the peritoneal cavity the anastomosis is made in a manner similar to that described in gastro-jejunostomy. The two pouches are joined together, side by side, with a continuous, non-penetrating silk suture carried in a straight cambric needle. The parts should be united thus, in a straight line, for a distance of two and one-half or three inches if possible. This line of suture forms the posterior half of the "outside serous ring." An incision is then made into each pouch from two to two and one-half inches long, parallel with and about one-quarter inch distant from the line of suture that has been applied. These incisions should be shorter than the line of suture. The contiguous margins of the two openings are then united to each other, all around, with a continuous penetrating suture of catgut. After this line of suture has been completed, the edges of the openings having been joined to each other all around, the needle, carrying the thread of the first non-penetrating Lembert suture and which was temporarily laid aside, is again taken in hand and the anterior half of the non-penetrating suture—"outside serous ring"—is applied. This serves to bury the penetrating catgut sutures that unite the edges of the openings in both pouches and thus completes the anastomosis. The parts are wiped clean with a pad wet with hot saline solution and returned into the abdomen. One should carefully investigate the condition of the pylorus, and if any constriction is discovered a gastro-jejunostomy should be performed, in addition to the gastro-gastrostomy, the junction being made between the distal, pyloric, pouch and the upper part of the jejunum. The abdominal incision is closed layer by layer.

For the relief of hour-glass contraction where the presence of adhesions precludes the performance of a gastro-gastrostomy, a gastro-jejunostomy may be made between the proximal, cardiac, pouch, and the intestine. The operator must be certain to secure this part of the stomach; it may be the smaller of the two pouches and concealed beneath the ribs.

This operation may be done with the clamps in a manner similar to the "Gastro-jejunostomy, Clamp Method."

Gastrectomy.—Excision of the stomach may be partial or complete. The partial may be either atypical or cylindrical.

Partial Atypical Gastrectomy.—Excision of a limited portion of the wall of the stomach, without interruption of the continuity of the organ; for non-malignant ulcer (see also gastrotomy for bleeding ulcer). The operation is indicated in those cases where the ulcerated area is limited and accessible.

The stomach is exposed through an incision in the linea alba. Adhesions that are encountered are gently broken down with the fingers and the diseased portion brought into view and excised. A diseased area of the posterior wall may be excised from within the stomach, working through an opening made in its anterior wall, or else this portion of the stomach may be made accessible by tearing through the gastro-colic ligament or through the transverse mesocolon as described in the operation of "Posterior Gastro-jejunostomy." The opening that remains in the stomach after the ulcerated area has been excised is closed with a through-and-through suture of chromic catgut, which is, in turn, reinforced and buried by a continuous Lembert suture of silk. The through-and-through suture controls the bleeding from the edges of the stomach wound. Spurting vessels may be clamped and ligated with catgut. Mitchell has suggested that simple infolding of the diseased area without excision would answer very well in many of these cases.

This plan of excision of the ulcer can only be applied to those cases where the diseased portion of the stomach can be made accessible. It would be rather more difficult to follow this method of treatment if the ulcer involved the posterior wall or in cases of deep ulceration with firm adhesions between the stomach and adjacent organs,—liver, pancreas, etc. Under these conditions the operator might wisely content himself with a gastro-jejunostomy. It would probably be advisable in all these cases to establish a gastro-jejunostomy in addition to excising the ulcerated area, etc., because stenosis of the pylorus is associated with the condition of chronic ulcer in a considerable number of cases.

Partial Cylindrical Gastrectomy.—Resection of an entire segment of the stomach. May be of the pyloric portion only, pylorectomy; or the pylorus and a considerable part of the body of the stomach may be resected, the partial gastrectomy of Hartmann, Mayo, and Moynihan.

PYLORECTOMY.—Resection of the pyloric portion of the stomach. This operation has, until recently, been the routine one practiced for operable cases of malignant disease of the pylorus; but in the light of recent experience the more extensive operations of Hartmann and of Mayo are to be preferred in all cases of malignant disease of the stomach even if the condition is apparently still confined to the pylorus. The operation of pylorectomy is indicated in some cases of chronic non-malignant ulceration limited to the pyloric portion of the stomach.

The incision is placed in the middle line and should be sufficiently large, extending from the ensiform process down to the umbilicus or beyond this point if necessary. The pyloric end of the stomach is drawn into the wound and well surrounded with gauze pads and the left lobe of the liver is held up out of the way by an assistant.

Billroth's First Method.—The first step in the operation is to secure and ligate the vessels that course along the upper and lower borders of the stomach. Corresponding to the upper border, near

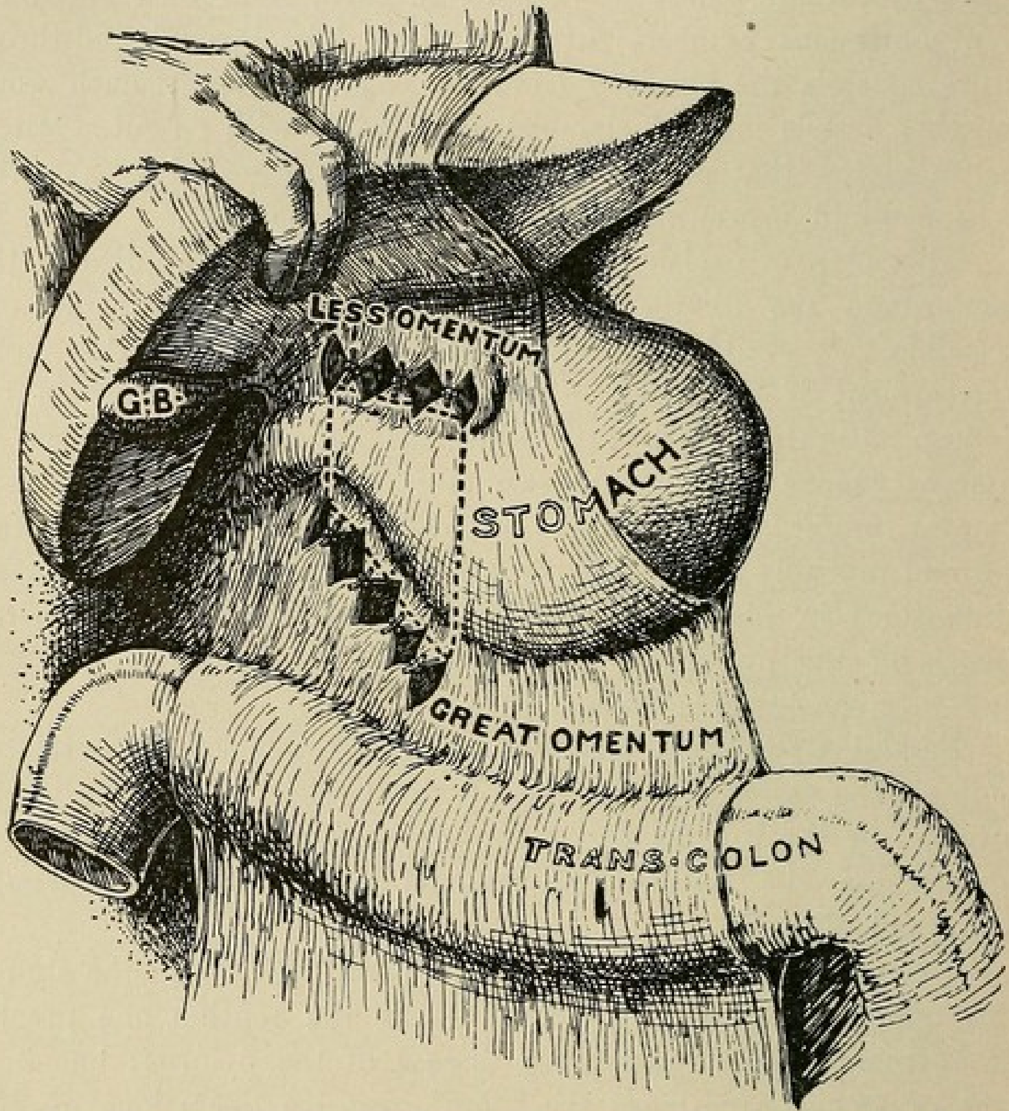

Fig. 177.—Pylorectomy. Anterior edge of the liver is lifted up; the lesser and greater omenta are shown. The lesser and greater omenta, corresponding to the portion of the stomach that is to be excised, have been ligated in sections. The dotted lines indicate the line of section through the stomach and omenta. Instead of being applied as represented in this picture, the ligatures may be placed double and the line of incision carried between them.

the pyloric end is the pyloric artery, a branch of the hepatic; toward the cardiac end of the stomach is the gastric. Corresponding to the lower border we have the gastro-epiploica dextra coming from the right, and the gastro-epiploica sinistra from the left. These vessels should be ligatured with plain catgut. The next step of the operation consists in the detachment of the pylorus (diseased part to be excised) from the greater omentum below and from the lesser omentum above. With a blunt-pointed ligature carrier, armed with catgut, the greater and lesser omenta, corresponding to the diseased pylorus, are transfixed and tied off in sections. Each ligature should include from one to one and one-half inches of the omentum, and should be applied double so that when the operator divides each segment of the ligated omentum,

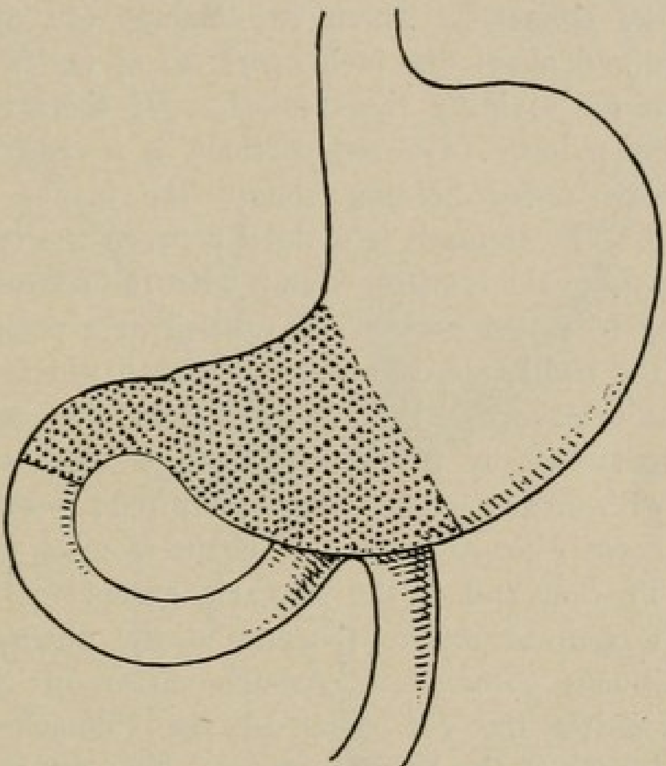

Fig. 178.—Pylorectomy (*Billroth*). Shaded part indicates the portion of the stomach that is resected.

he may do so between the ligatures. Usually two or three ligatures will suffice for the lesser omentum, gastro-hepatic ligament, and three or four for the greater omentum, gastro-colic ligament. One should be mindful of the location of the common bile-duct and the portal vein in the free right edge of the lesser omentum. After the pylorus has been thus separated, cut away, from its omental attachment above and below, the hand is passed over the lesser curvature into the lesser peritoneal cavity and down behind the stomach to thoroughly separate it posteriorly. The detached pyloric portion of the stomach, after it has been thus separated, may be drawn pretty well out through the abdominal incision, so that the subsequent steps of the operation may be executed with more ease.

Before excising the diseased portion of the stomach, clamps are applied about the duodenum and about the stomach. Two pair of short, narrow-bladed clamps are applied to the duodenum. Of the two clamps the one nearer the pylorus is a crushing clamp; the other, which is placed farther along on the duodenum, about one inch distant from the first clamp, is an elastic-bladed, rubber-sheathed holding clamp. Two long-bladed clamps are applied across the stomach, one inch or more distant from the diseased portion of the stomach. These two clamps are applied parallel to each other and about one inch apart, so as to leave ample space between them for dividing the stomach. Of these two clamps the one nearer the pylorus (diseased portion) is a crushing clamp, the other an elastic-bladed holding clamp—the blades sheathed with rubber tubing. The stomach is divided between the two clamps, cutting rather close to the crushing clamp with the scissors. The stump of the pylorus (diseased portion) enveloped in a compress is turned over toward the right side, the crushing clamp which is still applied preventing any leakage. Hemorrhage from the cut end of the stomach is controlled by the holding clamp. Any spurting points are caught with artery clamps and ligatured; oozing and venous hemorrhage cease when the cut end of the stomach has been closed by suture. The cut end of the stomach, except for the lower part which is left open to receive the end of the duodenum, is closed with a continuous through-and-through suture of chromic catgut. This suture unites the cut edges of the stomach that protrude between the blades of the holding clamp. The suture is commenced above, working downward toward the greater curvature. It is applied with a straight needle and in such a manner as to invert the edges of the stomach. Each stitch is drawn fairly tight. The lower part of the opening in the stomach is left unclosed for a length sufficient to allow for the implantation, later, of the end of the duodenum. A second line of suture, a continuous, non-penetrating Lembert suture of silk, is introduced. This suture inverts and buries the first line of suture, the through-and-through catgut suture. The end of the stomach is wrapped in a compress and temporarily laid aside, and the attention of the operator is directed to the duodenum.

The duodenum is divided between the two clamps, rather close to the crushing clamp, and the resection of the pylorus is thus accomplished. The end of the duodenum that protrudes between the blades of the rubber-sheathed holding clamp is wiped clean with a gauze compress.

After the protecting gauze pads have been renewed the end of the duodenum is sutured into the opening that has been left in the stomach.

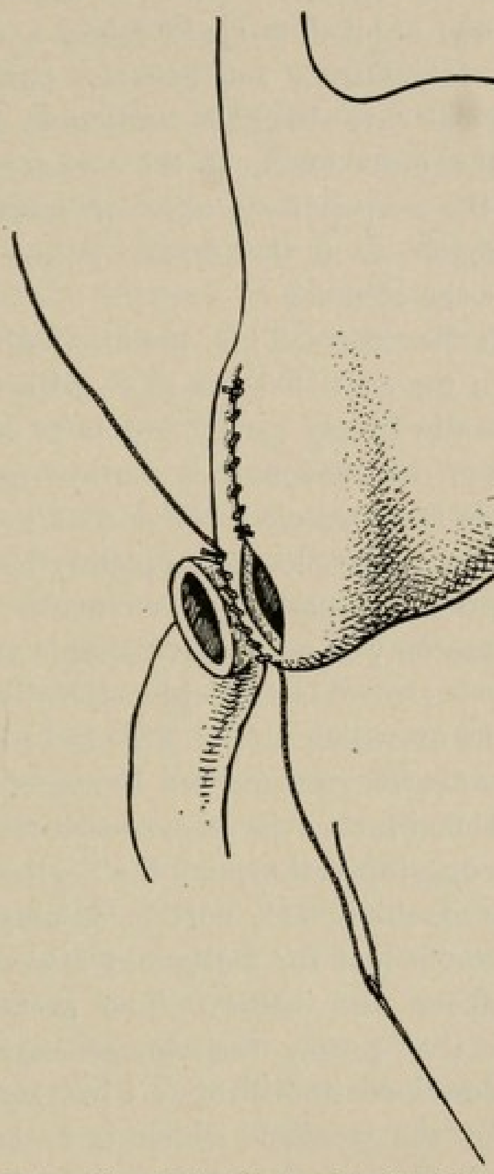

Fig. 179.—Restoration of the Gastro-intestinal Canal, Billroth's First Method. The posterior half of the non-penetrating, "outside serous ring" suture has been applied.

The end of the duodenum is joined to the margin of the opening in the stomach with a continuous non-penetrating suture of silk. This suture catches the wall of the duodenum about one-quarter inch beyond its cut edge and joins it to the wall of the stomach about one-quarter inch away from the edge of the opening. This suture is applied only half-way around (the posterior half) and then the needle is laid aside until required later to complete this outside ring of suture. With a through-and-through suture of chromic catgut the edge of the duodenum is accurately sewed all around to the edge of the opening in the stomach. After this line of suture has been completed the needle carrying the silk thread with which the posterior half of the outside, non-penetrating suture was applied is again taken in hand and the operation completed by introducing the anterior half of the non-penetrating suture. Special care should be exercised, in making the anastomosis of the end of the duodenum to the stomach, to accurately secure the point where the perpendicular line of suture, that which closes the end of the stomach, meets the circular suture that joins the end of the duodenum to the stomach.

Billroth's Second Method.—This opreation differs from the one just described only in the part that has to do with the restoration of the continuity of the alimentary canal, and is to be preferred tc it especially if the stump of the duodenum is short or fixed.

After the pylorus has been resected, the end of the stomach and the end of the duodenum are both closed completely by inversion and suture and a posterior gastro-jejunostomy then made. According to Billroth, the gastro-jejunostomy is made with simple suture, but any of the methods described (see "Gastro-jejunostomy") may be employed for this step of the operation. (See Fig. 186.)

Method of Kocher (Resection of the Pylorus with Gastro-duodenostomy).—The abdominal cavity is opened through an incision as described in the preceding operation and the portion of the stomach which is to be removed, the pyloric portion or maybe the greater part of the body of the stomach if for malignant disease, is separated from its attachments above and below. The greater and lesser omenta and the vessels that supply the stomach are ligated in a manner similar to that described in Billroth's First Method.

After the portion of the stomach which is to be resected has been isolated and separated above and below, it can be lifted out of the incision provided it is not adherent to the pancreas, transverse mesocolon, etc., and the operation can be continued with more facility. Two heavy holding clamps with bare blades are applied to the stomach, reaching from the greater to the lesser curvature. These are applied fairly close together and at least two fingers' breadth away from the external limit of the diseased area. The stomach is divided with the scissors between the two clamps, cutting close up against the second clamp, that one which is applied toward the healthy portion of the stomach. The edge of the stump of the stomach still held in the clamp is wiped clean with a gauze pad wet in alcohol. The stump of the stomach secure in the grasp of the clamp is then wrapped in a compress and laid aside temporarily. The diseased part of the stomach in the grasp of the other clamp is turned over toward the right side. Traction is made on the duodenum to ascertain whether the duodenum is sufficiently free and movable to be brought up into apposition with the stomach for anastomosis after the resection has been completed. Two straight forceps with bare blades are applied to the duodenum quite close together and well beyond the diseased limits, and the duodenum is divided between them. The diseased portion of the stomach is thus removed. The cut edge of the duodenum grasped between the blades of the holding clamp is wiped clean with a pad wet with alcohol.

The forceps which grasps the end of the stomach is taken up and steadied by the assistant and the end of the stomach closed with a chromic catgut suture carried in a long straight needle. The suture is applied through-and-through proximal to the blades of the crushing forceps. After the suture has been introduced the forceps is removed and if the edge of the stomach beyond the suture line is too wide it may be trimmed away. If there is any hemorrhage from the edge of the stomach the bleeding points may be clamped and ligated. A second line of suture is introduced. This suture, of silk, penetrates the serous and muscular coats only and inverts the edges and buries the first line of suture. A third non-penetrating line of suture, silk, may be introduced and this in turn buries the second line.

The stump of the stomach is held up and steadied by an assistant and the end of the duodenum still in the grasp of the holding forceps is brought up close to the stomach. The duodenum just beyond the edge which is held between the blades of the forceps is sutured to the posterior wall of the stomach, low down, parallel with and close to the line of suture that closes the end of the stomach—within two inches. This is accomplished with a continuous non-penetrating suture of silk. After the posterior half of the circumference of the stump of the duodenum has been sutured to the wall of the stomach, the clamp is removed from the end of the duodenum and the needle, still carrying the thread which was used to sew the duodenum to the stomach, is temporarily laid aside. Before the clamp is removed from the end of the duodenum a strip of narrow tape is passed around the duodenum or a compressor clamp with rubber-sheathed blades is applied so as to prevent the escape of contents from the duodenum when the clamp is removed. The stomach is incised just in front of and parallel with the line of suture that joins the end of the duodenum to it. Hemorrhage from the incision in the stomach is controlled by clamping and ligating bleeding points. With a through-and-through

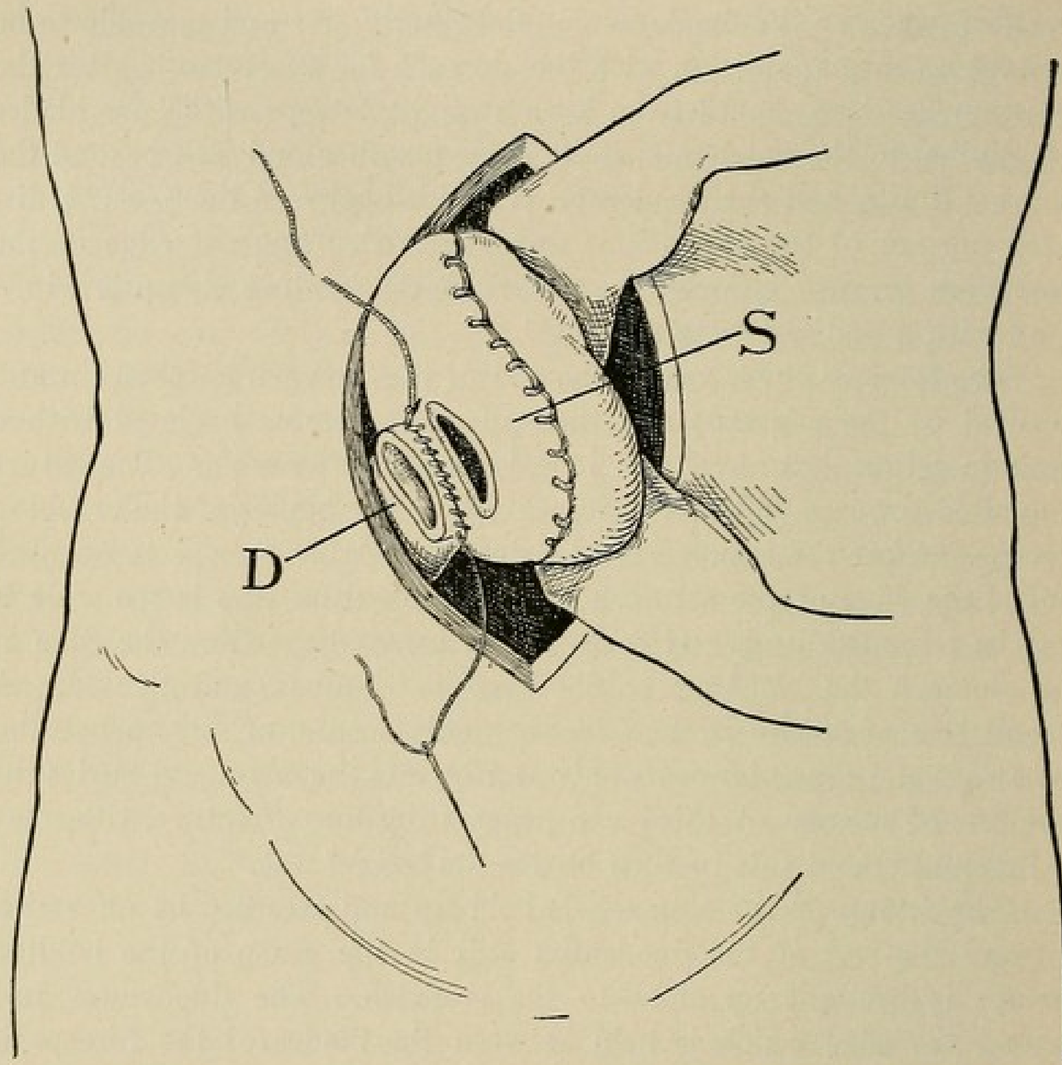

Fig. 180.—Pylorectomy (*Kocher*). Stump of the duodenum has been joined to the posterior wall of the stomach by a row of continuous Lembert sutures. Opening has been made in the stomach to receive the end of the duodenum.

chromic catgut suture the edge of the duodenum is united to the edge of the incision on the stomach all around. This suture includes all the coats, especial care to include the edges of the mucous membrane. After the end of the duodenum has thus been sutured to the opening in the stomach all around the needle, carrying the silk thread with which the posterior half of the non-penetrating suture that joins the duodenum to the stomach was introduced, is again taken in hand and the anastomosis completed by introducing the anterior half of the outside, non-penetrating ring suture.

Hartmann's Method of Gastrectomy.—The partial gastrectomy, according to the method of Hartmann, is performed for cancer of the pyloric portion of the stomach, and is based upon the normal arrangement of the lymphatics of the stomach. It consists

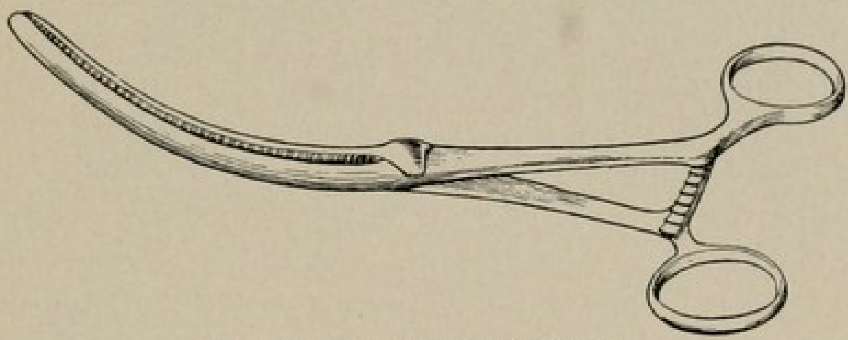

Fig. 181.—Doyen Holding Forceps.

of resection of the pylorus and part of the body of the stomach and the adjacent lymphatic nodes. The pylorus is drained chiefly by the lymphatics that terminate in the nodes situated along the lesser curvature—along the course of the gastric artery—between the folds of the gastro-hepatic omentum, and for this reason cancer originating in the pylorus, the usual site of the disease, spreads

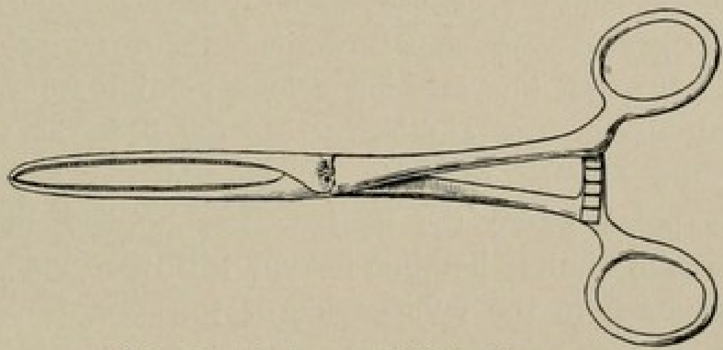

Fig. 182.—Hartmann Holding Forceps.

more rapidly along the lesser curvature than along the greater curvature (see Fig. 160), involving not only the lymphatic nodes, but also affecting the mucous membrane of this part of the organ early. The fundus is not affected until late in the disease.

In this operation the pylorus and body of the stomach, all of the lesser curvature, and a considerable part of the greater curvature, together with all the adjacent lymphatic nodes are removed in one mass, the fundus only remaining; the continuity of the alimentary canal is restored either by a gastro-duodenostomy or a gastro-jejunostomy.

The abdominal incision must be sufficiently liberal, reaching from the tip of the ensiform cartilage downward in the middle line as far as the umbilicus or beyond that point. The hand is introduced into the abdomen and the conditions investigated. As a rule, the stomach, tumor, can be brought out through the incision. If the tumor cannot be drawn out thus, because fixed by dense adhesions and by the extension of the disease to the surrounding organs,—pancreas, liver, spleen, diaphragm, etc.,—then the case is probably not a suitable one for this radical operation, but rather for a palliative gastro-jejunostomy. Inflammatory adhesions that are not too dense may be broken up with the fingers. The liver, etc., are retracted upward by the assistant and the stomach seized by the operator and drawn downward and the index finger of the left hand poked through the gastro-hepatic omentum. In this way the operator is able to explore the posterior wall of the stomach, the lymphatic nodes in the gastro-hepatic omentum along the lesser curvature, and also locate the gastric artery where it approaches the stomach near the cardiac end of the lesser curvature. A catgut ligature is passed around the gastric artery with a ligature carrier and tied. The pyloric artery, a branch of the hepatic, is also tied near the pyloric end of the lesser curvature. An opening is then made in the gastro-colic omentum near the lower border of the stomach, and through this opening a long holding forceps with bare blades is introduced and applied across the body of the stomach, the tip of the forceps reaching up beyond the lesser curvature close to the point where the ligature was applied to the gastric artery. A second similar holding forceps with bare blades is applied across the stomach to the pyloric side of this first forceps and also reaching from the greater to the lesser curvature. These two forceps are applied very tightly. The left gastro-epiploic artery is ligated close to the holding forceps. This vessel is found running from left to right close to the lower border of the stomach. The stomach is divided between the two holding forceps and then detached along its greater curvature, working toward the right as far as the pylorus. The gastro-colic ligament is ligated in sections, each section being tied double and the ligatures applied sufficiently far away from the border of the stomach so as to get well beyond any diseased lymphatic nodes that may be present. If there are

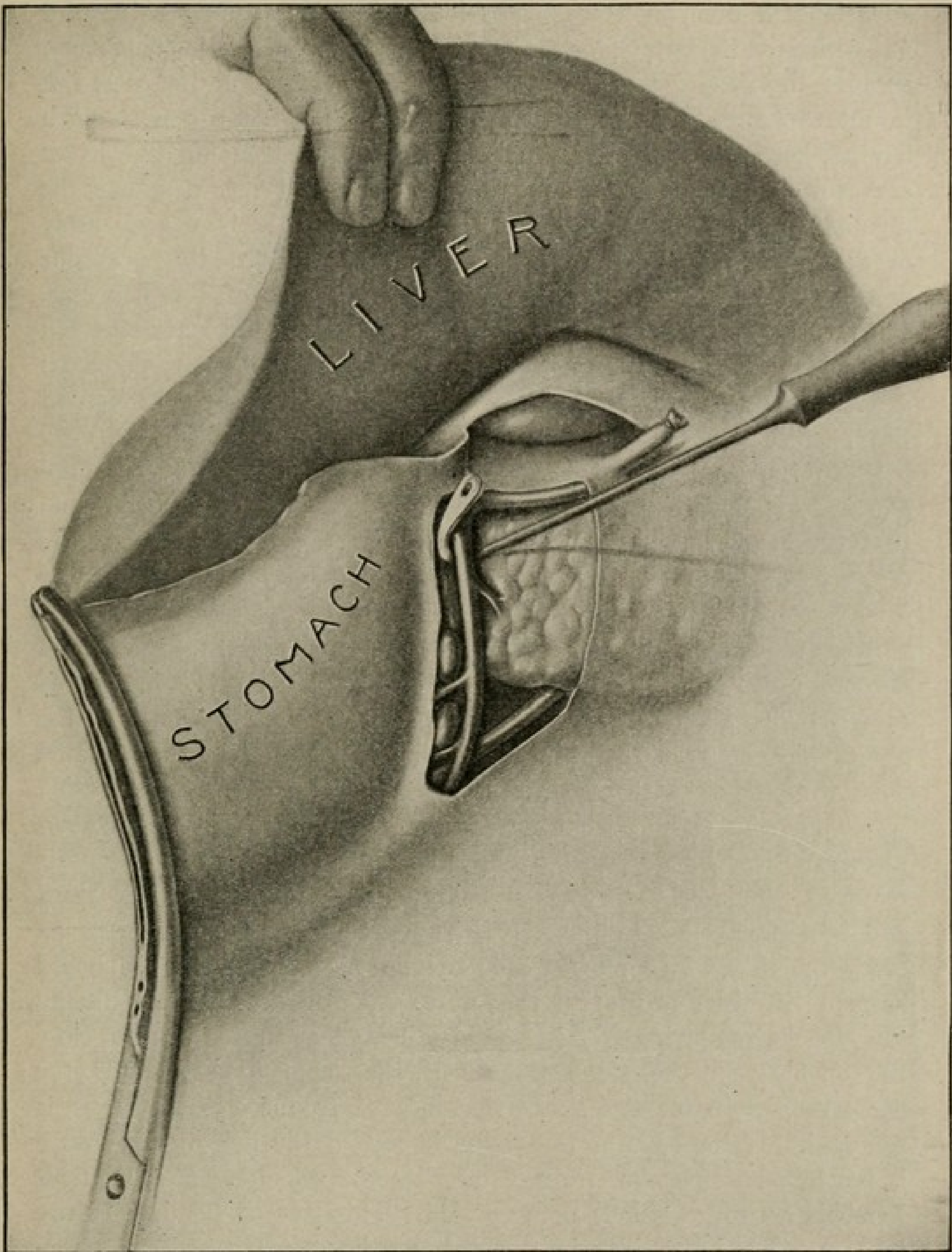

Fig. 183.—Gastrectomy (*Hartmann*). Gastric artery has been tied and the gastrohepatic ligament divided. The stomach has been divided and the portion which is to be resected with the clamp still applied is turned over toward the right side in order to facilitate the ligation of the gastro-duodenal artery. A portion of the peritoneum has been removed from the anterior surface of the head of the pancreas in order to expose this vessel, which has been picked up with the blunt ligature carrier.

adhesions to the transverse mesocolon the operator must be careful not to injure the arteria colica media nor to include it in a ligature, because this vessel supplies the transverse colon, and its occlusion would result in gangrene of this part of the bowel. The stomach having been thus divided and separated above, along the lesser curvature from the gastro-hepatic ligament and below, along the greater curvature from the gastro-colic ligament, is drawn away over toward the right and there are thus exposed the posterior aspect of the stomach and pylorus and the head of the pancreas, which is covered by the parietal layer of peritoneum that is reflected upward upon the posterior abdominal wall. The gastro-duodenal artery is now sought for and ligated. This artery is a branch of the hepatic and is found behind the pylorus, passing downward between the head of the pancreas and the second part of the duodenum. It is necessary to tear through the layer of peritoneum that covers the anterior surface of the pancreas in order to secure the vessel. The detachment of the lymph-nodes that accompany this vessel and its main branch, the gastro-epiploica dextra, and which are located behind and below the pylorus, is accomplished without much difficulty or hemorrhage. Two straight holding forceps with bare blades are finally applied to the duodenum and the gut divided between them, and thus the extirpation of the diseased portion of the stomach is accomplished.

The open end of what remains of the stomach is closed completely with a line of suture which is applied before the forceps is removed. This is a through-and-through suture of chromic catgut and is applied close to the blades (upon their proximal side). At every fourth or fifth puncture of the needle a "back-stitch" should be made in order to prevent the suture from drawing and producing the "puckering-string" effect. This line of suture serves to close the opening in the stomach and at the same time controls the hemorrhage. After the suture has been introduced the forceps is removed. If the edge of the stomach beyond the line of the suture is too broad it may be trimmed off with the scissors. A continuous Lembert suture of silk is then applied. This row of Lembert suture takes a good, broad bite in the wall of the stomach at each puncture, and inverts the edges and completely buries the first through-and-through catgut suture.

After the end of the stomach has been thus closed we are ready for the final step of the operation, the restoration of the

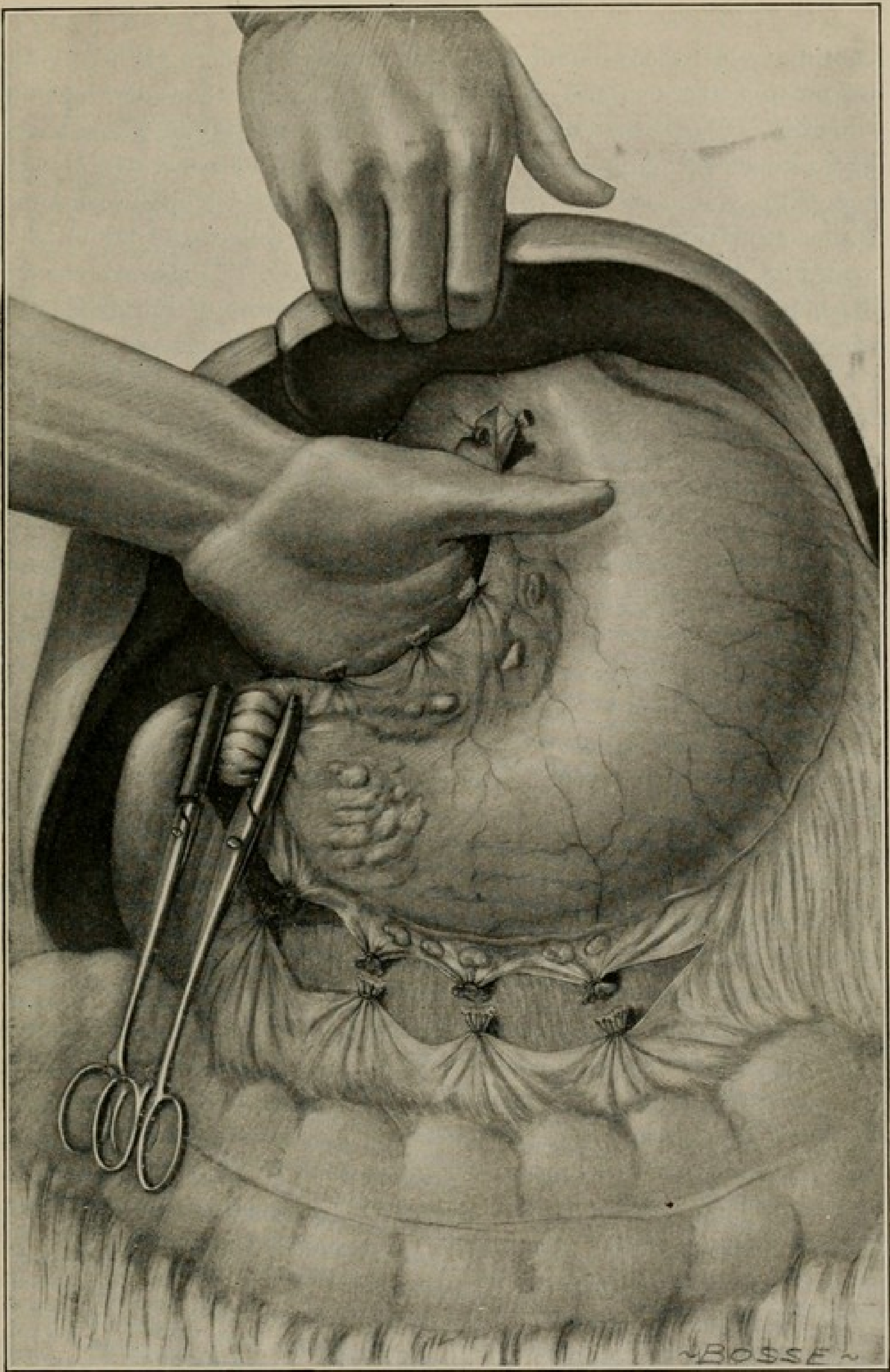

Fig. 184.—Gastrectomy (*Mayo*). The great and lesser omenta have been tied off and divided, and the gastric and pyloric arteries ligated. The hand is passed down behind the stomach to free it from adhesions, etc., posteriorly. Two clamps have been applied to the duodenum preparatory to dividing it. The blades of the distal clamp are sheathed with rubber.

continuity of the alimentary canal. This is accomplished either by uniting the cut end of the duodenal stump to a new opening which is made in the posterior wall of what remains of the stomach, gastro-duodenostomy according to the method of Kocher; or else the end of the stump of the duodenum is closed by suture and a communication established between the stomach and a coil of the jejunum—a gastro-jejunostomy. The choice between these two procedures will depend upon the mobility and length of the stump of the duodenum, the preference being given to the gastro-duodenostomy.

If a gastro-duodenostomy is decided upon, this is established by sewing the end of the stump of the duodenum into an opening made for the purpose in the posterior wall of the stomach according to the method of Kocher, for details of which see page 391.

If the conditions are unfavorable to the performance of the gastro-duodenostomy, if the stump of the duodenum is too short and cannot be brought up into apposition with the stomach, the end of the duodenum is closed in a manner similar to that employed in closing the end of the stomach and the continuity of the alimentary canal restored by making a posterior gastro-jejunostomy. (See Fig. 186).

Mayo's Method of Gastrectomy.—Removal of the pylorus and a considerable part of the body of the stomach—all of the lesser curvature and the greater curvature up to a point well beyond the limits of the disease. For malignant disease of the pylorus.

The incision is made in the linea alba, or preferably a little to the left of the middle line, reaching from the ensiform cartilage downward to the umbilicus or beyond that point if necessary.

The left lobe of the liver is lifted by the assistant and the stomach pulled firmly downward and toward the right. The vessels that supply the stomach are ligated double and divided between the ligatures. The gastric artery is tied first; the finger is thrust through the gastro-hepatic ligament and the vessel secured near the cardiac end of the lesser curvature. The ligature is applied double and the vessel divided between the two ligatures. The pyloric artery, which is a branch of the hepatic, is next secured, tied double, and divided; it is found near the pyloric end of the lesser curvature. Between these two points the lesser omentum, gastro-hepatic ligament, is tied off in several sections; each section is tied double and divided between the ligatures. The ligatures are applied sufficiently far away from the lesser curvature to permit enlarged diseased lymph-nodes to remain attached to the stomach. The lesser curvature of the stomach is thus detached along its entire length. The fingers are passed through the opening in the lesser omentum down behind the stomach, separating adhesions that fix the stomach posteriorly. Two pair of narrow straight forceps are applied to the duodenum well below the limits of the disease. The first is a holding forceps with bare blades and as a rule is placed about one inch away from the pylorus. The second is an elastic-bladed forceps, the blades sheathed with rubber tubing, and is placed about one inch distant from the first. The duodenum is divided between the two forceps, nearer to the one with the bare blades. Enlarged lymph-nodes lying in the omentum near the lower border of the pylorus are carefully separated so as to remain attached to the pylorus and all bleeding points clamped and ligated. The pyloric portion of the stomach in the grasp of the bare-bladed forceps is lifted up, away from the pancreas and the arteria gastro-duodenalis as it lies in the space between the head of the pancreas and the duodenum is secured, tied double and divided between the ligatures. The gastro-colic ligament (omentum) is tied off in several sections, each ligature being applied double and cutting between and working along the lower border of the stomach from the pylorus toward the left as far as the point where it is intended to divide the stomach. These ligatures are applied well below any enlarged lymph-nodes so that when the tissue is divided between the ligatures the diseased nodes remain in connection with the stomach. Care must be exercised to avoid the arteria colica media when applying the ligatures to the gastro-colic ligament. This vessel is the sole medium of supply to the transverse colon in many cases, and if occluded gangrene of this part of the bowel would result.

Corresponding to the point on the lower border of the stomach where it is proposed to divide the stomach, the arteria gastro-epiploica sinistra is secured and ligated. In this way the entire blood-supply of the portion of the stomach which is to be removed is cut off. Two long-bladed clamps are applied across the body of the stomach about one inch back of the intended line of section and, reaching from the greater curvature up to the lesser curvature, close to the point where the gastric artery was ligated. Of these two clamps the one nearer the diseased area is a holding clamp with bare blades, the other an elastic-bladed holding clamp, the blades sheathed with rubber tubing. The clamps are placed parallel to each other and about one inch apart. The tip of the rubber-sheathed clamp reaches well up to the stump of the gastric artery. The stomach is divided close to the bare-bladed clamp, leaving a margin of the stump of the stomach about one inch broad protruding between the blades of the rubber-sheathed clamp. The diseased portion of the stomach, together with the diseased lymph-nodes, fat, etc., still connected with it, is thus resected in one mass.

The end of the stomach is closed with a continuous suture of chromic catgut. Commencing at the greater curvature and working upward toward the lesser curvature this suture is applied with a straight needle. Any portion of the suture line which tends to ooze or which is not satisfactorily closed should be secured with one or more additional sutures. A second line of suture, continuous, non-penetrating Lembert suture of linen or silk, buries the first line of suture, inverting the cut edges of the stomach and accurately apposing the serous margins.

After the stomach has been closed the continuity of the gastro-intestinal canal is re-established either according to the method of Kocher, implanting the end of the duodenum into an opening which is made for the purpose in the lower part of the posterior wall of the stomach; or else the end of the duodenal stump is closed in a manner similar to that described for the stump of the stomach and a posterior gastro-jejunostomy without a loop, made according to the second method of Billroth.

The stumps of the gastro-colic omentum are brought together with several catgut sutures. If the stomach tends to sag it may be anchored to the parietal peritoneum, to the left edge of the incision, with several chromic catgut sutures.

Complete Gastrectomy.—Extirpation of the entire stomach. First case by Schlatter, 1897. A healthy heart is essential to the success of this operation. The operating room should be kept warm and the patient dressed in flannel garments to prevent as much as possible loss of body heat by radiation. The stomach should be washed out immediately before the operation is commenced, after the patient has been anæsthetized.

The incision is best made in the linea alba, and must be liberal, —from six to seven inches in length,—reaching from the ensiform process to the umbilicus or even beyond this point.

After the abdomen has been opened the stomach is recognized and examined, and search made for secondary deposits in the liver, pancreas, and adjoining lymphatic glands.

The first step consists in the isolation of the stomach, detaching it from the greater and lessor omenta and from its attachment to the spleen: gastro-splenic omentum. In many cases the stomach

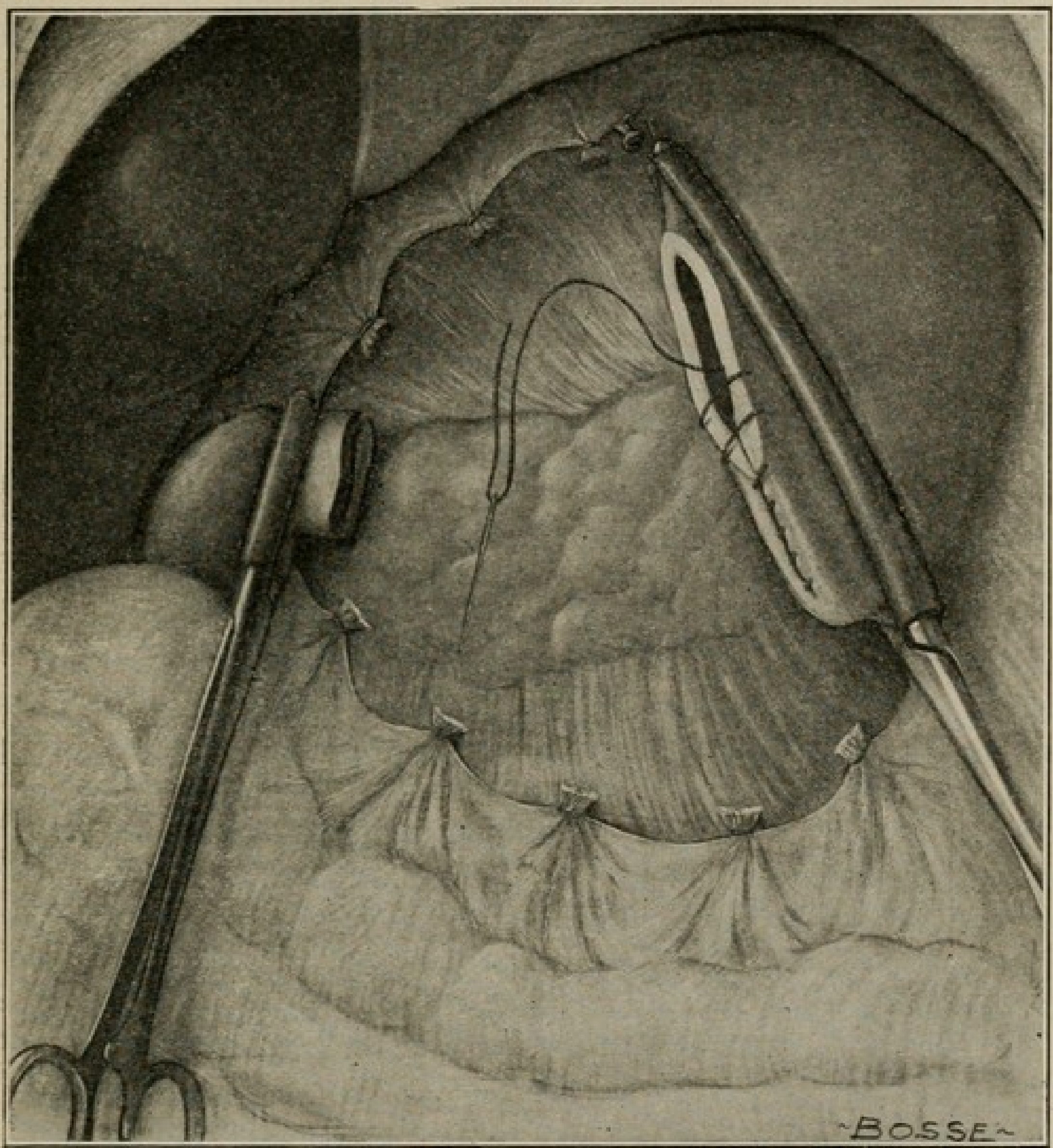

Fig. 185.—Gastrectomy (*Mayo*). Diseased portion of stomach has been excised. The end of the stump of the stomach has been partly closd by suture. Blades of the clamps sheathed with rubber.

can be drawn almost entirely out of the abdomen and under these conditions the performance of the operation is greatly facilitated.

Commencing at the pyloric end of the stomach, the omenta are tied off in sections,—first the lesser and then the greater omentum,—each section including about one and one-half inches of the omentum and being tied double, so that the latter can be divided between the ligatures. In ligating the lesser omentum the liver

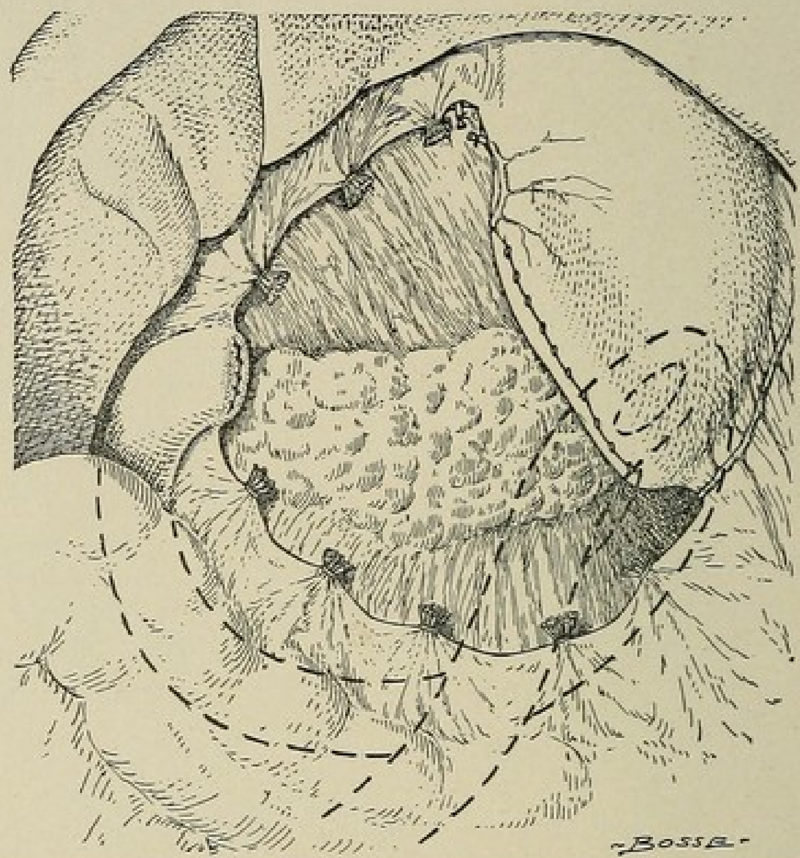

Fig. 186.—Gastrectomy (*Mayo*). The ends of the stumps of the stomach and duodenum have been closed by suture. Dotted lines indicate the method of restoring the gastro-intestinal canal by Billroth's second method, posterior gastro-jejunostomy.

must be drawn up out of the way and the stomach pulled down. The presence of the common bile-duct, etc., between the layers of the lesser omentum, near its free right border, should not be forgotten. The ligatures are passed with the blunt ligature carrier. After the lesser and greater omenta have been ligated as far as the middle of the stomach and have been divided, the section may be made between the pylorus and duodenum, in order that the stomach may the better be drawn down, so as to make the detachment of its cardiac end less difficult; or else one may wait until the whole length of the lesser and greater omenta has been ligated and cut away from the stomach before this division is made.

The omentum is divided between the double ligatures with the scissors, cutting, piece by piece, from one ligature hole into the next. The main arterial branches that supply the stomach should be secured and ligated. Above, corresponding to the lesser curvature, the pyloric and gastric. Behind the pylorus the gastro-duodenalis, from which the gastro-epiploica dextra is derived, is sought for and ligated. Corresponding to the cardiac end of the stomach, passing forward in the gastro-splenic omentum to reach the stomach, is the gastro-epiploica sinistra. This branch is derived from the splenic and is included in the ligature that secures the gastro-splenic omentum.

After the stomach has been detached from its omenta along the lesser and greater curvatures, and the arteries that supply the stomach secured and ligated, we are ready for the next step of the operation: the excision of the stomach. The stomach is divided first at its pyloric end, if this has not already been done. A rubber-sheathed holding clamp is placed about the duodenum, about one and one-half inches from the pylorus, and a clamp with bare blades about the pyloric end of the stomach, and between these the intestine is divided with the scissors. Any escaping contents are caught upon a gauze pad, and the end of the duodenum, sterilized and wrapped in gauze, and with the compressor still applied, is dropped back, temporarily, into the abdomen.

A ligature is thrown around the gastro-splenic omentum; this is the peritoneal fold that reaches from the fundus of the stomach to the spleen, and through it the vasa brevia pass to the stomach. This ligature is applied double so that we may divide between the two. Special pains should be taken to secure the vessels in the gastro-splenic omentum, leaving the ligature long that the pedicle may be drawn forward, so that, if necessary, the individual vessels may be secured with additional ligatures.

To reach the œsophagus the stomach must be pulled well downward. A rubber-sheathed holding clamp is placed about the œsophagus a short distance below the diaphragm, and a clamp with bare blades about the œsophageal end of the stomach, and between these the œsophagus is divided with the scissors. The stomach is thus removed.

After the stomach has been excised it becomes necessary to restore the continuity of the alimentary canal, either by joining the end of the duodenum to the end of the œsophagus, œsophago-duodenostomy, or else by inserting the end of the œsophagus into the jejunum, œsophago-jejunostomy.

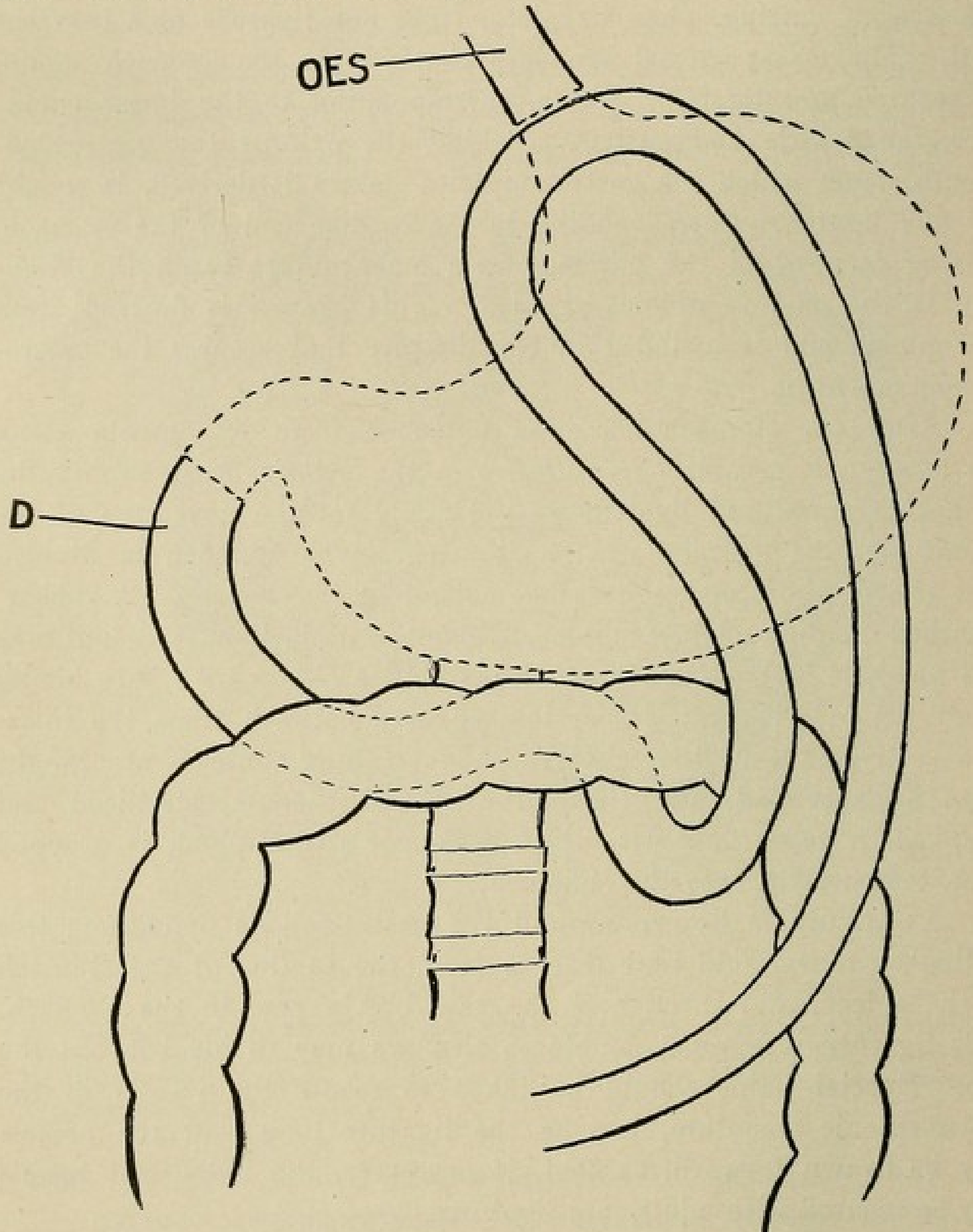

Fig. 187.—Gastrectomy. *OES*, stump of œsophagus; *D*, end of the duodenum. Dotted lines indicate the excised stomach. The small intestine (jejunum) has been drawn up into apposition with the stump of the œsophagus, as in œsophago-jejunostomy.

In most cases the œsophagus can be drawn down and the duodenum sufficiently mobilized to allow of its being brought up into apposition with the end of the œsophagus without undue tension. In this case the parts may be joined together with a Murphy button or else they may be sutured, end-to-end (see "End-to-End Anastomosis"). If the button is used for the purpose of restoring the continuity of the alimentary canal, then, after it has been inserted and the compression clamps removed from the duodenum and œsophagus, a row of outside Lembert sutures should be applied to make the junction still more secure. These sutures include the serous and muscular coats, but do not pass through the mucous membrane. If unable to approximate the parts as described, the end of the duodenum may be inverted and closed with a double row of sutures and an œsophago-jejunostomy done, the end of the œsophagus being sutured into an opening which is made in the small intestine. The upper portion of the jejunum is sought in the upper back part of the abdominal cavity,—to the left of the body of the second lumbar vertebra,—and a coil of gut about eighteen inches beyond this point selected. A segment of this coil of gut about eight inches long is tied off with tapes; first one tape is tied about the gut and then, after the contents of the segment have been stripped along with the fingers, the other tape is tied. This segment of gut is brought up in front of the transverse colon, into apposition with the end of the œsophagus. The posterior half of the end of the œsophagus is sutured to the wall of the coil of gut with a row of continuous Lembert sutures. These sutures secure the wall of the œsophagus about one-fourth inch beyond its cut edge, and include the serous and muscular coats, but not the mucous. The needle, still carrying the thread, is then discarded temporarily, and an incision is made in the gut corresponding in length to the size to the end of the œsophagus. The edge of this opening in the gut is sutured to the end of the œsophagus all around with a continuous stitch of chromic catgut that includes all the layers. When this suture has been completed and the end of the œsophagus thus securely fixed to the opening in the intestine, the first needle, that with which the posterior half of the end of the œsophagus was joined to the gut, is again taken in hand and the anterior half of the "outside serous ring" suture applied. The abdominal wound is closed without drainage. It is advisable, in addition, to establish an entero-anastomosis between the most dependent portions of the two limbs of the attached coil of gut in order to insure the ready escape of the bile and pancreatic juice from the proximal into the distal arm of the gut.

During the course of the operation the solar plexus may be considerably molested, and at the time that the œsophagus is severed both pneumogastric nerves are also divided. The shock is therefore apt to be marked, and should be counteracted by avoiding as much as possible loss of body heat during the operation and by administering proper stimulation. The division of the pneumogastrics leads to disturbance of the heart's action; it becomes very greatly accelerated. An attempt should be made to regulate this, probably with proper doses of digitalis hypodermically. For the first few days the patient is nourished per rectum; after forty-eight hours fluids may be given per mouth, first small quantities of water and then broth, milk, etc., may be added. At the end of a week a moderate amount of solid food may be taken through the mouth.

THE SMALL INTESTINE.

The Surgical Anatomy of the Small Intestine. THE DUODENUM is the first part of the small intestine. It is about ten inches long and commences at the pyloric end of the stomach and ends at the jejunum. Its wall is moderately thick. It is usually described as consisting of three parts.

The first, or ascending, part is freely movable, continuous with the pylorus, and entirely invested by peritoneum. It passes from the pyloric end of the stomach upward and backward toward the right as high as the level of the twelfth dorsal vertebra; it reaches close to the under surface of the liver, with which it is connected by the so-called ligamentum hepatico-duodenale. This ligament is simply the free, thickened, right edge of the lesser omentum; ligamentum gastro-hepaticum. Between the layers of the lesser omentum are the hepatic artery, portal vein, and common bile-duct, the artery ascending to the liver, and the duct and vein descending behind this first part of the duodenum. Between the layers of the lesser omentum the artery lies to the left, the duct to the right, and the vein between and behind both.

The duodenum then makes a turn downward along the right side of the first and second lumbar vertebræ, lying upon the front of the right kidney, with the head of the pancreas to the left (*i.e.*, internal to this part of the duodenum). This is called the second part of the duodenum. It differs from the first part in being fixed to the posterior wall of the abdomen and in not being completely surrounded by peritoneum, but simply covered by the peritoneum upon its front surface, and therefore when we look for this part of the duodenum, after reflecting the transverse colon and the great omentum upward, it is not to be seen, and is only exposed to view after the peritoneum which covers its anterior surface has been cut through. The common bile-duct and the pancreatic duct open into the second part of the duodenum, adjacent to the head of the pancreas. These ducts pass obliquely through the wall of the duodenum, and join with each other, before entering the gut through a single common orifice, which is found upon the inner wall of the duodenum in the center of a papilla. A probe may be passed from this part of the duodenum into the common duct or into the pancreatic duct. Between the head of the pancreas and the second part of the duodenum in the injected cadaver there may be seen the anastomosis between the superior and inferior pancreatico-duodenalis arteries: branches derived from the hepatic and superior mesenteric, respectively.

At the level of the third lumbar vertebra the duodenum makes another turn, passing across the body of the third lumbar from the right to the left side of this vertebra, and at the same time ascending to the level of the second lumbar vertebra. This is known as the third part of the duodenum. The aorta, etc., lie behind this part of the duodenum, and the head of the pancreas is situated above it.

Upon the left side of the body of the second lumbar vertebra the duodenum is fixed to the vertebral column by a thickened portion of peritoneum; this fold contains some unstriped muscular fibers, and is called the suspensory ligament of the duodenum, the ligament of Treitz. This third part of the duodenum also is covered only upon its anterior surface by the peritoneum, and is fixed in the back of the abdomen, in common with the pancreas, by this layer. This portion of the duodenum is not to be seen until after the layer of peritoneum which covers its anterior surface and conceals it from view has been torn through. The whole duodenum is curved like a horseshoe, in the hollow of which the head of the pancreas is received.

THE JEJUNUM AND ILEUM, about twenty feet long, make up the rest of the tube of small intestine, and are the direct continuation of the duodenum, terminating in the cæcum in the right iliac fossa. Upon the left side of the second lumbar vertebra, where the duodenum ends and the jejunum begins, the intestinal canal becomes again provided with a complete peritoneal investment and a long mesentery.

The jejunum forms about two-fifths of the length of the small intestine and becomes the ileum where the valvulæ conniventes, which characterize its inner surface, cease to exist. It is thick walled and large in calibre, and therefore resembles somewhat the large intestine;

still, it is readily distinguished from this part of the gut by the absence of the longitudinal striæ and appendices epiploicæ and in not being sacculated.

At its commencement, upon the left side of the second lumbar vertebra, the jejunum seems to project directly forward, through the parietal peritoneum which lines the back of the abdominal cavity. This appearance is due to the fact that the portion of the gut, duodenum, which immediately precedes the jejunum, is not provided with a mesentery; it lies behind the peritoneum and is covered by it upon its anterior surface only, whereas the commencement of the jejunum and the rest of the small intestine are provided with an investment of peritoneum, which completely surrounds them, and a mesentery, which suspends them to the back of the abdomen, and, therefore, where this arrangement commences, the gut appears to project directly forward through the peritoneum from the posterior wall of the abdomen. The process of peritoneum that incloses the first part of the jejunum marks the commencement of the mesentery. The first portion of the jejunum lies in close relation with the posterior wall of the stomach. We can locate it by reflecting the great omentum, and with it the transverse colon, upward out of the way, and then, passing the hand backward, along the under surface of the transverse mesocolon to the vertebral column, this coil of intestine is found lying just to the left of the body of the second lumbar vertebra. An attempt to draw this coil of gut out of the abdomen will show that it is fixed within the abdomen and this fact will serve to identify it positively.

The ileum, which is the continuation of the jejunum, constitutes three-fifths of the length of the small intestine. It becomes progressively smaller in calibre and thinner as we trace it toward its termination at the cæcum, where its wall is thinnest and its calibre narrowest.

The jejunum and ileum are suspended free in the abdominal cavity arranged coil upon coil, and are provided with a complete peritoneal envelope and a long mesentery by which they are attached to the vertebral column in the back of the abdomen.

The Mesentery is a reflection of peritoneum containing some unstriped muscular fiber, fat, etc.; it serves to suspend the gut in the abdomen and at the same time supports the blood-vessels, lymphatics, nerves, etc., in their course to and from the small intestine.

The mesentery is fan-shaped. The distal border is very long, corresponding to the whole length of the small intestine to which it is attached; the proximal border is short and is fixed to the anterior surface of the vertebral column, reaching from the left side of the

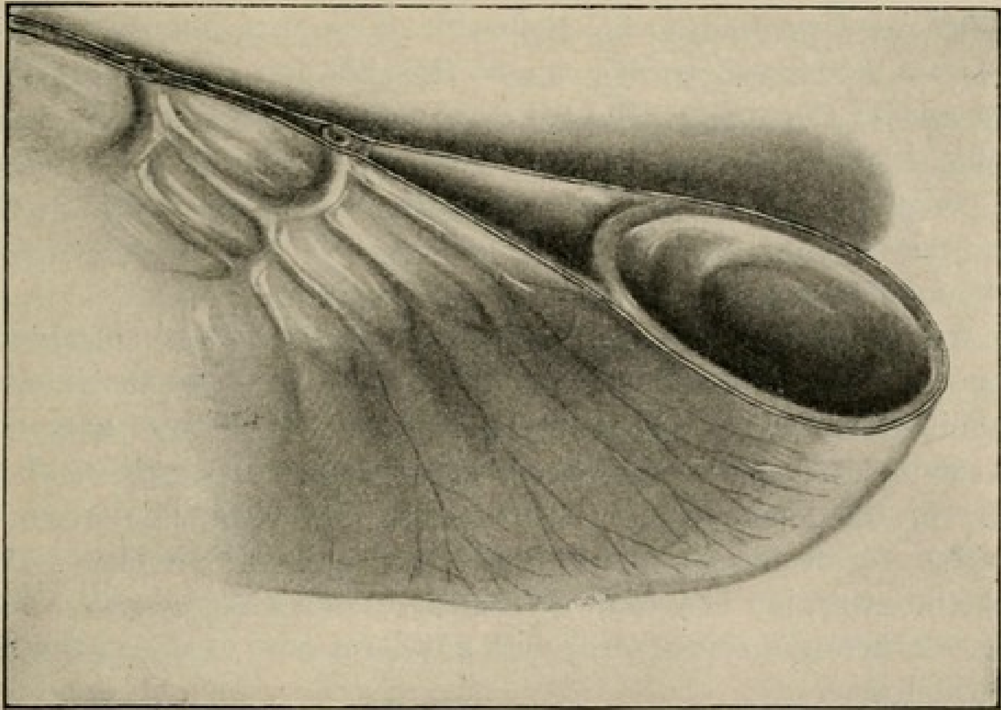

Fig. 188.—Section of Intestine and its Mesentery to show Separation of its Layers and the "Dead Space."

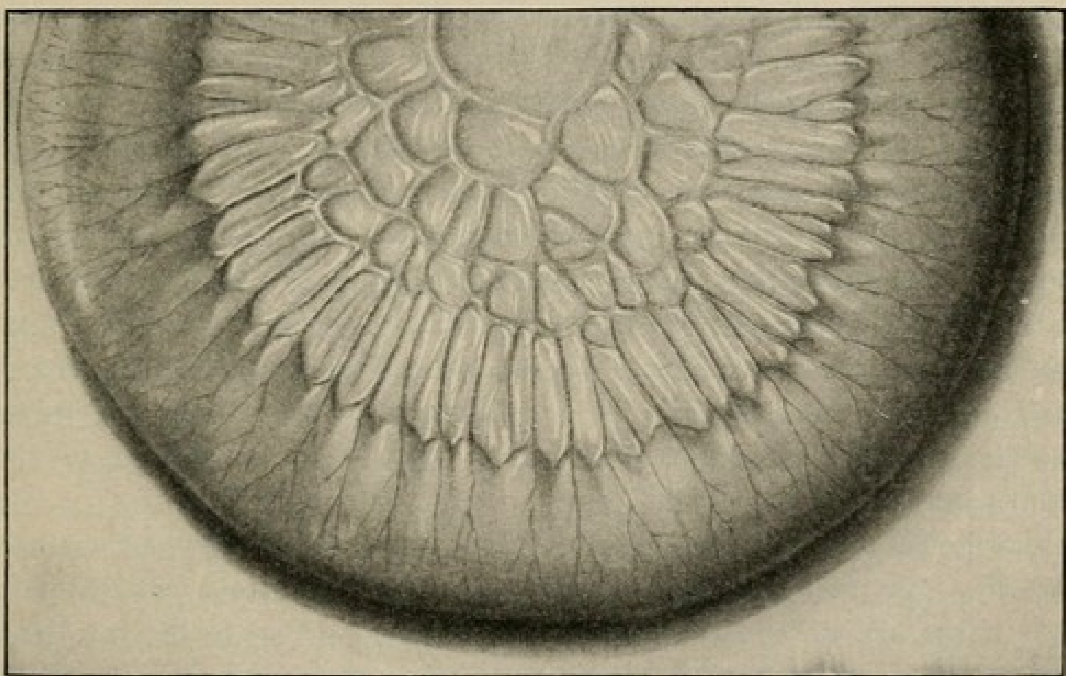

Fig. 189.—Blood-supply of Small Intestine. Absence of free anastomosis between the ultimate vessels may be noted.

second lumbar vertebra, where the duodenum ends and the jejunum commences, downward, to the right side of the fifth lumbar vertebra; its line of attachment is thus oblique from the left side, above, downward and to the right. The vertebral ledge of the mesentery is but six inches long, whereas the distal, intestinal edge is about twenty feet long, and in order to accommodate these two borders to each other the intestinal end of the mesentery is folded and folded upon itself, making a series of plaits.

Where the two layers of peritoneum of which the mesentery is composed meet the intestine, they diverge and surround the intestine in a sling-like fashion, the intestine being entirely invested except for the small "dead space" which corresponds to the separation of the layers of the mesentery at the so-called mesenteric border of the intestine. Here the mesentery is not applied directly to the surface of the intestine, but is separated from it, leaving a small space—"dead space"—where the serous layer does not form part of the wall of the intestinal tube.

THE BLOOD-SUPPLY OF THE SMALL INTESTINE is furnished by the superior mesenteric artery. This vessel is given off from the anterior aspect of the aorta, and passes forward between the lower border of the pancreas and third part of the duodenum; it is located between the layers of the mesentery, and courses, in a curved direction downward and to the right, toward the right iliac fossa. The superior mesenteric is a short, thick trunk. From its convex side it gives off branches to supply the whole length of the small intestine; from its concave side it gives off branches to the large intestine, to the cæcum and vermiform appendix, ascending colon, and transverse colon, finally anastomosing with a branch from the inferior mesenteric (see below). The superior mesenteric vein accompanies the artery and its branches, and behind the pancreas joins with the splenic to form the portal vein. The blood in the portal vein is derived from the intestine; before reaching the general circulation it passes through the liver; it leaves the liver through the hepatic veins, two or three in number, which empty into the inferior vena cava.

The branches of the superior mesenteric, which supply the small intestine, are given off, as already mentioned, from the convex, left, side of the artery. These branches do not pass direct to the intestine, but anastomose with each other, forming a series of arches. From this set of arches another series of branches is given off, and thus this peculiar anastomotic arch formation continues until the intestine is almost reached; finally the individual branches from the ultimate arches are distributed to the wall of the intestine. They pass to the intestine from between the layers of the mesentery, where these separate to envelop the intestine—that is, at the mesenteric border—through the so-called "dead space." After the ultimate vascular branches reach the wall of the gut they do not communicate freely with each other; therefore each segment of gut is dependent almost exclusively upon one or two definite vessels for its nutrition and integrity. The same arrangement holds good for the ultimate veins. If several of these ultimate vascular branches are severed close to the gut or become embolized or thrombosed, we are apt to have, as a result, gangrene of the corresponding segment of the gut. Wounds of the intestine at the mesenteric border are unfavorable for suture on account of the absence of the serous, peritoneal covering, at this part. Wounds at the mesenteric border of the gut almost of necessity include division of the ultimate intestinal arteries and veins, and therefore interfere seriously with the blood-supply to the corresponding part of the gut.

OPERATIONS UPON THE SMALL INTESTINE.

Enterotomy.—Incision into the small intestine. For the removal of foreign bodies from the intestine. The operation may also be done during the course of laparotomy for acute intestinal obstruction, after the obstruction has been relieved, for the purpose of emptying the bowel above the point where it was obstructed; or the operation may be deliberately undertaken with the object of relieving the bowel of its poisonous contents in advanced cases of acute peritonitis. In cases of acute peritonitis the contents of the distended paralyzed bowel are oftentimes excessively poisonous and are the chief source of the toxins that endanger the patient's life.

A coil of gut is selected and constricted with a piece of narrow tape. The coil of gut is then emptied by stripping between the fingers and a second piece of tape passed around the gut and tied; or rubber-sheathed holding clamps may be used to compress the gut. The coil of gut which has thus been emptied is incised. According to the plan of Moynihan a long, straight, glass tube with a length of rubber tubing attached to one end is introduced through the incision in the bowel, and after the constricting tapes or clamps are removed the glass tube is pushed gently onward into the gut, at the same time drawing the gut over the tube. In this way a considerable length of the bowel may be reached by the tube and emptied. The bowel may be flushed with salt solution by puncturing it high up with a medium-sized needle with tube and funnel attached. Above the place of puncture a constricting tape or clamp is placed upon the gut. As the water runs into the intestine the glass tube is slowly withdrawn, being followed down by the stream of water, which enters the bowel through the needle and escapes from the intestine through the glass tube. The openings in the bowel are closed with several Lembert sutures of silk.

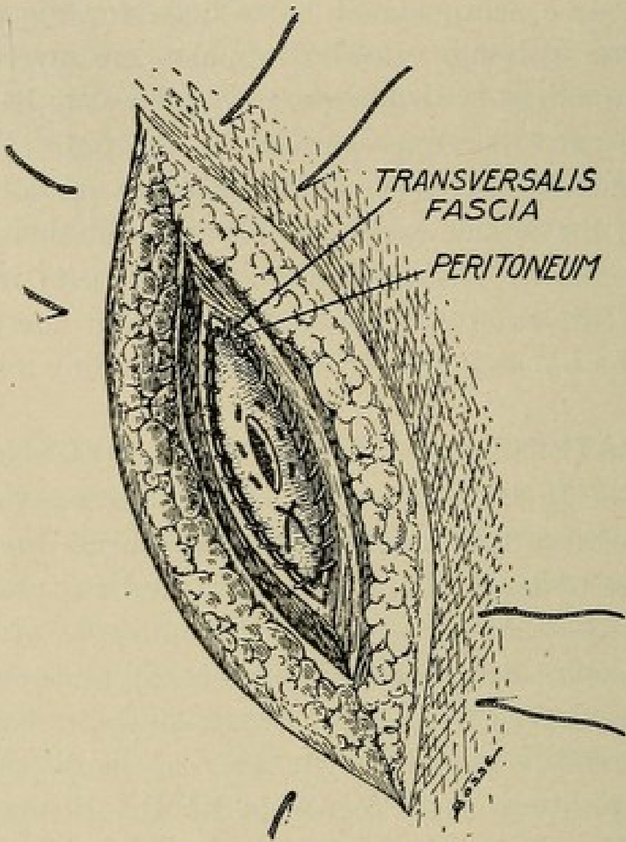

Fig. 190.—Enterostomy, temporary. The wall of the gut has been sutured all around to the edges of the peritoneum and fascia transversalis with a non-penetrating stitch. A purse-string has been introduced in the wall of the intestine, which has been incised to permit introduction of a tube.

Enterostomy.—The establishment of an opening into the small intsetine for the purpose of providing temporary drainage of the intestinal canal, temporary enterostomy, or may be for the purpose of introducing nutriment in cases of inoperable malignant disease of the stomach, etc., permanent enterostomy, for example, "Jejunostomy."

Temporary Enterostomy is resorted to in cases of acute septic peritonitis with distention and paralysis of the bowel. The contents of the intestinal canal undergo septic changes and form the chief source of the poisons that are absorbed. Striking improvement will often be observed in these cases after irrigation of the stomach and large bowel—the patients are relieved of at least a part of the septic material. In many cases, however, these measures are not sufficient to eliminate the poisons, and direct drainage is provided by making the opening into the intestinal canal. Some very desperate cases of acute septic peritonitis may be saved by this means. The fistulous opening may be expected to close spontaneously in many cases after it has served its purpose.

The patients are often in collapse, so that the operation must be completed promptly and usually under local anæsthesia.

The incision is made in the right iliac region. An incision similar to that which is usually made for appendicitis is employed. When the abdomen is opened the gut may be found adherent, so that it cannot be drawn out of the incision. Under these circumstances the distended coil of intestine is fixed to the edges of the parietal peritoneum and fascia transversalis. The lower down, nearer the cæcum, the coil of gut which is secured, the better, or the cæcum itself may be used if it presents in the incision. The coil of gut is fixed to the edges of the peritoneum and fascia transversalis, all around, with a continuous suture of fine silk carried in a thin curved needle. The suture does not penetrate the entire thickness of the wall of the bowel. One or two sutures of silk are introduced in each end of the incision and penetrating all the layers of the abdominal wall, including the peritoneum. These stitches are introduced before the gut is sutured to the edges of the peritoneum, but they are not tied until after this succeeding step of the operation has been accomplished. They serve to close the incision for part of its extent. A small opening is made in the bowel with a narrow-bladed knife. When the bowel is opened a rubber tube is introduced into the bowel and fixed near the edge of the opening with a chromic catgut suture. The edges of the opening in the bowel are drawn tightly around the tube with a purse-string suture of chromic catgut, which is introduced before the gut is incised. By this means the discharge from the bowel will be prevented from leaking around the tube, and will be conducted away from the incision at least for a few days until the tube works loose.

The edge of the skin are covered with rubber tissue, and the incision packed around the tube with iodoform gauze. It is desirable to delay incising the bowel, if the conditions will permit, if only for a period of twelve hours, in order to allow time for adhesions to form between the bowel and the edges of the peritoneum.

When the gut is not adherent and can be drawn out of the abdominal incision, it may be opened immediately and a rubber tube or a Paul glass tube introduced. A coil of distended gut is drawn out of the incision and emptied of its contents as completely as possible by stripping between the fingers, and two rubber-sheathed compressor forceps applied or two pieces of narrow tape tied around the gut. Gauze compresses are placed around and under the coil of gut to protect the peritoneal cavity. A small incision is made in the bowel and the tube introduced, and the edges of the opening in the bowel drawn tight around the tube with a through-and-through purse-string suture of chromic catgut. The purse-string suture is introduced before the bowel is incised. If a rubber tube is used it is fixed with a catgut stitch which passes through it, to the edge of the incision in the gut. The compressor forceps or tapes are removed from the gut and a clamp placed temporarily upon the end of the rubber tube to prevent escape of intestinal contents during the final steps of the operation. The gut is fixed to the edges of the abdominal incision with two or more sutures of chromic catgut. These sutures pick up the wall of the gut a short distance above and a short distance below the place where the tube emerges. They take several good broad bites in the wall of the gut without penetrating and catch the edges of the peritoneum and transversalis fascia on either side of the incision. When these sutures are tied later they serve to suspend the coil of gut and fix it to the peritoneal edges in the incision. The incision is closed in part by one or two through-and-through sutures of fairly heavy silk which are placed in the upper and in the lower end of the incision. After the through-and-through sutures have been introduced the two suspension sutures of catgut that secure the gut are tied and finally the through-and-through sutures are tied.

The edges of the skin are covered by rubber tissue and the incision packed around the tube with iodoform gauze.

Permanent Enterostomy is made, usually, for the purpose of introducing nutriment in cases of inoperable cancer of the pylorus, etc. The Maydl operation may be employed or the fistulous tract may be established according to the plan of Witzel, as described in gastrostomy, by infolding a rubber catheter in the serous surface of the wall of the intestine.

Jejunostomy, Maydl.—The formation of a jejunal fistula for the purpose of feeding. The procedure is employed in those cases of inoperable malignant disease of the pylorus where a gastro-jejunostomy cannot be made.

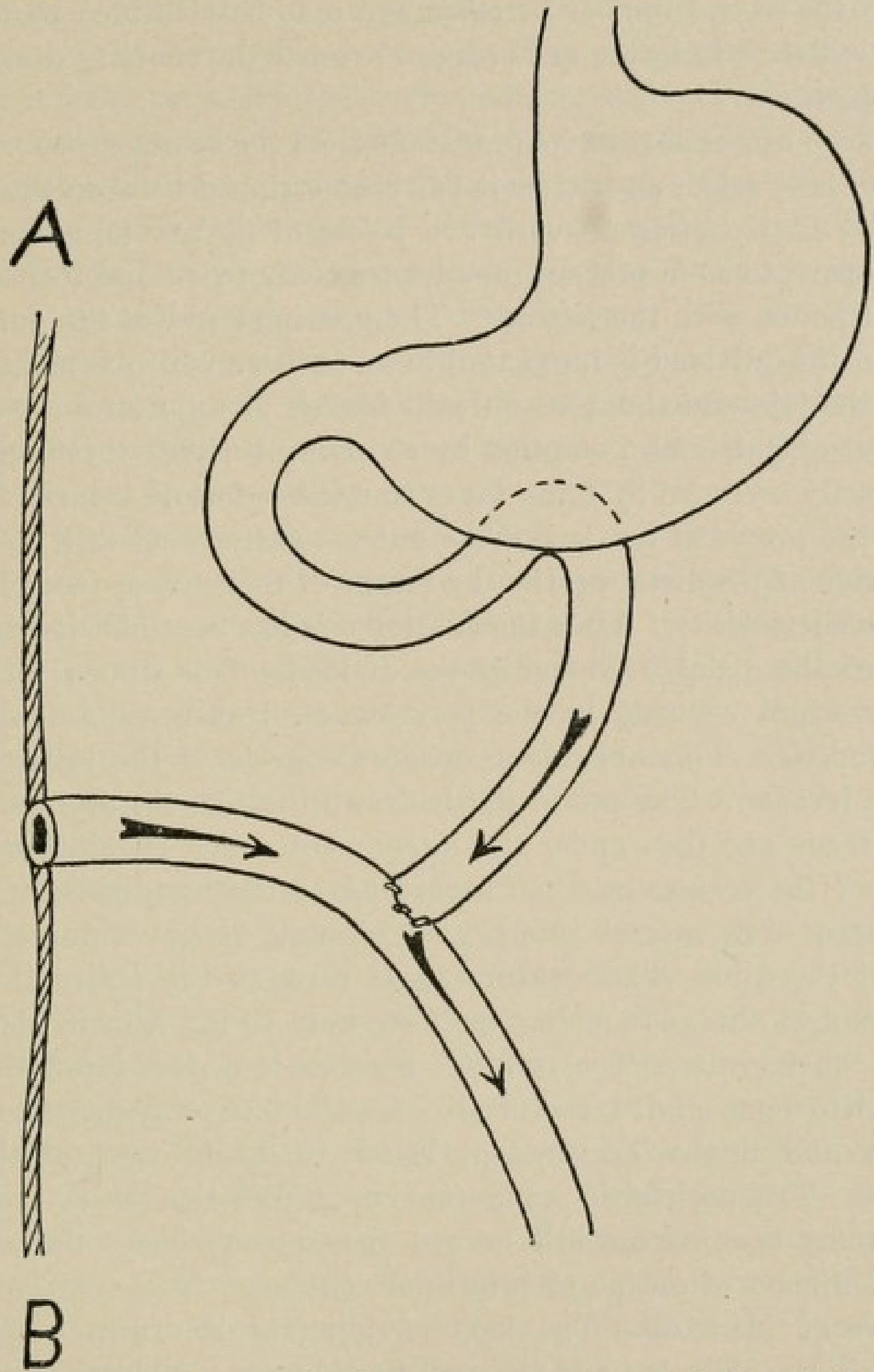

Fig. 191.—Jejunostomy (*Maydl*). The upper segment of the gut has been anastomosed into the side of the lower segment. The end of the latter has been fixed in the incision in the abdominal wall *A-B*. The arrows indicate direction of the peristaltic wave.

The abdomen is opened by an incision through the middle of the left rectus, reaching upward from the level of the umbilicus for a distance of three or four inches. Through this incision the operator is able to investigate the condition of the stomach, etc.

The uppermost portion of the jejunum is sought for and drawn out of the incision. This part of the gut is found to the left of the body of the second lumbar vertebra and may be identified by the fact that it is fixed within the abdomen and resists the effort to draw it out of the incision.

A loop of gut about 20 cm. distant from the commencement of the jejunum is selected, and, after it has been stripped between the fingers to empty it, it is tied off with two pieces of narrow tape five or six inches apart, so as to prevent re-entrance of contents, and then divided straight across with the scissors. The proximal end of the gut which has been thus divided is implanted in an incision which is made in the side of the jejunum about 20 cm. still farther along, nearer the cæcum. This coil of gut is also emptied by stripping between the fingers and temporarily occluded by tying tapes about it before it is incised. The end of the proximal portion of the gut is anastomosed to the opening in the side of the distal portion by means of the sutures (see "End-to-Side Anastomosis"). After the anastomosis has been effected as above described the distal, free end of the divided coil is drawn through a separate small opening in the peritoneum, transversalis fascia and rectus muscle. This opening is made alongside of the lower end of the first incision. The end of gut is drawn through the opening which is thus made and then under the integument which is raised with the handle of the scalpel into the lower end of the first incision, and is there fixed with several interrupted chromic catgut sutures to the edges of the skin. These sutures pass through the entire thickness of the end of the gut and fasten it securely to the skin in the lower end of the incision. The original incision is closed, layer by layer, first peritoneum and transversalis fascia, then muscle, then aponeurosis and finally skin except below where the end of the gut presents. The peristaltic wave runs in a direction away from the jejunostomy opening onward toward the cæcum; hence there is but little likelihood of escape of intestinal contents.

Witzel Method.—The loop of jejunum is drawn out of the incision in the abdomen and the wall folded over a rubber catheter the end of which pierces the gut through a small incision in a manner similar to that described in the Witzel method of gastrostomy. The abdominal incision is closed except at the place where the catheter protrudes.

Enterorrhaphy.—Suture of the intestine for gunshot and stab wounds and for perforations due to ulceration, typhoid, chronic duodenal ulcer, fistulæ, etc.

For Gunshot and Stab Wounds.—These injuries are usually accompanied by hemorrhage from wounded vessels in the mesentery. The several vessels should be ligated with catgut. If large, and especially if divided close to the gut, it is well, after ligating the bleeding vessels, to resect the corresponding segment of the gut, as such injuries are very apt to be followed by gangrene of that part of the intestine which is dependent for its supply upon the injured vessels. The incision for injuries of this character is usually made in the middle line four or five inches long, reaching from the umbilicus downward toward the symphysis. The incision may be prolonged upward toward the ensiform cartilage, passing to the left of the umbilicus. The operator should avoid laying the abdomen open from the ensiform cartilage down to the symphysis pubis in the eagerness of his search for wounds in the gut.

After the abdomen has been opened, a careful and systematic examination is made of the intestine from one end to the other, commencing at the lowest part of the ileum, where it enters the cæcum. This part of the gut should be sought and drawn out upon the abdomen and from this point onward the small intestine and mesentery are carefully inspected, coil after coil being drawn out and examined and then replaced, continuing thus until the upper end of the gut has been reached.

As a rule, penetrating gunshot and stab wounds of the abdomen are accompanied by multiple perforations of the gut and mesentery—may be as many as fifteen or twenty,—and, when one perforation in the gut is located, usually a second is found in the same segment at a corresponding point opposite. Each time a projectile passes through the gut it makes two wounds—one of entrance and one of exit.

Where a perforation of the gut is located the mucous membrane is usually found protruding and tending to plug up the opening, nature's effort. Here we pause, replace the mucous membrane, wipe off the margins of the opening with a gauze pad moistened with alcohol followed by one wet with saline solution, and then close it with two or three interrupted Lembert sutures of fine silk; these sutures are placed about one-eighth inch apart and care should be taken to invert the edges of the wound and to bring the serous surfaces into close apposition. The wounds may also be closed with a purse-string suture applied in a circle around the margin of the opening. In suturing these wounds care should be taken not to reduce the calibre of the intestine more than one-third.

We then continue in the search for further wounds. Those involving the mesenteric border of the gut, especially if the adjoining mesentery is torn, are unfavorable for suture; in the first place, the serous coat on this part of the gut is imperfect, has a "dead space"; and, in the second place, if any of the mesenteric vessels are divided close to the gut, the corresponding segment of the gut on account of interference with the blood-supply is apt to become gangrenous; therefore it is wise, in many of these cases, to resect such a segment of gut at once.

Bleeding vessels in the mesentery are clamped and tied with plain catgut.

After the whole length of the small intestine has been explored the surgeon should examine the entire length of the large intestine, the stomach, and the bladder for perforations, and look further for hemorrhage, which might indicate wounds of the liver, spleen, kidneys, etc.

Hemorrhagic oozing from the solid viscera is usually readily controlled with the Paquelin cautery or by packing, or the edges of a gaping wound may be brought together with several deep catgut sutures, although these tend to tear through if much tension is made. Any spurting vessels in the solid viscera should be clamped and tied with catgut.

Having thus completed the examination of the entire length of the alimentary canal, etc., closed all wounds, and controlled the hemorrhage, the whole abdominal cavity may be flushed out with hot saline solution, using a considerable quantity—best poured from a pitcher in order to wash out material that may have escaped from the stomach and intestine.

During the search for wounds, etc., the gut should be replaced, coil after coil, as fast as it is examined. While the intestine is outside the abdomen it should be carefully protected with hot sterile towels, which may be wet in hot saline solution. After a time the wet cloths, if not repeatedly wet with hot water, become cooled; therefore some surgeons prefer dry sterile compresses for this purpose.

If necessary to have a considerable portion of the length of the gut outside upon the abdomen, it should be supported so that it does not drag upon the mesentery, and care should be exercised that the gut does not become twisted upon its mesentery to such an extent as to interfere with the venous return. The withdrawal of a considerable portion of the length of the gut out of the abdomen should be avoided however, as much as possible, as the shock is greatly augmented and there may be some difficulty experienced in returning the distended coils of gut back into the abdomen again.

If, owing to the distention of the guts with gas, it becomes difficult to replace them within the abdomen, it may be necessary to puncture them in order to allow the gas to escape. For this purpose it is better to make a rather larger opening with the knife and introduce a glass tube into the gut in either direction to facilitate the escape of gas, etc. The incision in the gut is afterward closed with a Lembert suture.

The abdominal incision is carefully closed layer by layer, the peritoneum and fascia transversalis with plain catgut, the edges of the muscle with several stitches of plain catgut and the aponeurosis with a continuous suture of chromic catgut and finally the skin.

For Typhoid Perforation.—Perforation of the bowel at the site of an ulcer may occur any time during the course of typhoid fever from the first week up to the termination of the disease. Perforation occurs most commonly during the third week. It is more frequently seen in adult males than females and is rather rarely seen in children. Operation saves about 25 per cent. of the cases.

The perforation is found in the ileum, usually the last two feet, in about 80 per cent. of the cases; in about 12 per cent. the perforation is located in the large intestine; and in about 5 per cent. in the appendix. The perforation is usually single, but they may be multiple. The perforation is accompanied by peritonitis, either local or general. Perforation of ulcer in "walking cases" of typhoid may be mistaken for cases of acute gangrenous appendicitis.

Operation should be undertaken as soon as the diagnosis is made and in case of doubt an exploratory incision may be resorted to. This can be done under cocain if desirable.

Incision is made through the right rectus as for appendicitis and should be sufficiently liberal so as to permit of proper work—may be five to six inches long. The median incision from the umbilicus downward is sometimes employed, but that through the outer part of the rectus gives much better access to the portion of the bowel which is usually the site of the perforation. When the abdomen is opened there is, as a rule, an escape of sero-purulent fluid. There may or may not be some inflammatory adhesions present which serve the purpose of walling off the damaged portion of the bowel from the general peritoneal cavity.

The cæcum is sought and drawn into the incision and used as a guide to the appendix and commencement of the small intestine.

The appendix, if perforated or seriously affected, is removed. Commencing at the cæcum, the small intestine is drawn out, coil after coil, and carefully inspected and wiped clean with gauze pads or it may be washed with salt solution. If desired this investigation may be continued until the entire small intestine has been examined. If the coils of gut are not immediately returned to the abdominal cavity but are retained outside the abdomen, they must be supported and protected with hot, sterile towels.

The perforations vary in size from a pinhead to a fairly large, ragged opening. Usually there is only one perforation, but there may be several. The hole in the gut is closed, without paring its edges, with non-penetrating sutures of silk. A purse-string suture may be applied around the margin and the opening thus closed or one or two rows of interrupted Lembert sutures can be used. These may be applied in mattress fashion. It is immaterial whether the opening is closed in a direction longitudinal or transverse to the long axis of the gut, but care must be taken not to reduce the calibre of the gut too much—surely not more than one-third. If any very thin areas are encountered during the examination of the intestine it might be advisable to take a stitch or two in such portions of the gut in order to fortify them against the danger of perforation later.

If the opening in the gut can be closed and the peritoneal cavity thoroughly cleansed either by wiping with dry gauze pads or by irrigation with salt solution, it may be permissible to close the abdominal incision without drainage. In doubtful cases it is well to provide for drainage. If it is decided to use drainage a plug of strip gauze is introduced into the abdomen, reaching well down into the pelvic cavity. The abdominal incision is closed except where the drainage strip emerges. Drainage may be facilitated by keeping the patient in a partly sitting posture after the operation.

If the gut is badly damaged or very much thickened about the perforation or presents several openings close together it may be wise to resect the affected portion and restore the continuity of the gut by an end-to-end anastomosis; a better plan under these conditions would probably be to draw the damaged coil of gut out of the abdomen and fix it to the edges of the incision with several non-penetrating sutures of chromic catgut and thus establish an intestinal fistula (see "Enterostomy").

If it is found at the time of operation that the soiling of the peritoneum has been general it may be advisable to turn the entire small intestine out of the abdomen in order to cleanse the peritoneal cavity either by wiping with dry, sterile gauze pads or else by irrigating with saline solution; after the intestines have been treated in a similar manner they are returned to the abdomen. Drainage is arranged in these cases as already indicated above.

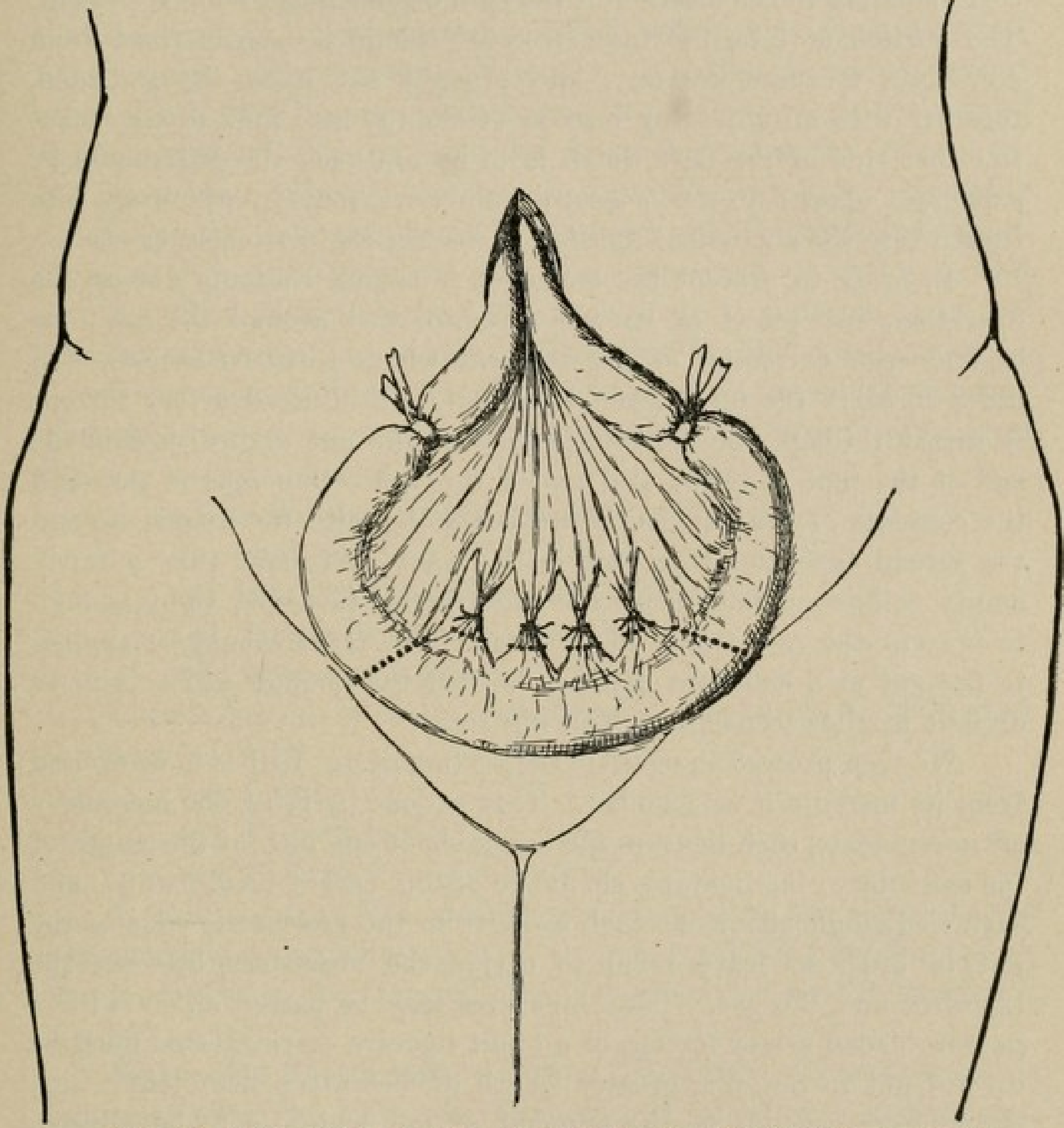

Fig. 192.—Enterectomy. A loop of intestine has been drawn out through the abdominal incision and tied off with tapes. The mesentery corresponding to the portion of gut that is to be excised has been tied off in sections. The dotted lines indicate the lines of section through the mesentery and gut.

Enterectomy.—Resection of a portion of the gut (small intestine); the length of gut resected may vary from several inches to several feet. The operation is performed for wounds which may not be safely closed by suture; for those associated with division of the mesenteric vessels, especially if they are divided close to the intestine; for malignant growths; for gangrene, strangulation; for fistula, etc.

The incision is usually made in the middle line, four or five inches long, reaching from the umbilicus downward toward the symphysis or corresponding to the location of the fistulous opening if one is present. The portion of intestine to be resected should be gently freed from adhesions, if there are any, and brought out upon the abdomen, together with an adjoining portion of healthy gut, four to six inches to either side of the part which is to be resected; the gut should be supported upon dry, sterile gauze compresses, some of which are also tucked into the abdominal incision to protect the peritoneal cavity.

In order to prevent the escape of intestinal contents during the operation, two pieces of narrow tape are tied around the gut, one beyond each extremity of the segment which is to be excised. In order to carry the tapes around the gut, a thin-nosed artery forceps is thrust through the mesentery close to the gut and with this the end of the tape is seized and pulled through. One tape is tied and the contents of the gut gently stroked along with the fingers beyond the second tape and then this is tied also. We have thus a fairly empty coil to operate upon, the tapes being tied just tight enough to prevent the re-entrance of contents. The tapes should be applied to the gut at a sufficient distance beyond the portion which is to be excised to allow convenient working space.

We then proceed to separate the portion of gut that is to be excised from its mesenteric attachment. This is done by tying the mesentery off in segments, each ligature including about one inch of the length of the mesentery; the ligatures should be of thin catgut (No. 1 or 2), and each tied single about one inch away from the mesenteric edge of the gut in order to leave room to divide the mesentery between the ligatures and the gut. These ligatures may be passed either with a narrow-bladed artery forceps or a blunt ligature carrier. One must be careful not to tie off a greater length of mesentery than that which actually corresponds to the segment of gut which is to be excised, because gut which has been deprived of its mesentery is deprived of its blood-supply and is bound to slough. The surgeon should rather err in the other direction, tying off a little less mesentery than that which corresponds to the length of the segment of the gut that is to be excised. After the mesentery has been thus tied off, the segment of gut that is to be excised is cut away from its mesenteric attachment, using the straight scissors and cutting between the ligatures and the gut; the point of the scissors should be introduced into the openings made by the ligatures and the mesentery cut from hole to hole and thus finally through into the last ligature opening. We are then ready to sever the gut and this is done with long, straight scissors that will divide the gut in one clean sweep. The gut is divided straight across at right angles to its long axis, or, still better, somewhat obliquely, so that the segment of gut excised measures rather more upon its distal border than upon its mesenteric border. Bleeding points on the cut edges of the intestine are clamped, but, as a rule, these do not require ligation, since after a few moments' pressure or after the ends of the gut have been sutured, the hemorrhage usually stops. Spurting arterial points, however, should be clamped and tied with fine catgut. Contents that escape from the ends of the bowel are sponged away and care should be taken that the pads of gauze are so arranged as to prevent the entrance of any of this material into the abdominal cavity.

We are now ready to restore the continuity of the intestinal canal. This step may be accomplished by any one of the several procedures that are described below.

1. End-to-end anastomosis, the most desirable.
   (*a*) Suture.
   (*b*) Invagination and suture (Mounsell).
   (*c*) Suture by Connell method.
   (*d*) Murphy button.

2. Side-to-side, or lateral, anastomosis; applicable to both small and large intestine.
   (*a*) Suture.
   (*b*) Murphy button.
   (*c*) McGraw's rubber ligature.

3. End to side; this method is used to join the ileum to the large intestine (see "Resection of Cæcum") and to join the end of the duodenum to the stomach after pylorectomy (see "Pylorectomy, Kocher"), etc.

End-to-End Anastomosis. SUTURE (McGrath).—The ends of the intestine, after they have been cleansed and wiped with a gauze pad moistened with saline, are sewed together all around with a through-and-through suture of chromic catgut.

Two straight cambric needles are threaded on a piece of chromic catgut, No. 1, about twenty-four inches long and, with this the two ends of the bowel are joined together at their mesenteric border in such a manner that the "dead spaces" are obliterated and the serous surfaces are secured and brought into accurate and close apposition. The proper application of this mesenteric suture is essential to the success of the operation. The mesenteric border, "dead space," is likely to be the weak point in end-to-end anastomosis, and this suture secures it absolutely. The stitch passes through the edge of the gut at the mesenteric border, piercing the gut from its mucous aspect about one-quarter inch away from its edge; it traverses the "dead space" and pierces the mesenteric serous layer; it then pierces the mesenteric serous layer of the other end of bowel, passes through the "dead space" and the edge of the gut, emerging upon the mucous surface of the second piece of the bowel. Here

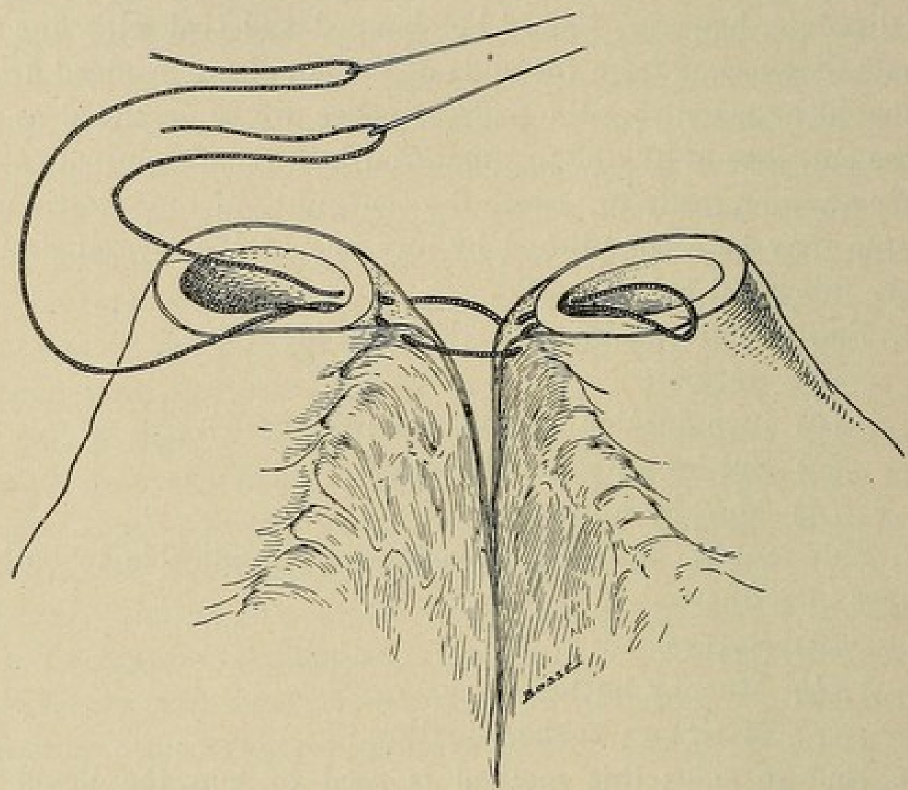

Fig. 193.—End-to-End Anastomosis. The mesenteric suture has been introduced. Note how it traverses the "dead space."

it turns back, forming a loop upon the mucous surface of the second end of bowel and, traveling in the reverse direction to that already described, it passes again through the two ends of the bowel and finally emerges upon the mucous surface of the first end of bowel alongside of the point where it originally started. It will be observed that when this suture is drawn tight and tied it brings the two ends of the gut, corresponding to their mesenteric borders, together very accurately and obliterates the "dead spaces" and necessarily brings the mesenteric serous surfaces into close apposition with each other. The two threads corresponding to the tails of the suture, and each provided with a needle, are used to unite the corresponding edges of the two ends of the gut, sewing around

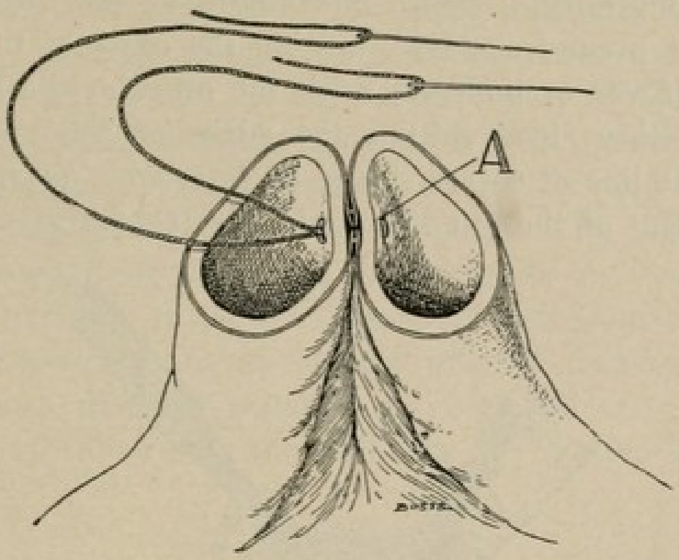

Fig. 194.—End-to-End Anastomosis. Mesenteric suture, *A*, drawn tight and tied. Shows accurate apposition of the mesenteric borders of the gut and complete obliteration of the "dead space."

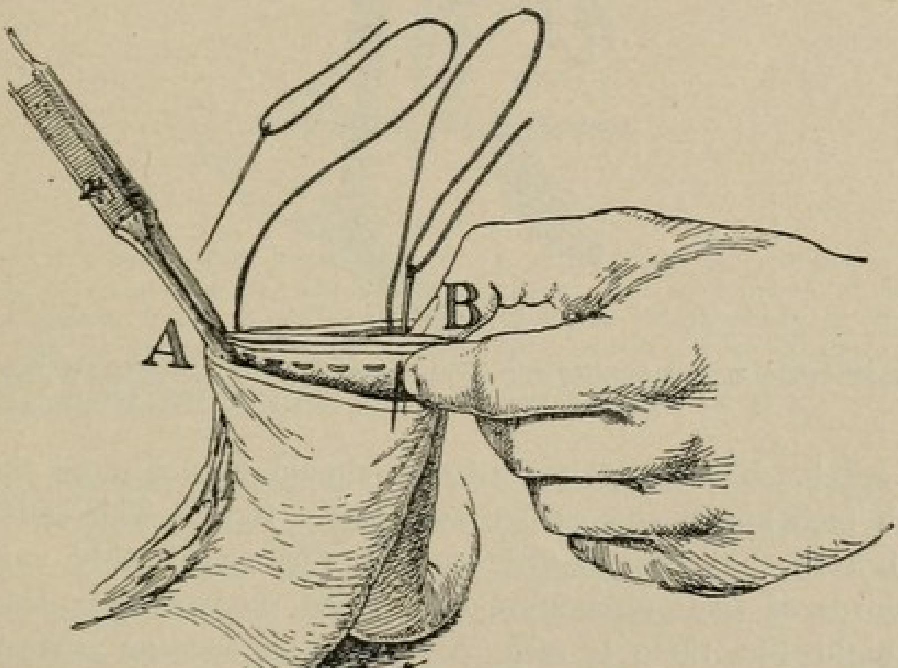

Fig. 195.—End-to-End Anastomosis. Edges of gut seized with self-holding forceps at *A*. Edges of gut sutured from *A* as far as *B* with one of the tails of the mesenteric suture.

one side with one needle and around the other side with the other needle, and commencing with each at the fixed point, the mesenteric border, which is identified in the illustration as point *A*. To facilitate the introduction of the suture the edges of the gut corresponding to the mesenteric stitch *A* are secured in the grasp of a toothed holding-forceps. With one needle we sew from the mesenteric stitch *A* around one side, uniting the edges of the gut toward *B* nearly half-way around, and with the other needle from point *A* around the other side, uniting the edges of the gut toward the point *C*. The line of suture should be inserted a quarter of an inch below the edges of the gut so as to insure catching both edges with

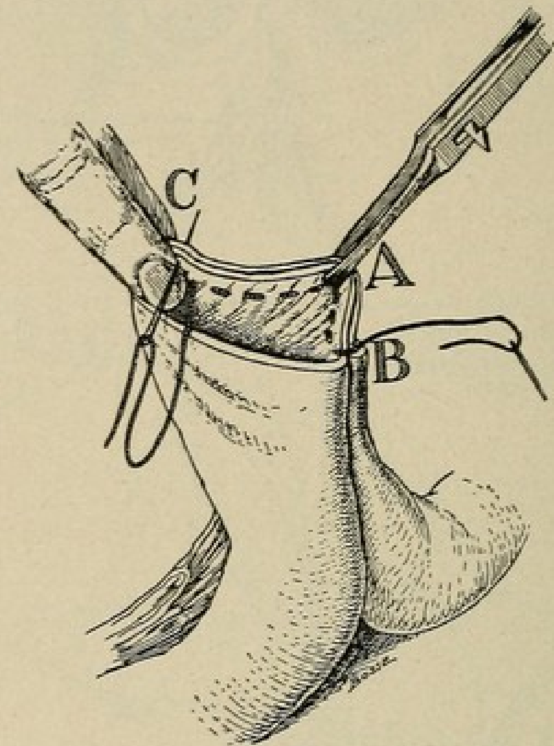

Fig. 196.—End-to-End Anastomosis. The edges of the gut sutured together from *A* as far as *C* with the other tail of the mesenteric suture.

each stitch. The individual stitches should be not more than one-eighth inch apart, and each drawn fairly tight. The ends of the bowel have thus been sewed together for considerably more than two-thirds of their circumference. When the gut is pulled out in a straight line there is seen to remain an opening corresponding to less than one-third of the circumference still to be closed. The needles are thrust through the edge of the bowel so that they present upon the outer surface, and partly with one needle and partly with the other the opening that still remains is closed. A Lembert stitch is used for this purpose. Each stitch takes a good deep bite even at the risk of penetrating into the mucous layer. Finally the anastomosis is completed by tying the two threads together.

The lines of union of the two ends of gut may be reinforced by applying a silk Lembert suture all around. This is, however, as a rule unnecessary, yet it is easily and quickly applied after the ends of the gut have been joined together as described above.

The hole that is left in the mesentery after the segment of gut has been resected and the ends sutured, is closed with several sutures of catgut. These sutures should not be tied so tightly as to obliterate the vessels that may be included in their grasp and which are necessary for the supply of the gut at the line of junction.

The constricting strips which were placed around the gut are removed and the sutured bowel returned into the abdomen.

Mounsell's Method.—After the segment of gut has been excised as above described, the cut ends are placed close together

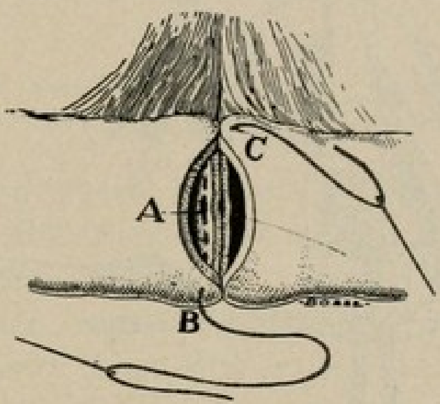

Fig. 197.—End-to-End Anastomosis. The axis of the gut restored. The opening that still remains, less than one-third of the circumference, is closed with a Lembert suture, using both tails of mesenteric suture in part to accomplish this. *A* shows location of the mesenteric suture. *B* and *C* where the needles are thrust through the edges of the gut preparatory to introducing the final Lembert suture that closes the opening that remains.

edge to edge and supported outside the abdomen upon gauze pads. With a moderately large, straight needle and fairly thick silk the edges of the cut ends of the gut are fixed to each other at four different points of their circumference equidistant from one another. These sutures are to serve simply as tractors. The first is applied at a point corresponding to the mesenteric attachment, the second at a point directly opposite this, and the other two at points midway between these. Each of these sutures should include all the coats of the gut, special care being taken to catch the mucous membrane and the serous coats. Each suture is applied from within the gut, so that, when tied, the knot will be upon the inner, mucous membrane aspect of the gut. As each of these four tractor sutures is passed, it is immediately tied and one end cut short, leaving the other end long. In tying, the sutures should be tied rather loosely so that afterward they may be readily removed.

In one or the other segment of the gut, a longitudinal incision is then made. This incision is placed opposite the mesenteric border, should be about one inch long, and commences about one and one-half inches distant from the cut edge of the gut. Through this incision a narrow artery forceps is passed into the gut and the tails of the four tractor sutures seized and pulled through, thus drawing the ends of the gut after them, with the result that the one segment of gut is invaginated into the other, their serous surfaces lying in contact with each other and their corresponding edges

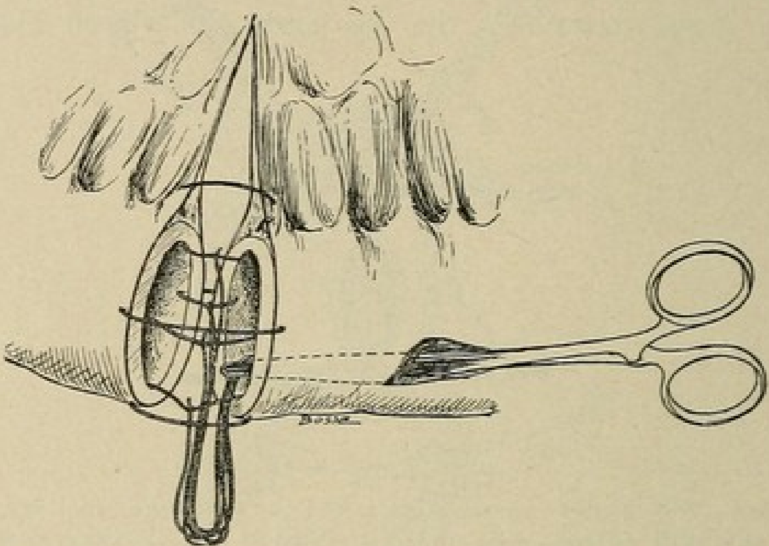

Fig. 198.—End-to-End Anastomosis (*Mounsell*). The four tractor sutures have been introduced, the ends seized with a forceps passed through an incision in one segment of the gut.

in apposition all around. The four tractor sutures are held by assistants and put somewhat upon the stretch and then the corresponding edges of both segments of the gut are ready to be joined by suture. The edges are sewed together with a through-and-through stitch, using a straight needle and chromic catgut. This suture should be applied about one-quarter inch below the edges of the gut so as to leave a margin that wide between the suture line and the edges of the gut. The stitches should be placed quite close together (intervals of one-eighth inch between the needle punctures) and each stitch should be drawn fairly tight. In order to avoid a "puckering or purse-string" effect in the suture a "back-stitch" should be taken every fourth or fifth puncture.

After the edges of the segments of the gut have been united as above described, the temporary tractor sutures are removed and the gut restored to its natural position by reducing the invagination. The incision in the gut is closed with a continuous Lembert stitch.

All around the circular junction of the segments, after swabbing with a pad moistened with alcohol, followed by one wet with

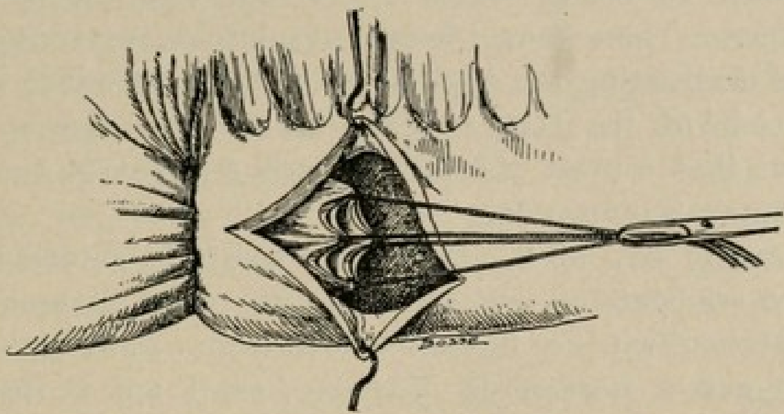

Fig. 199.—End-to-End Anastomosis (*Mounsell*). Shows how the ends of the gut are invaginated by pulling upon the tractors.

saline solution, a continuous Lembert stitch of fine silk may be applied; this suture still further inverts the edges of the gut and buries completely the penetrating, through-and-through suture. This additional outside line of suture is considered unnecessary by most surgeons, especially if the through-and-through suture has been accurately applied.

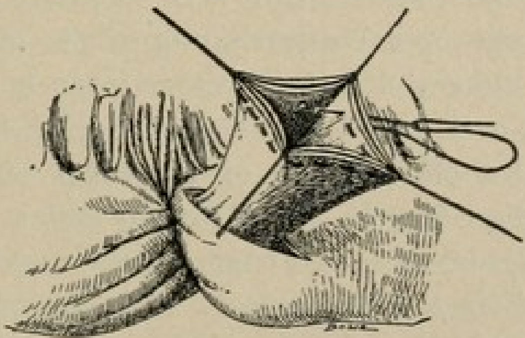

Fig. 200.—End-to-End Anastomosis (*Mounsell*). The two ends of the gut have been drawn through the incision in the gut. The tractors are held taut and the edges of the two ends of gut united all around with a through-and-through suture.

Connell Method.—According to this plan a through-and-through, right-angled suture is employed. The edges of the two ends of the gut that are to be united are held in apposition during the application of the suture with four tractor sutures. The first tractor secures the edge of either end of the gut at its mesenteric border. A second tractor pierces the edge of each segment of the bowel at a point a little more than half-way between the mesenteric border, where suture No. 1 has been introduced, and the distal border. Tractors Nos. 3 and 4 each catch the edge of the corresponding segment of the bowel at a point the same distance from its mesenteric border as suture No. 2, but upon its opposite, the outer, border. These four tractors are introduced simply for the purpose of facilitating the application of the suture that is to unite the two ends of the bowel. They are of silk and as they are drawn taut they convert the end of each segment of the gut into a triangular-shaped opening.

The second step of the operation consists in suturing the ends of the two segments of the bowel to each other all around. This is accomplished with a through-and-through, right-angled suture. While the gut is steadied by tractors Nos. 1 and 2, held by the assistant, the apposed edges of the gut are sutured together, commencing near tractor No. 2 and working toward and a little beyond tractor No. 1, which marks the mesenteric border of the gut. In this way the union between the two ends of gut is accomplished for the first third of their circumference. After the first stitch has been introduced the thread is tied, the tail of the suture being left long.

Tractor No. 2 is then cut away and traction made with tractor No. 1. At the same time tractors Nos. 3 and 4 are drawn around so as to approximate the corresponding edges of the two ends of the gut for that portion of their circumference which is included between tractor No. 1 and tractors Nos. 3 and 4. With the same needle and thread these portions of the edges of the gut are then united, working from tractor No. 1 toward and a little beyond tractors Nos. 3 and 4, and thus the edges of the gut are united for the second third of their circumference. The line of suture should be placed one-quarter inch away from the edges of the bowel so as to leave a margin that wide. The stitches should be placed close together—the needle punctures one-eighth inch apart—and a "backstitch" should be made at every fourth or fifth puncture in order to fix the suture and avoid the "purse-string," or puckering, effect.

The remaining tractors, Nos. 1, 3, and 4, are removed and we then proceed to suture the edges of the bowel for the last third of their circumference. As this must be done without the assistance of the tractors, attention must be given to the detail of the stitch. The needle is thrust through the edge of the one segment of the gut, entering upon its mucous-membrane aspect immediately adjacent to the point where it last emerged, and then the needle is carried across to the other segment of the bowel, and this is pierced near its edge, penetrating from the serous surface and emergnig upon its mucous aspect. To make each successive stitch the needle is thrust through the edge of the same segment of the bowel and just alongside of where it last emerged, penetrating from the mucous to the serous surface, then across to the other segment of the bowel, which it pierces from the serous to the mucous surface. As each stitch is introduced the thread is drawn tight. Toward the end, the last few stitches are left a little slack so as to allow sufficient room for the manipulation that is necessary in introducing the terminal stitches. The last puncture of the needle as it completes the suture should show the thread emerging upon the mucous-membrane aspect of the gut immediately adjacent to the tail that has been tied, and which marks the commencement of the suture. The tail of thread that corresponds to the termination of the suture should be left longer than the tail that is tied and which marks the commencement of the suture in order that it may be thus identified.

The last step of the operation consists in tying the ends of the thread so that the knot will be within the lumen of the gut. The end of a narrow, straight, ligature carrier is introduced into the bowel between the stitches at a distance of about three-fourths of an inch away from the space through which the two ends of the suture emerge. The point of the carrier is pushed out through this space (through which the suture ends emerge) and the ends of the suture are threaded into its eye. The instrument is then withdrawn, pulling the tails of the suture after it. A little traction is made upon the longer of the two suture ends in order to tighten up the slack of the last few stitches. The ends are then tied and cut short. By rolling the bowel between the fingers the knot will be made to slip into the lumen of the gut.

WITH MURPHY BUTTON.—Having resected the gut as above described, a running string is placed in the edge of each segment of the gut which, when drawn tight and tied, puckers the end of the gut and grasps the button about its shank, leaving the flange or cup of the button within the gut. This running stitch, or purse-string, is applied in overhand fashion, is of chromic catgut and carried upon two long, straight needles, one at each end. This stitch includes all the layers of the gut, especially the serous and the mucous membrane; it should not include too wide a margin of the gut, since the amount of tissue which is grasped between the flanges, or cups, of the button may be too bulky to allow exact coaptation; a margin of rather less than one-fourth inch is sufficient. The running stitch is commenced by piercing the mesentery

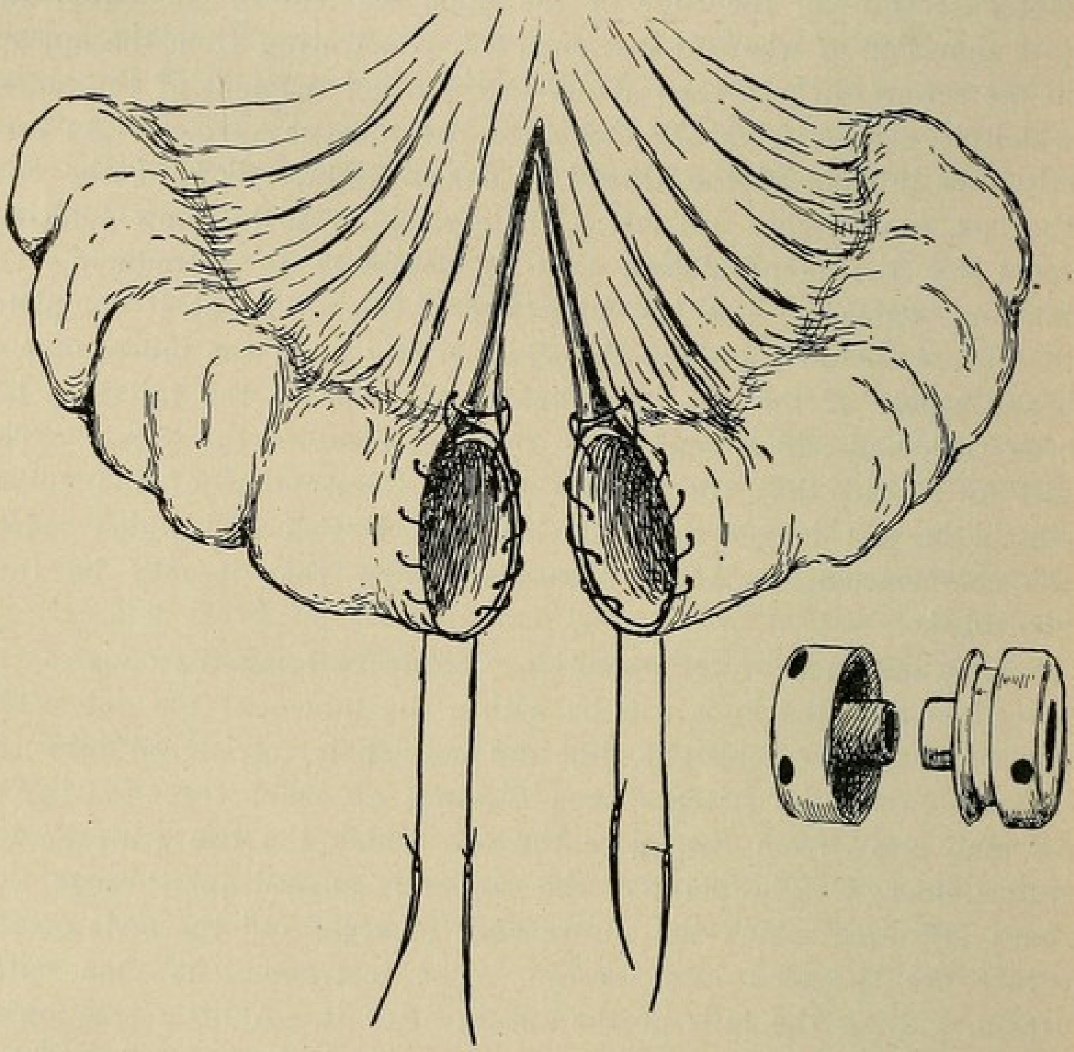

Fig. 201.—End-to-End Anastomosis (*Murphy Button*). With the purse-string suture a loop is taken through the layers of the mesentery, close to the wall of the gut, in order to obliterate the "dead space."

close to the surface of the gut, and then, carrying the same needle back over the edge of the mesentery, it is again thrust through, so that we thus have a loop around the cut edge of the mesentery close to the surface of the gut. With this same needle the running suture is applied to the corresponding half of the circumference of the cut edge of the gut; each puncture of the needle should be made from within the lumen of the gut, from its mucous-membrane aspect, and the punctures should be about one-third inch apart.

When a point is reached directly opposite the mesenteric border of the gut, this needle is discarded; the second needle is then taken in hand and the second half of the circumference of the gut treated in exactly the same manner. In this way the whole circumference of the gut is included, leaving the two free tails of the suture which emerge upon the serous surface of the gut opposite its mesenteric attachment, ready for tying.

One-half of the button, grasped with a thumb forceps by the edge of its tubal part, is introduced into the end of the gut, turning the button a little on the side to facilitate its introduction, and while it is thus held the purse-string is tied around its shank, leaving the flange within the intestine. The ends of the purse-string are cut short so that they will not protrude between the flanges of the button when this is closed. This procedure is repeated upon the other segment of gut. The two halves of the button are then deliberately pressed home, and in doing this one should note that the corresponding mesenteric attachments of both segments of the gut are opposite each other.

When the two halves of the button are locked there should be presented between them a clean, smooth line with no raw mucous-membrane edge protruding, and at the mesenteric attachment the apposition of serous surfaces should also be assured.

Although it is probably not necessary in most cases to use a layer of Lembert sutures in addition to the Murphy button to secure accurate apposition, nevertheless it is wise in many cases to place a continuous Lembert stitch outside of the button after the halves have been pressed home, especially as the presence of the button makes the application of this stitch rather an easy matter.

Side-to-Side, or Lateral, Approximation (Lateral Intestinal Anastomosis).—This is the formation of a fistulous opening between two coils of intestine joined side to side.

This operation is indicated when the ends of gut that are to be united differ much in calibre,—for example, to unite the end of the ileum to the cæcum. It may be accomplished by suture, clamps, Murphy button, or McGraw rubber suture, etc.

Suture.—The intestine is brought well up into the wound or, if possible, outside upon the abdomen, and surrounded with gauze pads to protect the peritoneal cavity. Gauze strips or tapes are tied around the intestine, and after the diseased portion has been excised the cut end of each segment of the gut is inverted and closed with a double row of Lembert sutures, thus converting each end of the gut into a blind pouch. Care should be taken to include the invaginated mesentery in the suture. The invagination of the end of the gut is commenced at its mesenteric border, inverting a margin about one inch in width.

The next step is the union of the two blind ends of the gut to each other, side to side, and in such a manner that the intestinal canal, through the new opening that is to be made, will be continued in a direct line, and not reversed in passing from one segment into the other. The ends of the gut should be so placed that they overlap each other for a distance of four to five inches. Their apposed lateral surfaces are then united to each other for a distance of from three to four inches by a single row of continuous Lembert sutures of fine silk. After this row of Lembert suture, which forms the posterior half of the "outside serous ring," has been applied, the needle, still carrying the silk thread, is laid aside until required later to complete this "outside serous ring." This line of Lembert sutures should be one inch longer than the proposed openings in the gut and each stitch should be rather less than one-eighth inch distant from its neighbor and should be drawn tight.

Each segment of the bowel is now opened with the scissors, the incisions being placed about one-fourth inch distant from the line of the Lembert suture; the openings in the bowel should be large so as to allow for subsequent contraction,—three inches long and at least one inch shorter than the line of the Lembert suture.

Bleeding from the edges of the incisions in the bowel is controlled with artery clamps which may be removed after a few minutes' pressure, as the hemorrhage usually ceases. The edges of the openings in the gut are wiped with alcohol followed by saline solution, and then, with a continuous suture of chromic catgut which at the same time controls the hemorrhage, the edges of the openings in the bowel are united with each other all around. Having thus united the edges of the openings all around, we again take up the needle carrying the original silk suture and complete the anastomosis by making the anterior half of the Lembert suture, the "outside serous ring."

In making the lateral anastomosis one should not have the blind ends of the overlapped gut too long. These ends are anchored to the adjoining wall of the intestine by several Lembert stitches.

It may be necessary to tear the mesentery somewhat in order to allow sufficient overlapping of the ends of the bowel. After the anastomosis has been made, the overlapping layers of the mesentery are

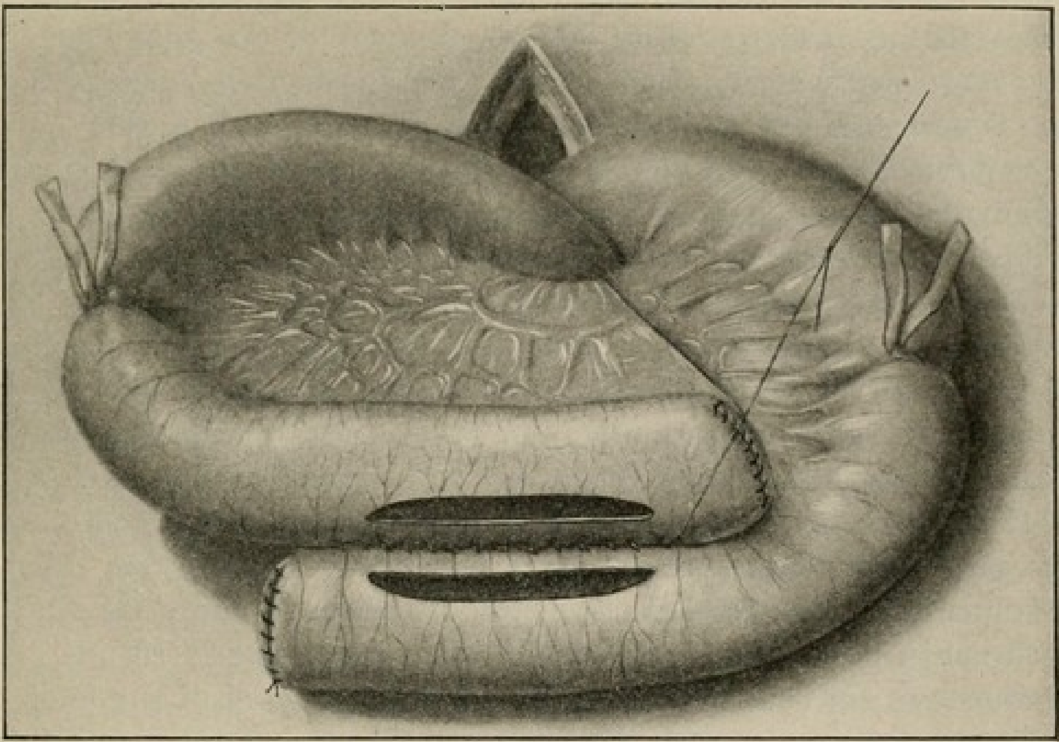

Fig. 202.—Lateral Anastomosis. The end of each coil of gut has been closed by suture. The two coils have been placd side by side and joined by a continuous non-penetrating suture. An opening has been made in the side of each coil of gut.

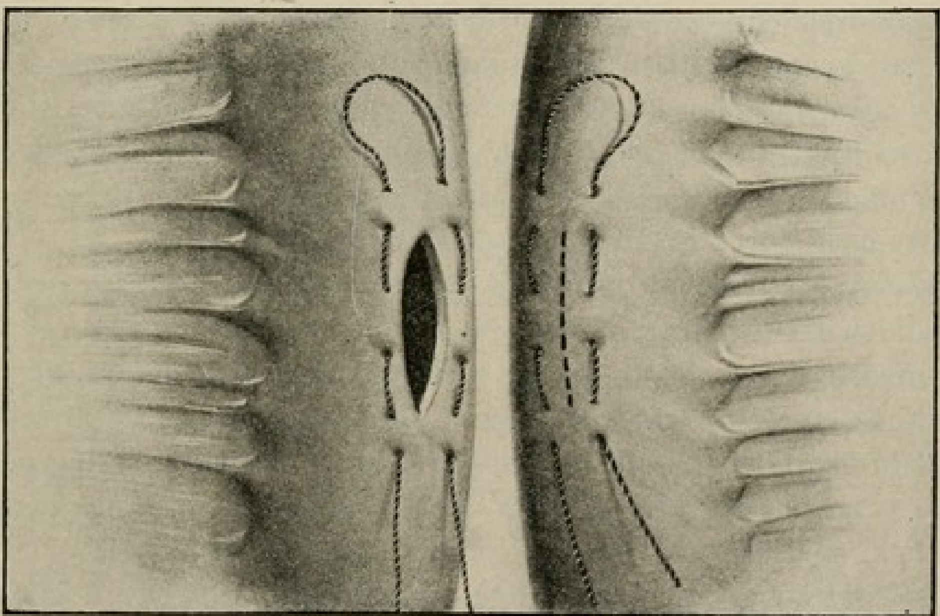

Fig. 203.—Lateral Anastomosis with Murphy Button. A purse-string has been introduced in both segments. One segment has been incised.

united with a continuous catgut suture loosely applied in order to obliterate any spaces or holes into which a coil of gut might find its way and become strangulated. When the anastomosis is complete it will be seen that the two segments of gut are united side to side.

With Clamps.—A fold of the wall of each of the two segments of gut that are to be joined together is grasped between the blades of the holding forceps, the blades sheathed with rubber tubing. The fold secured in the grasp of the forceps is about four inches long. The wall of each segment of gut is grasped in such a manner that the folds in the blades of the forceps will correspond to the lateral wall of the gut and be opposite each other. The forceps are placed with the blades holding the folds of intestine side by side (see Figs. 211, 213, 214), and the two folds of gut are joined together with a continuous non-penetrating suture of silk for a distance of three inches. When this line of suture has been completed the needle is laid aside temporarily until needed later to complete this outside ring of suture. An incision two and one-half inches long is made in each of the folds of gut which are grasped with the forceps, about one-quarter inch distant from and parallel with the suture line that unites the two folds. This incision penetrates the serous and muscular coats, the edges of which retract, exposing an elliptical area of the mucous layer, which is excised with a sharp-pointed scissors. Hemorrhage from the edges is controlled by tightening the clamps and ligating spurting points. The corresponding edges of the incisions in the bowel are sewed to each other, all around with a continuous suture of chromic catgut. The clamps are then removed and the needle carrying the thread with which the first line of non-penetrating Lembert suture was introduced is again taken up and used to apply the anterior half of the outside serous ring suture and thus complete the operation.

With Murphy Button.—A lateral intestinal anastomosis may be made with the Murphy button. After the ends of the gut have been inverted and closed with a suture as described in the preceding operations, the two ends are placed side by side and a purse-string placed in the lateral wall of each segment. The purse-string consists of two parallel rows with a space between them of not more than one-half inch, so that when the incision is made there will be a margin on each side of about one-fourth inch. Each leg of the suture should be made with three punctures of the needle, penetrating the entire thickness of the bowel with each thrust. Either silk or chromic catgut may be used as suture material. The writer prefers catgut. The first double loop of a surgeon's knot is taken with the ends of the suture and the incision in the bowel then made. The incision should not be too large—barely large enough to permit introduction of the half button and should be placed exactly between the two legs of the suture. The incision in the bowel is made with the scissors, the wall of the gut being picked up with two thumb forceps to facilitate this step. The two halves of the button are introduced, one into each loop of the gut, and sutured by tying the purse-string, pressed together and the operation thus completed (see Fig. 203). This is a comparatively simple method of doing a lateral intestinal anastomosis. One of the stitch methods, however, is preferable.

With McGraw's Rubber Suture.—With the rubber suture a lateral intestinal anastomosis may be conveniently made and with very good result in a manner analogous to that described for the gastro-jejunostomy. The surfaces of the two segments of gut that are to be joined are placed side by side and united for a distance of about two and one-half inches with a continuous Lembert stitch of silk as described in the previous operation, and then the needle carrying this stitch is temporarily laid aside. The rubber suture, 2 to 3 mm. thick, is introduced with a straight needle so as to include both segments of the gut in its grasp, is drawn tight, and tied. A silk ligature is tied around the knot in the rubber suture so as to secure the latter from slipping. About two inches of the length of each segment of the gut should be included in the constricting rubber suture; so that, when this cuts through, the opening left between the two coils of gut will be two inches in length (see "Gastro-jejunostomy with McGraw's Rubber Suture"). The needle, still carrying the silk thread and which was temporarily laid aside, is again taken up, and with this the two coils of gut are united along a line just in front of the rubber suture. This forms the second, the anterior half of the "outside serous ring" suture, and buries the rubber suture beneath it out of sight.

Gastro-enterostomy.—Gastro-enterostomy is the formation of an artificial communication between the stomach and the small intestine. The anastomosis may be made between the stomach and duodenum (gastro-duodenostomy) or between the stomach and jejunum (gastro-jejunostomy).

The operation has for its prime object the establishment of a sufficiently free exit for the escape of the stomach contents; for stenosis of the pylorus, whether simple and due to non-malignant chronic ulcer or the result of malignant disease; for hour-glass cicatricial contraction of the stomach; for the relief of symptoms of chronic ulcer and chronic gastritis; dilatation consecutive to pyloric stenosis, etc.; gastro-jejunostomy is performed for chronic ulcer of the duodenum with the object of diverting the acid stomach contents from this portion of the bowel.

Gastro-duodenostomy.—The anastomosis is made between the stomach and duodenum. This operation is illustrated in the method of implanting the end of the stump of the duodenum into the posterior wall of the stomach after resection of the pylorus, etc., and in the operation of Finney, described as "Pyloroplasty," but which is in reality a gastro-duodenostomy, and in the gastro-duodenostomy of Kocher.

Gastro-duodenostomy (Kocher).—After the abdomen has been opened, incision, etc., described in detail in "Gastro-jejunostomy," the duodenum is sought and mobilized to such a degree that it can be brought over toward the middle line into convenient apposition with the pyloric portion of the stomach.

In order to effect the mobilization of the duodenum it is necessary to incise the parietal peritoneum just to the outer side of and parallel with the descending portion of the duodenum. The incision is placed a thumb's breadth to the right of the descending portion of the duodenum, exposing the anterior surface of the right kidney. The incision is carried downward for a short distance into the commencement of the transverse mesocolon, which is held taut. Care must be exercised not to divide the large arterial branches in the transverse mesocolon.

The finger is introduced into the incision in the peritoneum and, working inward behind the duodenum, this part of the gut, together with the head of the pancreas, is carefully separated from the surface of the kidney and vertebral column and lifted upon the finger, forward into the incision and over toward the middle line in order to meet the pyloric portion of the stomach. A finger is hooked behind the pyloric portion of the stomach and this part likewise drawn forward into the incision.

A fold of the wall of the duodenum and a fold of the stomach wall are secured with two rubber-sheathed anastomosis clamps which are held side by side and the anastomosis accomplished in a manner similar to that described in "Gastro-jejunostomy with Clamps," "Lateral Anastomosis with Clamps," etc. The opening between the duodenum and stomach should be at least one and one-half inches long.

According to Kocher this operation has many advantages and gives very satisfactory remote results in cases of pyloric stenosis.

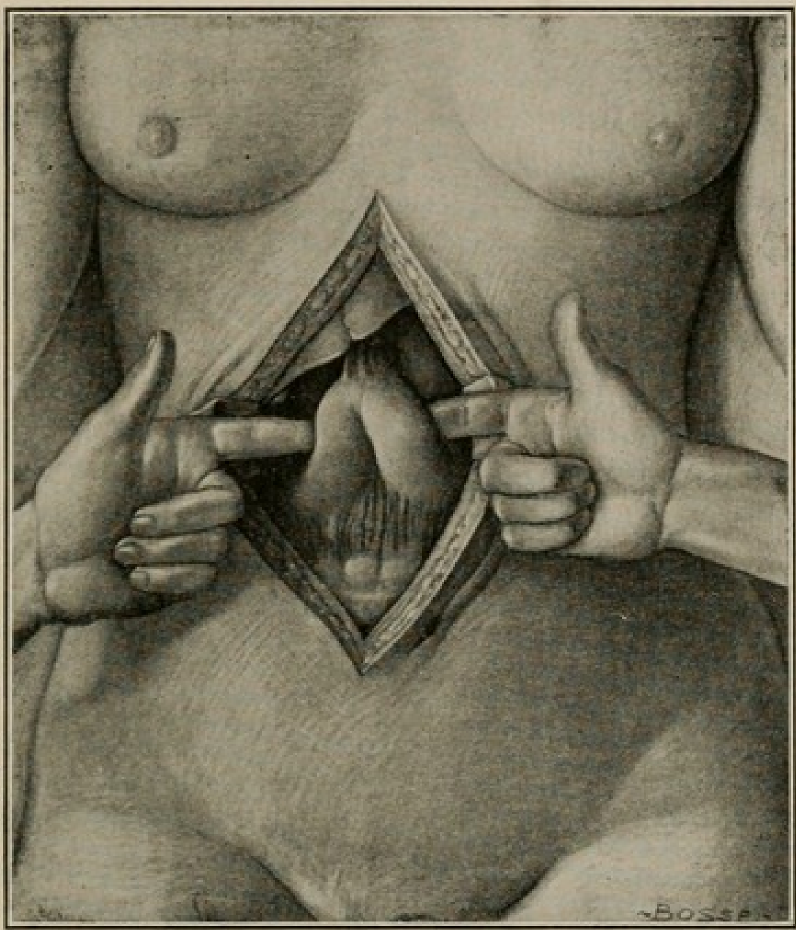

Fig. 204.—Gastro-duodenostomy (*Kocher*). The duodenum has been mobilized and hooked up upon the finger. A finger of the other hand is hooked in behind the pylorus. Both these parts are approximated preparatory to making the anastomosis between them.

Gastro-jejunostomy.—The junction is made between the stomach and jejunum. This operation was first performed by Woelfler in 1881. The loop of small intestine may be fixed to either the anterior or the posterior wall of the stomach.

ANTERIOR GASTRO-JEJUNOSTOMY (WOELFLER).—This consists in bringing a coil of the small intestine—jejunum—up in front of the great omentum and transverse colon, fixing it to the anterior wall of the stomach and establishing a communication between the two organs. The anterior gastro-jejunostomy is only resorted to when for some reason or other it is impossible or inadvisable to do the posterior operation. If the posterior wall of the stomach were involved in the disease or fixed by adhesions to the pancreas, or if a very short transverse mesocolon were encountered, the anterior gastro-jejunostomy would be indicated. The operation may be done with suture, clamps, Murphy button, or McGraw rubber ligature.

The stomach should be washed out with the stomach tube just before commencing the operation, before the patient is anæsthetized.

SUTURE METHOD.—An incision is made in the middle line through the linea alba from a point one inch below the ensiform cartilage down to the umbilicus, or even beyond this point if necessary. It is preferable as a rule to make this incision a little to the left of the middle line, penetrating between the fibers of the rectus muscle or, better, after the anterior layer of the sheath of the rectus has been incised the inner edge of the muscle is seized and drawn outward away from the middle line; the posterior layer of the sheath of the rectus is thus exposed and it and the fascia transversalis and the peritoneum are incised on a line directly behind the incision in the anterior layer of the sheath of the rectus. Through this opening the stomach is sought and examined.

After the stomach has been recognized the transverse colon, and with it the great omentum, is drawn out of the incision and search is then made for the commencement of the jejunum. This part of the gut lies in the back of the abdominal cavity, to the left of the vertebral column, upon a level with the body of the second lumbar vertebra, its mesentery being very short and serving to anchor it in this position. To secure this coil of gut the hand is introduced into the abdomen and carried backward, along the under surface of the transverse mesocolon as far as the posterior abdominal wall; just below the attachment of the transverse mesocolon to the vertebral column, at the place indicated upon the left of the column, the coil of gut is found. This part of the small intestine is readily identified by the fact that it is fixed within the abdomen, as is demonstrated when an effort is made to draw it out of the abdomen; any other part of the small intestine may be freely drawn through the fingers in either direction, and may be readily drawn out through the incision upon the abdomen.

A loop of gut about eighteen inches distant from the commence-

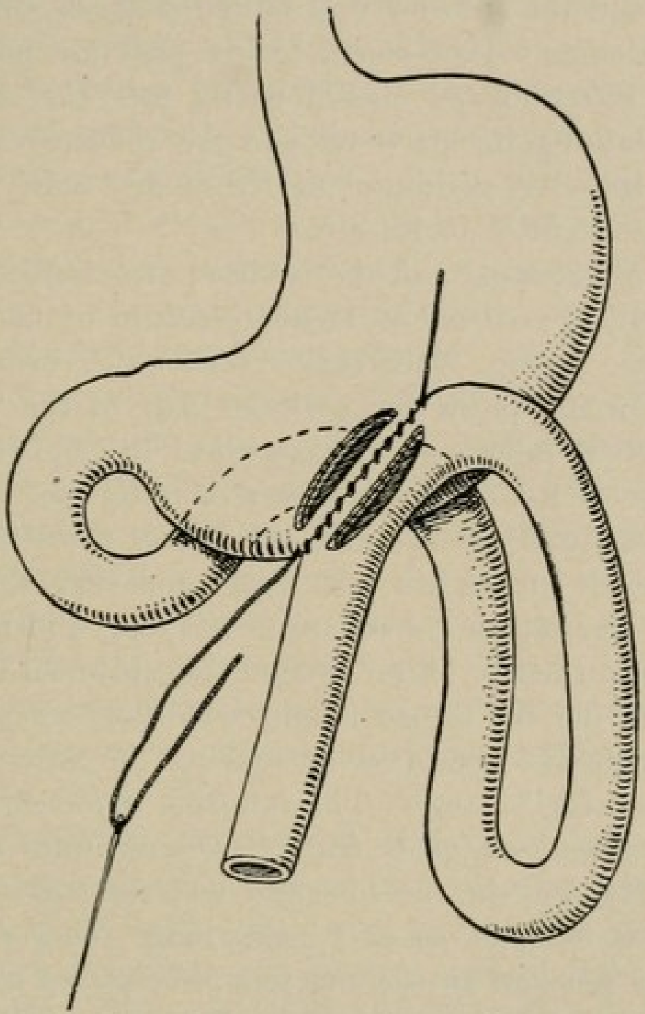

Fig. 205.—Anterior Gastro-jejunostomy. Suture Method. The jejunum has been united to the anterior wall of the stomach. The posterior half of the non-penetrating "outside serous ring" suture has been introduced. The stomach and intestine have been incised.

ment of the jejunum is selected for attachment to the stomach. About ten inches of this loop of gut is drawn out through the abdominal incision and surrounded for the purpose of constricting its lumen by two pieces of narrow tape. The tapes are carried around the gut with a sharp-nosed artery forceps which is thrust through the mesentery close to its attachment to the intestine, and with this the end of the tape is seized and drawn through. The one piece of tape is tied and the segment of gut emptied of its contents to a point beyond the second piece of tape by gently stripping it between the fingers and then the second tape is tied. The tapes should be tied just sufficiently tight to prevent the re-entrance of the intestinal contents into the segment of gut. After the coil of gut has been secured and the tapes applied, the transverse colon and great omentum are pushed back into the abdomen and the anterior wall of the stomach seized and drawn out of the abdomen. Dry, sterile, gauze pads are placed about the stomach and intestine and tucked partly into the incision for the purpose of retaining the parts outside the abdomen and to prevent the entrance into the peritoneal cavity of any material that might escape from the stomach or intestine.

The coil of intestine and the stomach are steadied, side by side, and united with a continuous Lembert suture of fine silk, using a straight cambric needle. This suture line, which includes the serous and muscular coats, forms the posterior half of the "outside serous ring." Each stitch takes a good, deep, broad bite, but should not penetrate into the cavity of the stomach or intestine. The suture is applied in a straight line two and one-half to three inches long; the stitches are about one-eighth inch apart and each should be drawn fairly tight. The tail of the suture is left long and may be held by the assistant as a tractor. After this line of suture has been completed, the needle carrying the thread is laid aside temporarily until needed later to complete the operation by making the anterior half of the "outside serous ring" suture. The intestine is joined to the stomach along a line running obliquely from above downward and toward the right. The incisions in the intestine and stomach are next made. They are two to two and one-half inches long. They are shorter than the line of the Lembert suture and should be placed about one-fourth inch distant from it. They should be straight, parallel with the line of suture, and clean cut. The intestine is incised first. The wall of the gut is picked up with two toothed forceps and a small opening made between these with a straight, sharp scissors and then the opening thus made is sufficiently enlarged. Any escaping contents are carefully caught with gauze wipes. The stomach is incised in a similar manner. The redundant edges of the mucous membrane which protrude through the incisions in the intestine and stomach are trimmed away with the scissors. Hemorrhage from the edges of the incisions stops after they have been sutured; any spurting points may be clamped, however, and tied with fine catgut.

The corresponding edges of the incisions in the intestine and stomach are sewed to each other with catgut in a medium-sized, straight needle, each stitch taking a good bite and passing through all the coats, including the mucous membrane, and drawn fairly tight; the needle punctures should be rather less than one-fourth inch apart. This suture is continued uninterrupted all around, uniting the corresponding edges of the incisions in the stomach and intestine to each other until these openings are entirely closed in and the anastomosis made. Before beginning this stitch the margins of the openings are wiped with a swab moistened in hot saline solution.

After the edges of the openings in the stomach and jejunum have been united all around we again take up the first needle carrying the silk thread with which the posterior half of the Lembert suture—"outside serous ring"—was made and complete the operation by making the anterior half of the "outside serous ring" suture.

When the operation has been completed we have the openings in the intestine and stomach, two to two and one-half inches long, united edge to edge, all around, by a continuous stitch which passes through the entire thickness of the margins of the openings and this surrounded, reinforced, by a continuous Lembert suture which passes through the serous and muscular coats only, and which serves the purpose of burying the penetrating mucous stitch. Should there be any doubtful points where the mucous penetrating stitch is not certainly buried, one or more supplementary interrupted Lembert stitches may be taken to remedy this.

It will be observed that the coil of gut is joined to the anterior wall of the stomach along an oblique line running from above downward and toward the right, the lower end of the line being at the greater curvature, the upper end pointing upward and toward the left, toward the cardia. The gut is joined to the stomach in such a way that the current of food in the stomach and in the loop of intestine will be in the same direction—the distal limb of the loop of gut toward the right or pyloric end of the stomach; this is accomplished by taking care not to twist the loop of intestine upon itself when drawing it up into apposition with the stomach.

The transverse colon and great omentum rolled upon itself lie together behind the junction formed between the jejunum and the stomach.

The constricting tapes are finally removed from the intestine and the parts mopped off with a swab wet in hot saline solution and replaced within the abdomen and the abdominal incision closed.

Clamp Method.—The anterior gastro-jejunostomy may be performed with great facility with the assistance of the holding clamps. The technique is similar to that described in detail in "Posterior Gastro-jejunostomy, Clamp Method." A fold of the anterior wall of the stomach is secured between the blades of the clamp along a line three to four inches in length and running obliquely from above downward and toward the right, the lower end of the fold corresponding to the most dependent part of the greater curvature. The commencement of the jejunum is sought for and recognized in the manner already described (see page 440), and a coil about eighteen inches beyond this point is secured and drawn out through the abdominal incision. A fold of the wall of this coil of gut similar in length to that of the stomach wall is secured between the blades of the holding forceps. Doyen, Moynihan or Scudder clamps are used for this purpose. The blades are sheathed with rubber tubing and grasp the wall of stomach just tightly enough to secure it from slipping, but not so tightly as to damage or crush it. The blades of the clamps holding the fold of the wall of the stomach and that of the wall of the jejunum are placed side by side and the anastomosis made between them as described in detail in "Posterior Gastro-jejunostomy, Clamp Method," page 450.

Anterior gastro-jejunostomy may be also made with the McGraw Rubber Ligature, Murphy Button, etc. Details of the application of these methods are described under "Posterior Gastro-jejunostomy."

Jaboulay and Braun Modification.—In some cases, after the anterior gastro-jejunostomy as described above has been performed, there occurs an accumulation of food, bile, and pancreatic juice in the short (proximal) limb of the loop of the intestine that is fixed to the stomach, with a consequent regurgitation into the stomach, and this is characterized by exhausting and fatal vomiting. The regurgitation and vomiting are due to a spur formation at the point where the coil of gut is attached to the stomach. The spur directs the stomach contents into the short or proximal arm of the gut, which becomes distended and with the result that the contents back up and overflow back into the stomach. In order to avoid the occurrence of this vomiting—"vicious circle"—a lateral communication is made between the two limbs of the coil of intestine which has been attached to the stomach. This may be done either at the same time that the gastro-jejunostomy is performed, or, since this regurgitation, etc., do not occur in all cases, it may be done later as a secondary operation, waiting for the appearance of symptoms indicating the necessity of the additional operation before submitting the patient to the additional risk. It is probably wise to do this entero-anastomosis at the same time as the primary gastro-jejunostomy, as it occupies but a few minutes' additional time. The secondary entero-anastomosis may be made with suture, clamps, Murphy button, or McGraw's rubber suture, etc. The communication

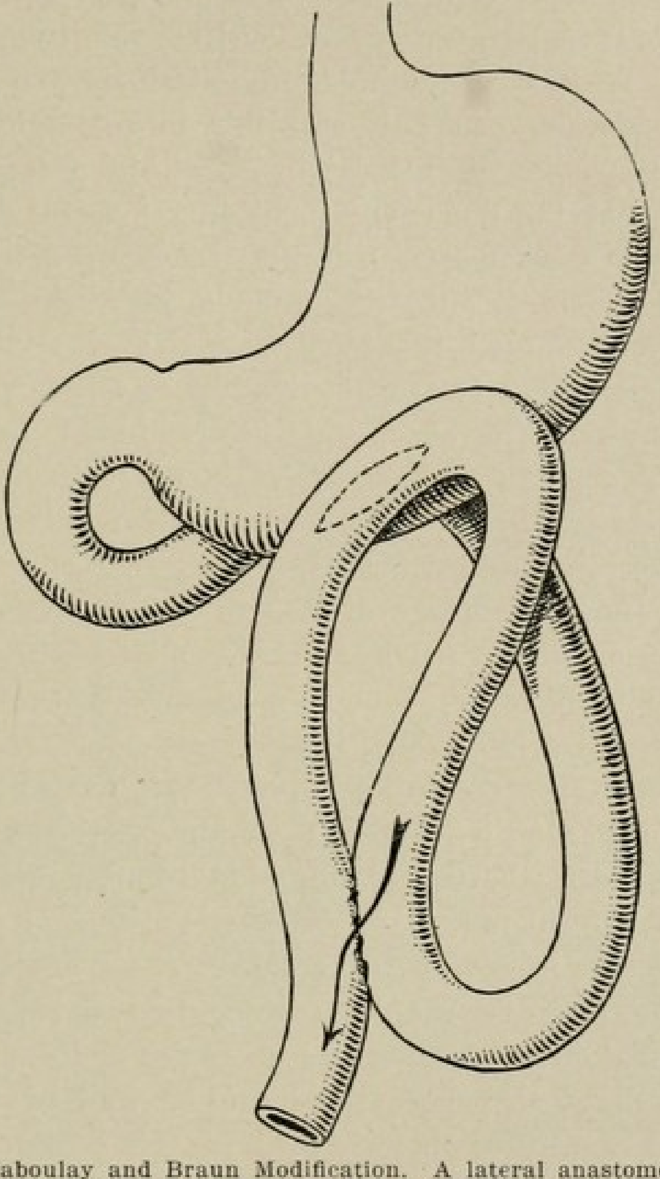

Fig. 206.—Jaboulay and Braun Modification. A lateral anastomosis has been established between the two arms of the loop of jejunum. The arrow indicates the opening through which contents may escape from one arm of the gut into the other.

between the two limbs of the loop of gut should be made at their most dependent part.

For the details of the operation of lateral intestinal anastomosis with the simple suture, clamps, McGraw rubber ligature, etc., the reader is referred to the description of these various procedures as they are given elsewhere in this volume.

Posterior Gastro-jejunostomy (von Hacker).—The jejunum is sutured to the posterior wall of the stomach, which is made accessible through an opening torn in the transverse mesocolon. As originally employed a loop of the jejunum, twelve to fourteen inches from its commencement, was anastomosed to the stomach. The operation was followed in many cases by the phenomena of the "vicious circle": regurgitation, exhaustive vomiting, and a fatal termination. It is most desirable to eliminate the loop arrangement of the anastomosed gut, and this is accomplished by using the uppermost portion of the jejunum, within a few inches of its commencement at the duodeno-jejunal junction, for the purpose of establishing the anastomosis with the stomach. This highest portion of the jejunum is situated normally just behind the stomach, close to its posterior wall, separated from it by the interposed transverse mesocolon only. It may be readily attached to the posterior wall of the stomach after an opening has been made in the transverse mesocolon. The posterior gastro-jejunostomy without a loop is the preferable operation in all cases where it is feasible, reserving the anterior gastro-jejunostomy for those cases that offer some counter-indication or impediment as disease of the posterior wall of the stomach, adhesions to the pancreas, abnormally short transverse mesocolon, etc. The operation may be performed with suture, clamps, Murphy button, McGraw rubber ligature, etc.

Posterior Gastro-jejunostomy Without a Loop, Suture Method.—An incision is made in the middle line or the incision may be placed a little to the left of the middle line, penetrating between the fibers of the rectus muscle, or the muscle may be displaced outward, as described in the preceding paragraphs. (See page 440.)

After the stomach has been recognized the transverse colon and great omentum are drawn out upon the abdomen and reflected upward. In order to expose the posterior wall of the stomach a small opening is cut or, better, torn in the transverse mesocolon, selecting a part which is devoid of blood-vessels. This opening is enlarged with the fingers until it is sufficiently large to accommodate three or four fingers. Care must be exercised not to injure any blood-vessels, particularly the arteria colica media, in making the opening in the transverse mesocolon. The posterior wall of the stomach is drawn partly through the opening which has been thus made in the transverse mesocolon, and the edges of the opening in the transverse mesocolon fixed at once to the posterior wall of the

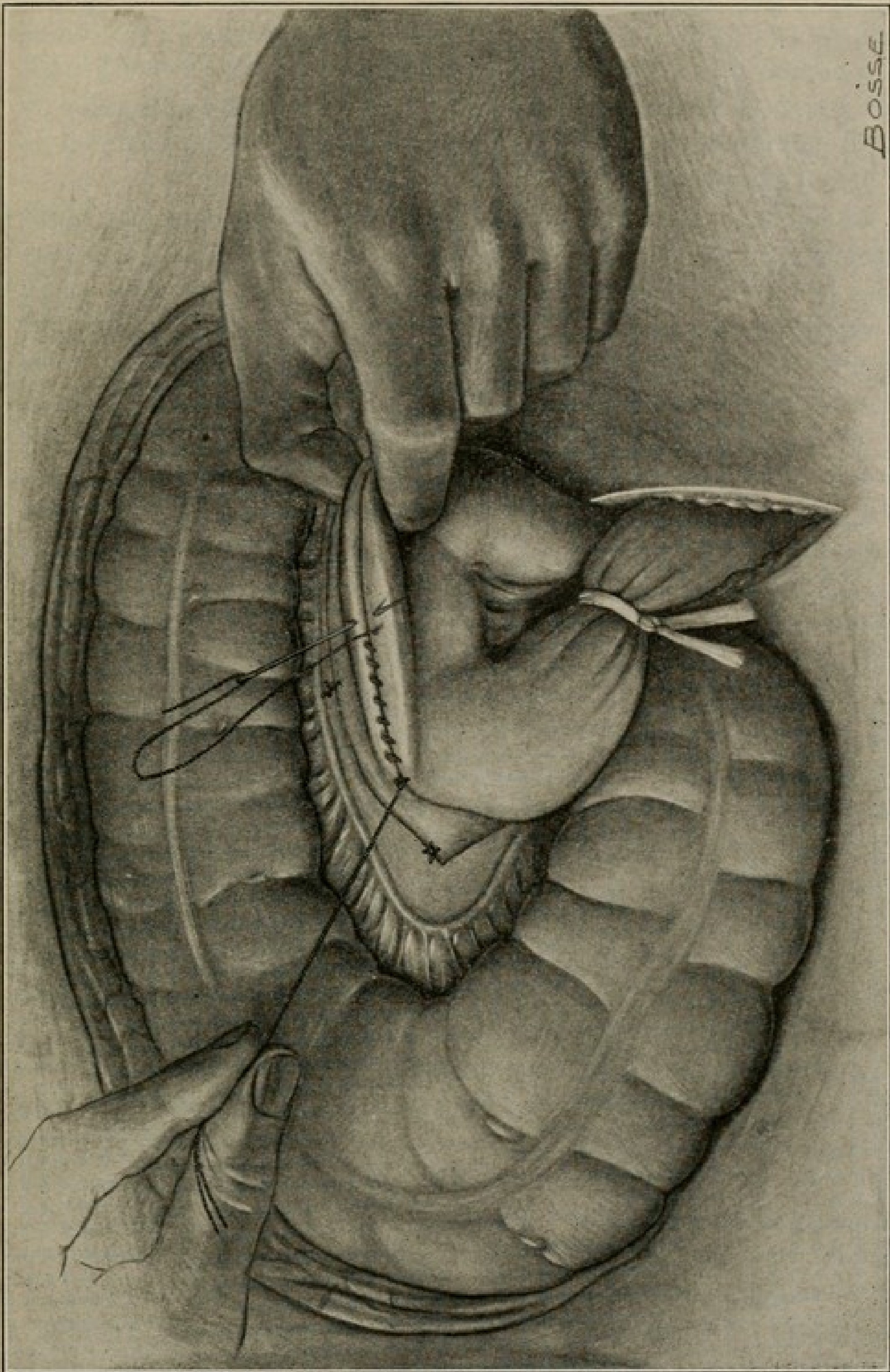

Fig. 207.—Posterior Gastro-jejunostomy. The jejunum is sutured to the posterior wall of the stomach, which has been drawn through an opening in the transverse mesocolon. The edges of the opening in the transverse mesocolon have been fixed to the wall of the stomach with several non-penetrating sutures.

stomach by several sutures of fine silk. These sutures do not pierce the entire thickness of the stomach wall. They penetrate the serous and muscular coats only. The exposed area of the stomach wall which presents through the opening in the transverse mesocolon is then brought out through the incision in the abdomen, where it is retained by an assistant.

As already described in the preceding operations, the commencement of the jejunum is found in the back of the abdomen to the left of the body of the second lumbar vertebra, just below the vertebral attachment of the transverse mesocolon. This coil of gut is secured and brought up into the abdominal incision. The portion of gut which is thus secured for attachment to the posterior wall of the stomach corresponds to the upper five inches of the jejunum. The coil of gut is stripped between the fingers to empty it, and a piece of narrow tape is passed around it ten or twelve inches farther along, away from its commencement. The tape is drawn through the mesentery with a sharp-nosed artery clamp which is thrust through the mesentery close to the gut. The tape is tied just sufficiently tight to prevent the re-entrance of contents into the coil of gut which has been emptied. The transverse colon and great omentum are pushed back into the abdomen. Pads of gauze are tucked about the viscera and partly into the abdominal incision to steady the parts and to prevent the entrance of material from the stomach or intestine into the peritoneal cavity, and the gastro-jejunostomy is then performed in a manner similar to that already described in detail in "Anterior Gastro-jejunostomy, Suture Method." The intestine is fixed to the posterior wall of the stomach with a Lembert suture along an oblique line for a distance of two and one-half to three inches, and reaching from the lowest part of the greater curvature upward and to the left—pointing toward the cardia. The stomach and intestine are incised. The incisions, two to two and one-half inches long, are made parallel with and about one-quarter inch distant from the line of the Lembert suture. The redundant edges of mucous membrane that protrude through the incisions are trimmed away with the scissors. The incisions are shorter than the line of Lembert suture that joins the jejunum to the stomach. The corresponding edges of the openings in the stomach and intestine are sewed together all around with a through-and-through stitch of chromic catgut, finally completing the operation by introducing the anterior half of the Lembert "outside serous

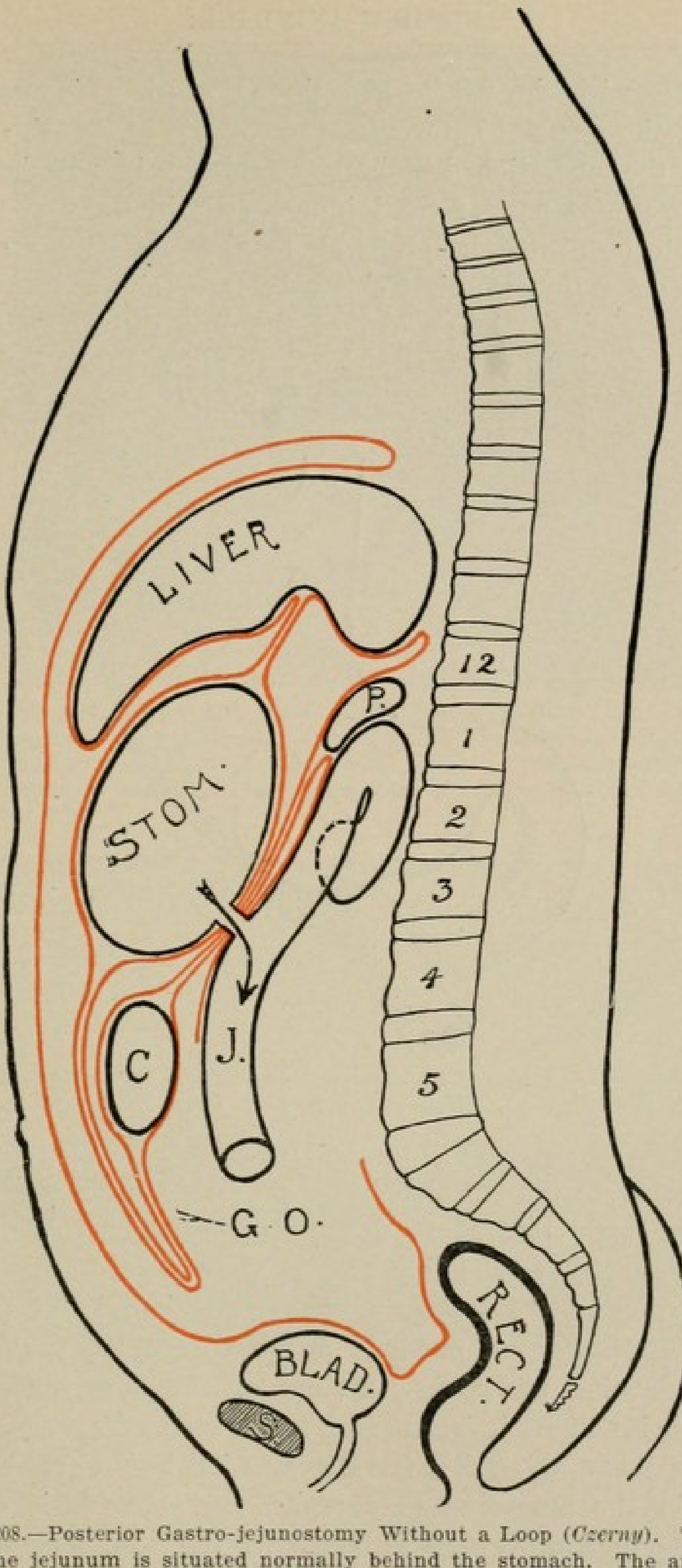

Fig. 208.—Posterior Gastro-jejunostomy Without a Loop (*Czerny*). The upper part of the jejunum is situated normally behind the stomach. The arrow indicates the anastomosis between the posterior wall of the stomach and the upper part of the jejunum. *C*, colon; *GO*, great omentum; *J*, jejunum; *P*, pancreas; *S*, symphysis pubis.

ring" suture, with the needle and thread which were used for the first half of the Lembert suture.

When the operation has been completed it will be observed that the uppermost part of the jejunum (within the first five inches of its commencement) is attached to the posterior wall of the stomach along a line running obliquely from above downward and toward the right, the lower end of the line corresponding to the lowest point of the greater curvature, and the upper end pointing toward the cardia. Mayo recommends that the line of attachment

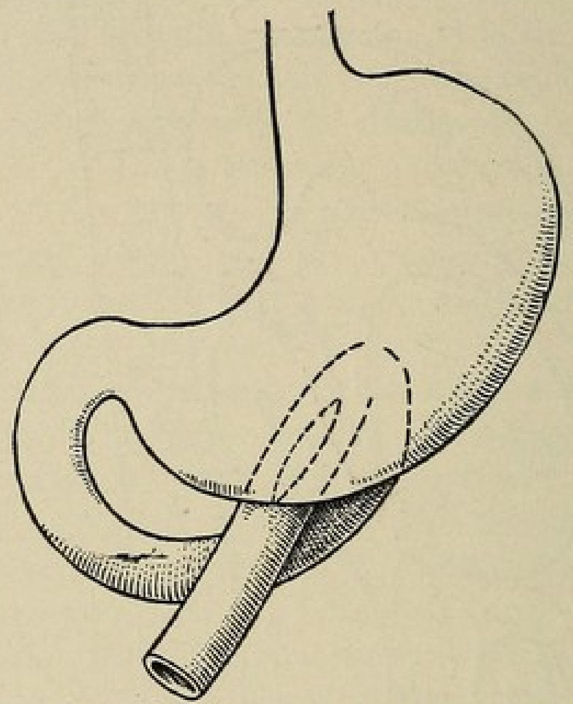

Fig. 209.—Posterior Gastro-jejunostomy. Shows the line of attachment of jejunum to the stomach running obliquely from above downward and toward the right.

of the jejunum to the stomach be reversed—*i.e.,* run obliquely from right to left and from above downward, beginning one inch above the greater curvature on a line prolonged downward from the longitudinal portion of the lesser curvature, and ending at the bottom of the stomach two and one-half inches to the left. This line of attachment avoids reversion, bending, of the anastomosed coil of gut at the point where it is attached to the stomach.

Clamp Method.—After the abdomen has been opened as already described in the preceding paragraphs, the stomach is drawn out through the opening which is made in the transverse mesocolon. The lowest point of the greater curvature of the stomach, as it lies in its natural position, is previously located and fixed for identi-

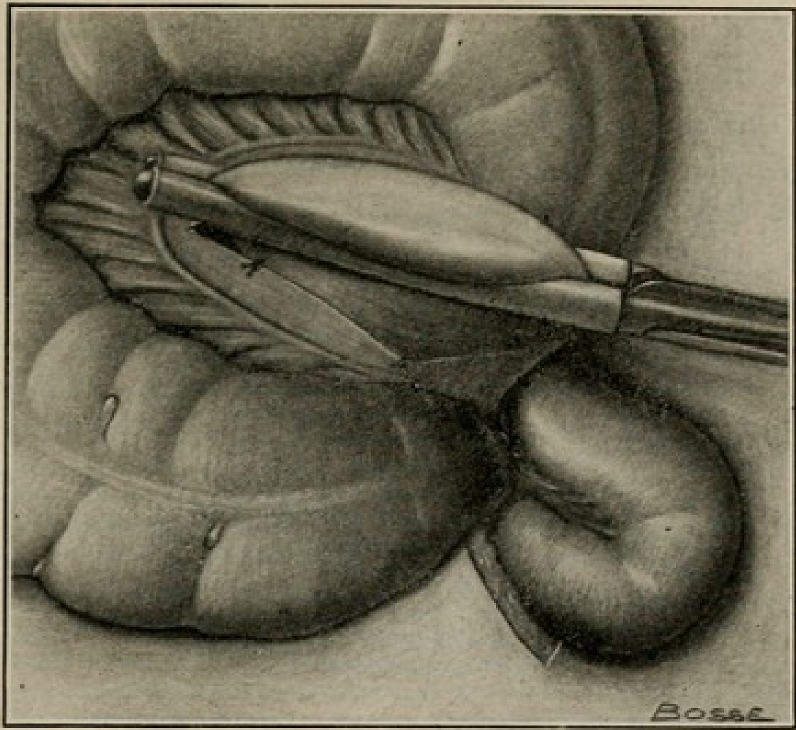

Fig. 210.—Posterior Gastro-jejunostomy, Clamp Method. An opening torn in the transverse mesocolon and a fold of the posterior wall of the stomach secured between the blades of the holding forceps. The edges of the opening in the transverse mesocolon have been fixed to the wall of the stomach with several sutures.

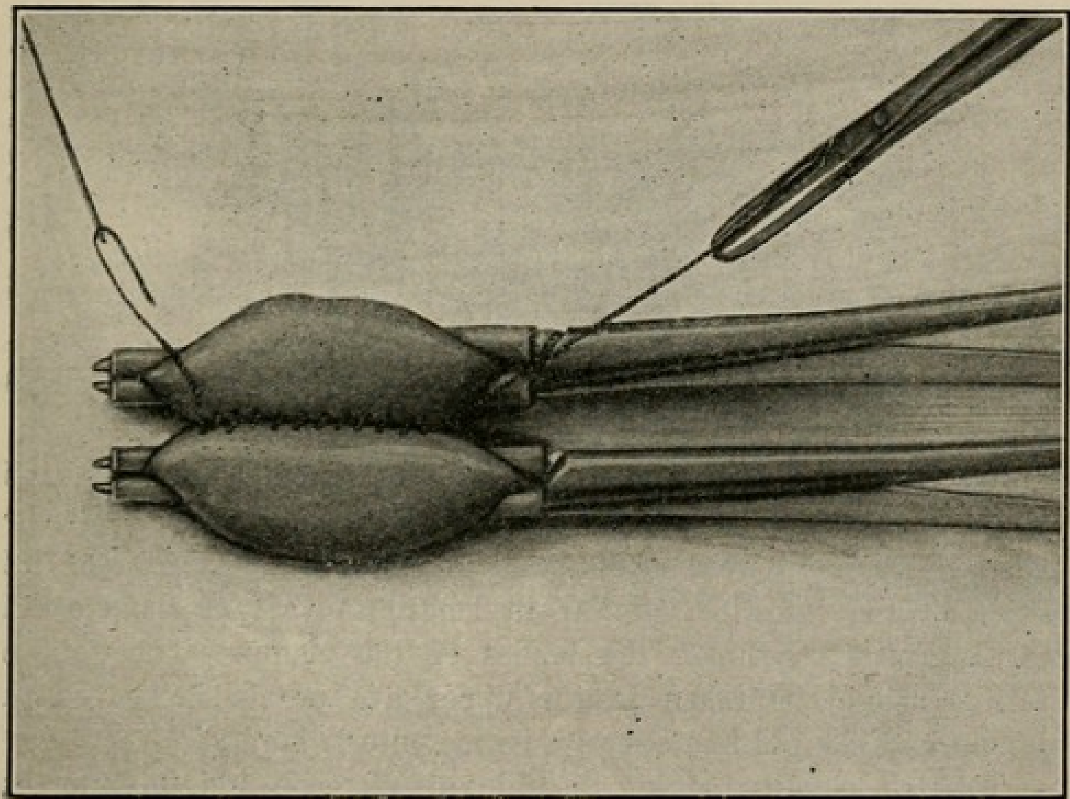

Fig. 211.—Gastro-jejunostomy, Clamp Method. The folds of the wall of the stomach and jejunum in the grasp of the holding clamps. The two folds have been joined together with the non-penetrating suture—the posterior half of the "outside serous ring" suture.

fication by the thumb and finger of the left hand in order to mark the lower end of the fold of the stomach wall that is to be grasped between the blades of the clamp. Reaching obliquely upward and toward the left from this point on the greater curvature, toward the cardia, a fold of the stomach wall three and one-half to four inches in length is secured between the blades of the clamp. A holding clamp with elastic blades after the pattern of Doyen, Moynihan, Scudder, with the blades sheathed with rubber tubing, is used for this purpose. The clamp is applied with the operator standing upon the patient's left side; the tip of the clamp as it grasps the fold of the posterior wall of the stomach is directed

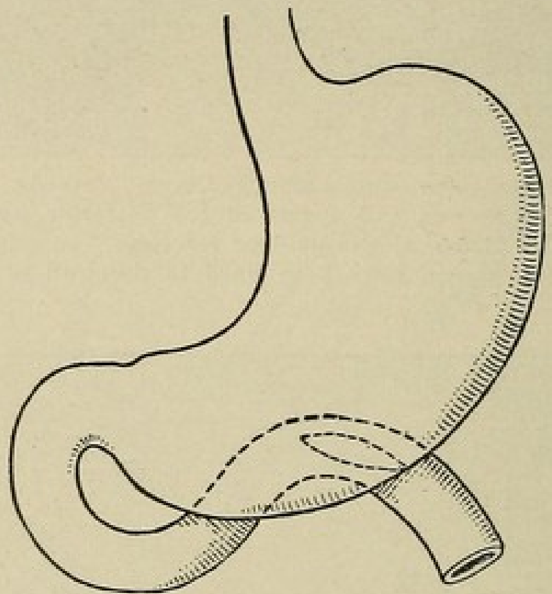

Fig. 212.—Posterior Gastro-jejunostomy. Shows the line of attachment of the jejunum to the stomach running obliquely from above downward and toward the left (*Mayo*).

upward toward the patient's right shoulder—the handles toward the patient's left side.

The commencement of the jejunum is next sought. It is found lying to the left of the body of the second lumbar vertebra (see page 440). A fold of the wall of the uppermost part of this portion of the intestine, similar in length to that of the stomach wall, is grasped between the blades of the clamp. The fold of intestine should be taken in the upper five or six inches of the jejunum and along a line opposite its mesenteric border.

The two clamps holding the folds of stomach and jejunum are placed side by side so that they lie transversely across the incision in the abdomen and the transverse colon, great omentum, are replaced back in the abdominal cavity. The folds of the stomach and

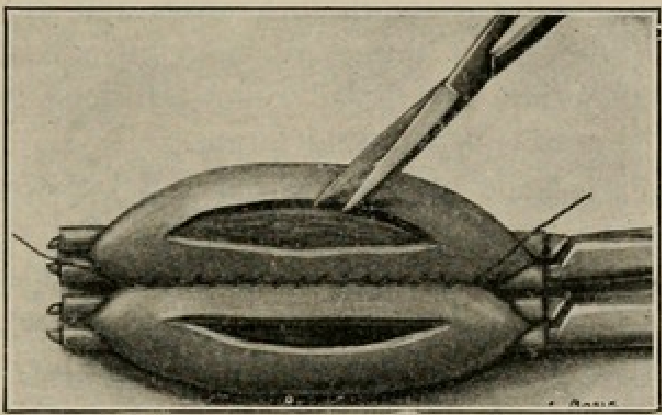

Fig. 213.—Gastro-jejunostomy, Clamp Method. The folds of stomach and jejunum have been incised down to the mucous layer. The edges of the incisions retract, exposing an elliptical area of the mucous layer, which is excised with the sharp-pointed scissors.

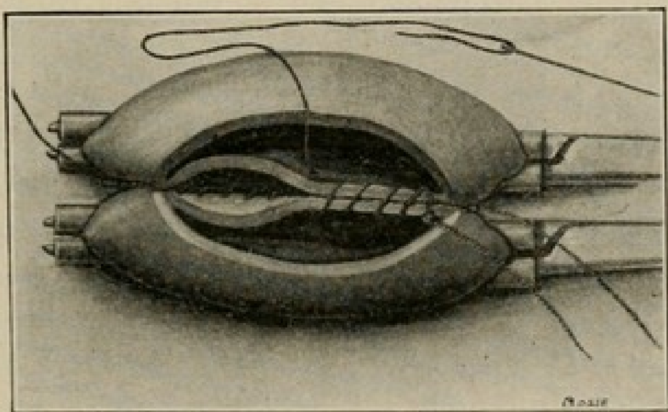

Fig. 214.—Gastro-jejunostomy, Clamp Method. The edges of the incisions in the stomach and the jejunum are united all around with an overhand continuous suture.

jejunum are joined together with a continuous non-penetrating suture of silk. This suture picks up the serous and muscular layers, commencing at the left and working toward the right—toward the tips of the clamps. The folds of stomach and jejunum are joined for a distance of two and one-half to three inches. The stitches are introduced about one-eighth inch apart and each drawn fairly tight. After this line of suture has been introduced the needle is temporarily laid aside, the thread being left long to be used later to complete the outside serous ring suture.

Incisions are made in the stomach and intestine. These incisions are shorter than the suture line, two to two and one-half inches long, and are placed parallel with and about one-quarter inch distant from the suture line. The incisions reach down through the serous and muscular coats only, exposing the mucosa. The incised serous and muscular coats retract, leaving exposed an elliptical area of the mucosa two to two and one-half inches long and one-half inch across at its widest part. The exposed areas of mucosa of the stomach and intestine are excised with a sharp-pointed scissors.

After the incisions have been made in the stomach and intestine the parts are wiped clean with a pad wet with saline solution, and the corresponding edges of the openings sewed to each other all around with a continuous stitch of chromic catgut carried in a medium-sized needle. Each stitch takes a good bite, passing through all the coats, especially the mucosa, and is drawn fairly tight; the needle thrusts should be rather less than one-quarter inch apart. This suture is continued uninterrupted all around, uniting the corresponding edges of the openings in the stomach and intestine until they are entirely closed in.

After the edges of the openings have been united all around the clamps are removed and the parts again wiped clean with swabs wet in hot saline, and the needle still carrying the silk thread with which the first, posterior, half of the non-penetrating suture, "outside serous ring," was made, is again taken up and with it the second, anterior, half of the "outside serous ring" suture is introduced and the operation thus completed.

It will be observed that the uppermost part of the jejunum is attached to the posterior wall of the stomach along an oblique line running from above downward and toward the right, the lower end of the line corresponding to the lowest point of the greater curvature. Mayo advises attaching the jejunum to the stomach along an oblique line commencing one inch above the greater curvature on a perpendicular with the longitudinal portion of the lesser curvature, and terminating two and one-half inches to the left at the greater curvature. (See Figs. 209 and 212.)

The parts are finally returned to the abdominal cavity, the stomach to its natural position, and the transverse colon and greater omentum drawn down into their normal position and the incision in the abdomen closed.

Gastro-jejunostomy with the Murphy Button.—This is a comparatively simple operation and much time can be saved by the use of the device. The button can be used for either the anterior or posterior gastro-jejunostomy. The Murphy button is much less frequently employed at present than formerly, the suture and the clamp methods being preferred by most surgeons. The use of the Murphy button is no doubt indicated in some cases, especially where a malignant condition exists and the time permitted for the performance of the operation is short. The medium-size button may be used for the gastro-jejunostomy, and a smaller one for the entero-anastomosis, if this latter operation is performed in addition.

If a posterior gastro-jejunostomy is made, the button, when liberated, is less likely to fall into the stomach than when the anterior gastro-jejunostomy is the operation performed. According to the suggestion of Weir, the margin of that half of the button which presents into the intestine may be provided with projecting flanges, which should hinder the button from falling into the stomach.

The stomach and intestine are brought out upon the abdomen as in the operations above described. A purse-string suture is introduced in the wall of the intestine and the wall of the stomach, penetrating through the entire thickness of each. The space included between the two limbs of the purse-string suture should be about one-half inch; for description of the running, purse-string suture and the method of its introduction see "Lateral Intestinal Anastomosis." This purse-string suture is applied first to the jejunum and then between the two limbs of the suture line an incision is made into the gut; this should be barely large enough to permit the introduction of the half button. That half button which is provided with the spring is seized with a thumb forceps and introduced through the incision into the gut, and, while it is thus steadied, the purse-string is drawn tight about its shank, tied, and the ends cut short.

In a similar manner, after the purse-string has been applied to the wall of the stomach, this is incised, and the other half of the button is introduced into this incision and the string tied about its neck. The parts adjacent to the openings are wiped with a pad wet with hot saline and the two halves of the button deliberately pressed home. They should be applied sufficiently tight to cause a gradual pressure necrosis of those parts of the walls of the viscera that are included within their grasp. If any raw edge of mucous membrane is seen presenting between the flanges of the button it should be seized with the thumb forceps and trimmed close with sharp scissors and then be still farther buried with several additional Lembert stitches. Murphy claims that the additional outside Lembert stitch is, as a rule, unnecessary; nevertheless, it is well to use it, especially if there are any doubtful points. The button being in position, the application of the Lembert stitch is easy. Spurting vessels in the edges of the openings in the intestine and stomach may be clamped and tied with fine catgut.

Gastro-jejunostomy with McGraw's Rubber Suture.—The gut is brought into apposition with the anterior or posterior surface of the stomach, as described in the preceding operations, and these two portions of the alimentary canal are joined to each other with a continuous silk Lembert stitch for a distance of two and one-half inches. After this line of suture has been introduced the needle still carrying the suture is temporarily laid aside.

The stomach is then united to the intestine with a single suture of solid rubber, smooth and round and from 2 to 5 mm. in thickness. This suture is carried in the eye of a long, straight needle; a large worsted needle or Hagedorn needle answers well for this purpose. It will be necessary to shave the end of the rubber suture so that it may enter the eye of the needle. The point of the needle is passed into the stomach and then out again, so that about two inches of the wall of the stomach, corresponding to its long diameter, is included between the two punctures. The rubber suture is put upon the stretch and the needle, pulling the suture after it, is then drawn through. With the same needle and suture and in a similar manner, the intestine is pierced, entering and emerging at points opposite the puncture holes in the stomach. The rubber suture is drawn very tight, thus constricting the parts included in its grasp, and tied. In order to secure the knot in the rubber suture a strand of stout silk may be placed underneath the rubber at the place where the knot is to be, and after one loop of the knot has been taken in the rubber suture the silk ligature is tied over it and then the second, final loop of the knot is taken

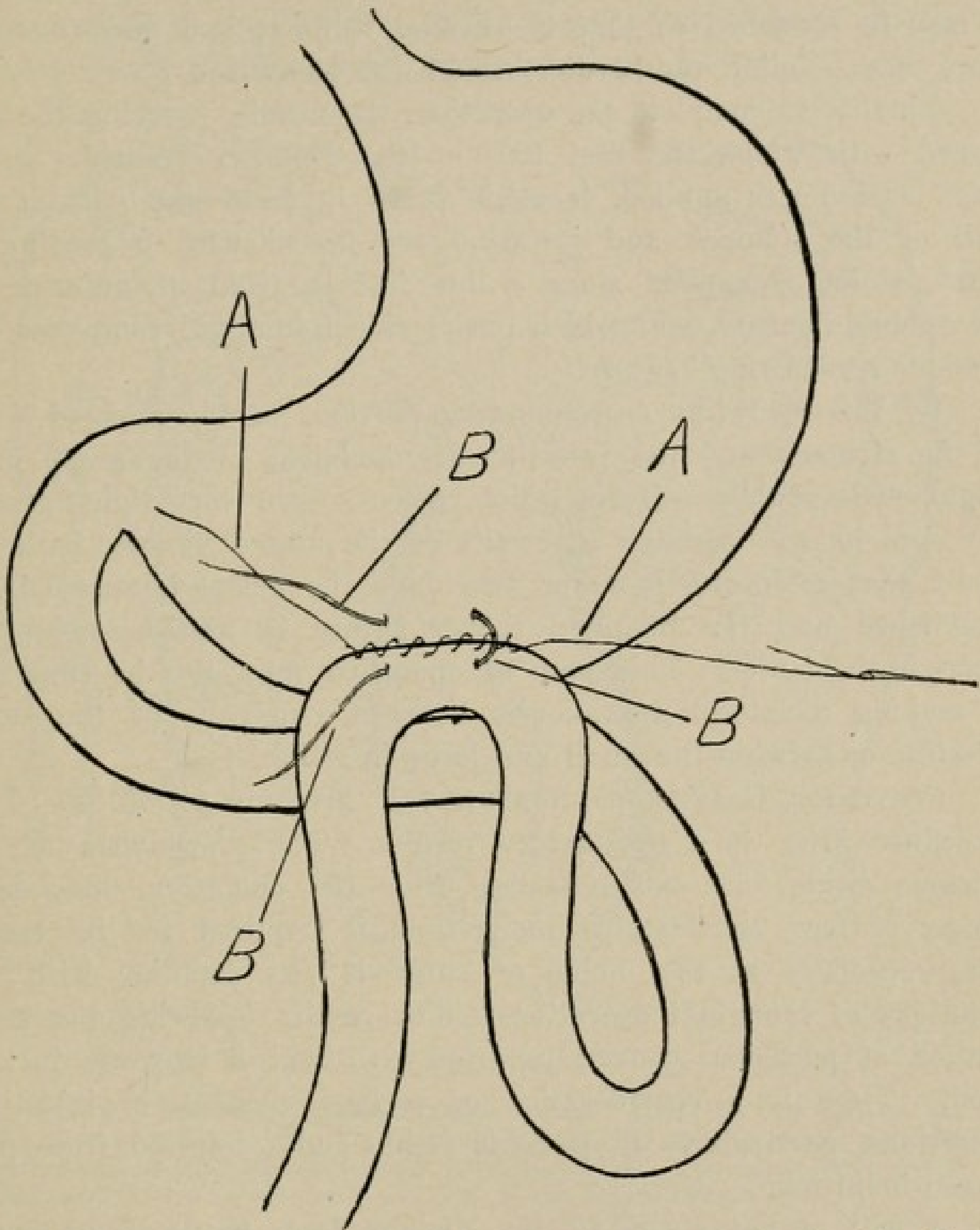

Fig. 215.—Gastro-jejunostomy (*McGraw*). A loop of intestine has been fixed to the wall of the stomach with a continuous, non-penetrating stitch (*A*, *A*). Rubber ligature (*B*, *B*, *B*), which has been passed through the stomach and intestine, ready for tying.

in the rubber suture and the silk ligature again tied over this. The ends of both rubber and silk ligatures are cut very short.

In passing the rubber suture one should make certain that the needle pierces the entire thickness of the wall of the organ and that it does not pick up the mucous membrane of the viscus on its way to make the second puncture—that of exit; in each viscus there should be two punctures only,—one as the needle passes in and one as the needle passes out. In drawing the rubber suture after the needle, through the wall of the stomach and intestine, it may be stretched so that it becomes thinner, and may thus the more readily follow the needle through the punctures.

Finally, to complete the operation, the needle, carrying the silk thread with which the first half of the Lembert "outside serous ring" suture was applied, is again taken in hand and with it the wall of the stomach and intestine are joined with a continuous stitch, which is applied along a line just in front of, anterior to, the rubber ligature, and which buries this latter and completes the "outside serous ring" suture.

By this operation corresponding portions of the apposed walls of the stomach and the intestine are included in the grasp of a single, elastic-rubber suture, which, when drawn very tight, gradually cuts its way through the walls of the united viscera, with the result that after the lapse of two days the gastro-jejunostomy is established and the liberated rubber suture is passed unobserved through the bowel. This plan of operation may also be employed in making a lateral anastomosis between two coils of the small intestine or between the small and large intestine.

Posterior Gastro-jejunostomy, Y Method of Roux.—This procedure gives very satisfactory results. The phenomena of the "vicious circle" are not observed after the operation, but, as a matter of fact, considerably more time is required for its execution, especially at the hands of surgeons less familiar with the technique of intestinal operations. The results following the usual method of posterior gastro-jejunostomy without a loop are just as good. Time is a consideration of serious moment in intestinal operations, particularly in patients feeble and exhausted from prolonged inanition.

A coil of gut about 20 cm. distant from the commencement of the jejunum is selected. The gut is stripped between the fingers in order to empty it, and a strip of narrow tape tied around the gut. Two straight elastic holding forceps are applied to the gut close together and the intestine divided between them with the scissors, the cut reaching into the mesentery as far as the first important vascular arch. The posterior wall of the stomach is then exposed by tearing through the transverse mesocolon, the edges of the opening in the transverse mesocolon being fixed to the wall of the stomach with several non-penetrating silk sutures. The distal, lower, end of the divided gut is lifted up and sewed into an opening made for the purpose in the posterior wall of the stomach and the proximal upper, end of the gut sutured into an opening made in the left side of the lower, distal loop of the gut—the part that has been sutured to the stomach.

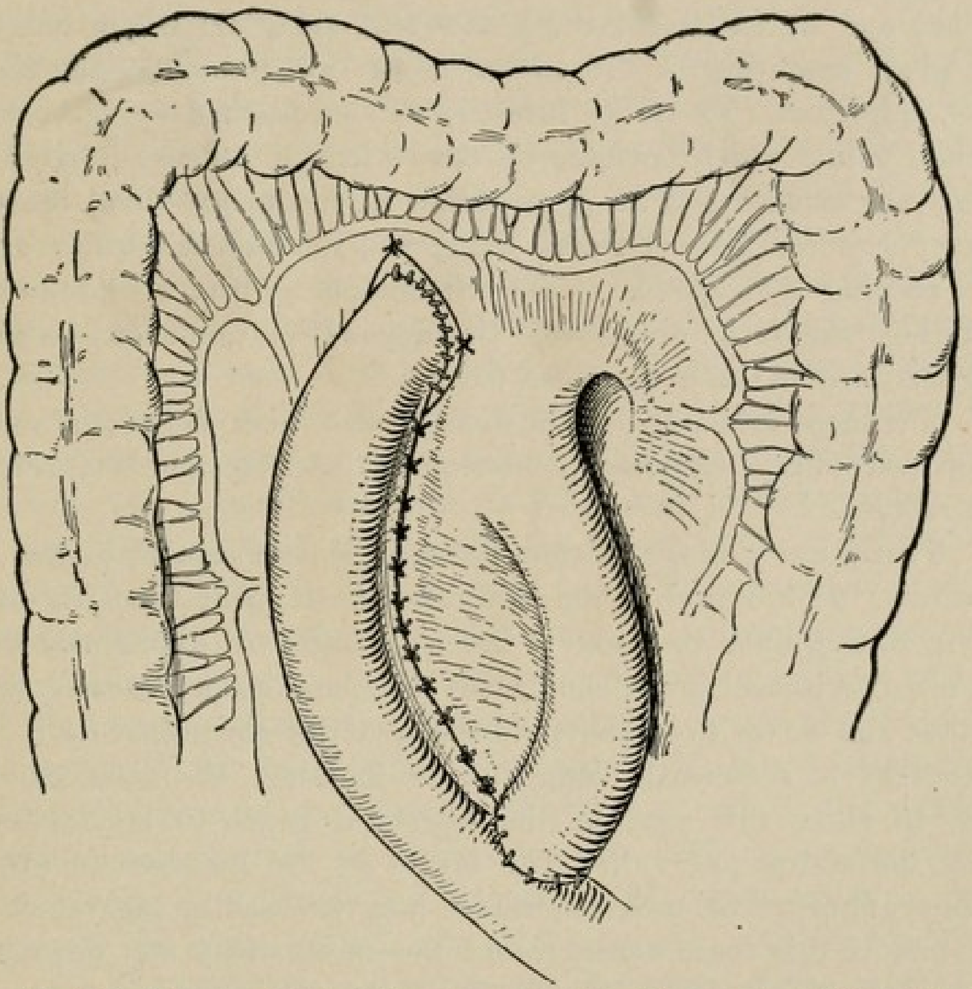

Fig. 216.—Posterior Gastro-jejunostomy (*Roux*). Upper part of jejunum has been divided and the lower segment sutured into an opening in the posterior wall of the stomach through a hole in the mesocolon. The upper segment has been sutured into an opening in the side of the lower segment.

The method of uniting the ends of the gut to the edges of the openings made in the stomach and intestine is similar to that employed in joining the end of the duodenum to the stomach in "Pylorectomy (Kocher)." (See page 391.)

Finally the cut edges of the mesentery are sutured to the adjacent underlying mesocolon and mesentery and the operation thus completed.

This method provides very excellent drainage for the stomach and eliminates almost positively the danger of regurgitation and "vicious circle" phenomena.

THE LARGE INTESTINE AND VERMIFORM APPENDIX.

The Surgical Anatomy of the Large Intestine, etc.—The large intestine may be distinguished from the small intestine by its large caliber and by its sacculation; attached along its whole length is the great omentum or the analogues of this structure, the appendices epiploicæ. The large intestine is also marked by three longitudinal bands which traverse its entire length. These longitudinal bands are made up of an aggregation of the longitudinal muscular fibers; one of them is found along the mesenteric border of the gut, another corresponds to the attachment of the great omentum and the little fatty processes,—the appendices epiploicæ,—and the third is located between these two.

The large intestine may be divided into three parts: the cæcum, colon (ascending, transverse, descending, and sigmoid flexure), and the rectum.

THE CÆCUM is the dilated, pouched commencement of the large intestine. It is found in the right iliac fossa, near the brim of the pelvis, resting upon the psoas or iliacus muscle. It is provided with a complete peritoneal investment, is movable, and has a mesentery which is short and serves to anchor it to the posterior abdominal wall. The mesentery is sufficiently long in the majority of instances, however, to allow this part of the intestinal canal to be drawn out upon the abdominal wall. The layers of the mesocæcum are but loosely adherent to each other and may be readily separated. As a result of this loose arrangement the cæcum may slip down from within the folds of its mesentery and escape into the inguinal canal and form a hernia which is only partly provided with a sac. In such a hernia when the sac is opened, it will be found that the cæcum is attached to the interior of the sac and cannot be separated because the mesenteric folds of the cæcum are directly continuous with the sac. The cæcum cannot, therefore, be independently returned to the abdomen. When the cæcum is returned into the abdominal cavity, the sac must be returned in part with it. The cæcum is continued upward into the ascending colon without any definite line of demarcation between them.

THE VERMIFORM APPENDIX is a blind, worm-like process, which is given off from the inner posterior aspect of the cæcum at the point where the longitudinal bands meet and from one to one and one-half inches below the junction of the small intestine with the cæcum. It is found lying more or less free in the abdominal cavity or dipping into the pelvis.

The base of the appendix corresponds to a point on the abdominal wall called "McBurney's point," which is located two inches to the inner side of the anterior superior iliac spine, upon a line drawn from the anterior superior iliac spine to the umbilicus.

The appendix varies much in size; it is usually as thick around as a lead pencil and its average length is four inches; it varies from two to six inches and may be longer. Usually it is a hollow tube, its canal extending as far as its tip; at times, however, the canal does not extend to the tip or may be absent entirely. Its inner surface is lined with mucous membrane. The appendix is an intraperitoneal structure, being completely invested by the peritoneum, and in nearly all cases it is provided with a mesentery of its own. This mesentery is a little fold derived from the under layer of the mesentery of the small intestine where the latter enters the cæcum; it incloses the appendix between its folds, and usually extends only part way down to the tip, leaving the lower third or half of the appendix free. This mesentery gives one the impression of being too short, causes the appendix to present its curled-up appearance, serves to limit its range of movement, and holds it in close relation with the cæcum. That part of the appendix, toward the tip, which is unprovided with mesentery is freely movable. In most cases the appendix is more or less fixed to the cæcum and to the posterior abdominal wall through its mesentery. Its position, as regards the cæcum, varies in different individuals; most commonly it is found lying upon the inner or left side of the cæcum, with its tip behind the ileum and pointing upward in the direction of the spleen. In other cases it lies upon the outer or right side of the cæcum, rather behind it, its tip pointing upward toward the liver; again, it may be found dipping down into the pelvis or lying across the front of the cæcum. In any of these positions the appendix may be more or less fixed either naturally or by inflammatory adhesions. Occasionally the appendix has no mesenteric fold, but is applied directly against the wall of the cæcum and covered over by the serous layer that invests the cæcum. Under these circumstances, if it becomes necessary to remove it, the peritoneal layer must be incised and the appendix shelled out of its bed. In many cases, especially if thickened, the appendix can be palpated through the abdominal wall.

In the female the appendix is connected with the broad ligament by a thin band, the so-called appendiculo-ovarian ligament and is frequently found adherent to the right uterine appendages in disease of these organs. The appendix is frequently diseased and gives rise to symptoms of its own in connection with disease of the right uterine appendages.

The appendix gets its arterial supply from a single small vessel derived from the ileo-colic which is a branch of the superior mesenteric. The venous return is through a corresponding single venous channel which empties into the superior mesenteric vein. These vessels run parallel with the appendix in the edge of the mesentery between its two layers; when the mesentery is absent they are found upon the surface of the appendix, beneath its serous coat. In the female the appendix receives an additional vessel through the appendiculo-ovarian ligament. The appendix is dependent for its nutrition upon this very limited blood-supply and no doubt this arrangement is, at least in part, responsible for the readiness with which the wall of the appendix becomes necrotic when its circulation is disturbed.

Occasionally some difficulty may be experienced in finding the appendix. The cæcum is the guide to the appendix. If the longitudinal bands upon the cæcum are traced downward they will be found to lead directly to the point where the appendix is given off and therefore these bands are good guides to the root of the appendix.

Just above the root of the appendix the small intestine terminates by entering the cæcum; it enters the cæcum upon its left side. The opening between the ileum and cæcum is guarded by the ileo-cæcal valve. This valve consists of two folds of mucous membrane containing some circular muscular fibers. These folds, projecting into the lumen of the gut, allow the contents of the ileum to pass freely into the cæcum but prevent the reverse. Fluids injected through the rectum, into the large intestine, cannot pass into the ileum unless this valve is forced and that requires enough pressure to threaten the rupture of the large intestine.

The Ascending Colon.—This is the continuation upward of the cæcum. It lies close to the posterior wall of the abdomen. The ascending colon has no mesentery and is only partly invested by the peritoneum, it being absent upon its posterior surface. The ascending colon ascends along the outer border of the right kidney, lying partly upon the kidney, from which it is separated by some interposed loose connective tissue and fat only. Continued upward as far as the under surface of the liver it makes a turn—the hepatic flexure—and becomes the transverse colon. The under surface of the liver shows a shallow depression corresponding to the hepatic flexure and here the colon is attached to the liver by a reflection of peritoneum, the ligamentum hepatico-colicum.

THE TRANSVERSE COLON stretches from right to left across the upper part of the abdominal cavity, lying below the first part of the duodenum and greater curvature of the stomach. Close to the spleen, on the left side, the colon makes a second turn,—the splenic flexure,—and from this point is continued downward as the descending colon. At the splenic flexure the colon is fixed to the diaphragm by a fold of peritoneum, the ligamentum phrenico-colicum.

The transverse colon is completely invested by peritoneum and has a long mesentery which suspends it from the posterior wall of the abdomen. The transverse colon enjoys considerable freedom of movement, but is connected with the greater curvature of the stomach by the peritoneum.

In the very young child the connection of the transverse colon to the greater curvature of the stomach does not exist, because the layers of peritoneum which invest the stomach and unite with each other at the greater curvature to form the great omentum have not become adherent to the peritoneum which envelops the transverse colon; this does not occur until later in life. (See Fig. 159.)

THE DESCENDING COLON passes downward in the left side of the abdominal cavity, lying close to its posterior wall, to which it is partly fixed. It has no mesentery, is only partly invested by the peritoneum, and cannot be drawn out upon the abdomen. The posterior wall of the descending colon, which is devoid of peritoneum, lies close to the outer border of the left kidney, lying partly upon its anterior surface. It is continued below into the sigmoid flexure.

THE SIGMOID FLEXURE is the last part of the colon; it is a redundant loop of gut curved upon itself and lying in the left iliac fossa. Its caliber is rather smaller than that of the other parts of the colon; it is completely invested by the peritoneum and has a fairly long mesentery which suspends it to the posterior abdominal wall and permits much freedom of motion. The layers of the mesentery are very loosely attached to each other, so that the sigmoid flexure may readily slip down between them and escape into the inguinal canal, giving rise to a hernia with an incomplete sac. When the sac is opened it will be found that the sigmoid is attached to the interior of the sac and cannot be detached, because the mesenteric folds of the sigmoid are directly continuous with the sac. When the bowel is returned into the abdomen the sac must be returned in part with it. In most cases the sigmoid flexure may be freely drawn out upon the abdominal wall. At the sacro-iliac synchondrosis it is continued down into the pelvis as the rectum.

THE BLOOD-SUPPLY OF THE LARGE INTESTINE. — The cæcum, appendix, and ascending and transverse colon are supplied by branches which are given off from the right, or concave, side of the superior mesenteric artery.

The descending colon and sigmoid flexure are supplied by the inferior mesenteric, which comes off from the front of the aorta just below the origin of the superior mesenteric; after supplying the parts mentioned this vessel dips into the pelvis, between the layers of the mesorectum, to supply the rectum as far as its lower end.

The arterial branches which are derived from the superior and inferior mesenteric for the supply of the ascending and descending colon, as they pass to their destination, lie upon the posterior abdominal wall covered by the peritoneum which lines the back of the abdomen; those which supply the cæcum, transverse colon, and sigmoid flexure, which parts of the large intestine are provided with a mesentery, reach their destination between the layers of the mesentery corresponding to the part.

The veins have a course similar to the corresponding arteries. The inferior mesenteric joins with the splenic vein, which, in turn, unites with the superior mesenteric to form the portal; hence, blood from the intestinal tract and rectum[1] must first traverse the portal circulation (through the liver) before entering the general circulation. Poisonous matter may be absorbed from the intestinal tract (colitis, hemorrhoids, etc.) and cause thrombosis in the veins leading from these parts or may result in abscess in the liver, etc.

As is the case with the vessels of the small intestine, the terminals of the arteries that are distributed to the large intestine do not anastomose freely with each other; hence division of a considerable branch will often result in gangrene of the corresponding part of the gut.

OPERATIONS UPON THE LARGE INTESTINE.

Colostomy.—The formation of a fistulous opening into the large intestine, a so-called artificial anus. The operation is resorted to in cases of obstruction due to stricture of the bowel, and as an emergency

[1] Some venous blood from the rectum enters the general circulation direct through the middle and inferior hemorrhoidal veins.

operation for the purpose of saving life in acute intestinal obstruction. The operation may be performed as a temporary measure for the purpose of draining the bowel preliminary to undertaking the operation of resection of the rectum, or to facilitate the healing of ulcerated areas in the colon, rectum, etc. It is desirable in all cases to make a complete colostomy, including the entire calibre of the gut in the artificial anus. In this way a spur is formed between the two openings which result from the operation, double-barrel shot-gun fashion, and in this manner the entrance of fecal matter into the lower constricted or diseased portion of the bowel is prevented.

The entrance of fecal material into the lower part of the bowel is very objectionable and is to be avoided if possible. It accumulates and becomes foul in cases of stricture, and in those cases where the colostomy has been performed as a preliminary to resection of the rectum it interferes with the healing process. The lateral colostomy in which no spur is formed should be done in those cases only where, owing to short mesentery, adhesions, etc., it is impossible to draw a loop of the bowel sufficiently long to permit of the spur operation, out of the abdominal incision. Even in these cases it will often be possible to free the bowel to a sufficient degree by carefully incising the mesentery or breaking up adhesions.

Left Iliac Colostomy.—Where the obstruction is in the rectum or in the sigmoid, the artificial anus is made in the left iliac region. A permanent artificial anus is established in the left iliac region in those cases where the rectum has been extirpated and it is not possible to draw the end of the sigmoid down to the site of the original anal orifice; or where the anal sphincter apparatus has been sacrificed on account of involvement of the anal portion. The incision is made parallel with Poupart's ligament, about three inches long, commencing above about one inch above and to the inner side of the anterior superior spine and terminating below about one inch above the middle of Poupart's ligament. The incision is carried through the skin and fat down to the aponeurosis of the external oblique, which is split in a line corresponding to the direction of its fibers. The fleshy portion of the internal oblique muscle is thus exposed. The fibers of this muscle are separated with the handle of the knife in the direction of their course, which is nearly at right angles to the line of the skin incision. The fleshy fibers of the transversalis are next exposed and are likewise separated bluntly. Blunt retractors are introduced to hold the edges of the incision apart and the transversalis fascia and peritoneum are incised along a line corresponding to the direction of the skin incision. These last two layers are usually divided as one layer, especially in thin subjects. The edges of the peritoneum and transversalis fascia are seized with two artery clamps, one on either side of the incision and taking a good broad bite. The fingers are introduced and the sigmoid sought. In order to secure this portion of the bowel two fingers are introduced into the abdomen and carried outward and backward, gliding upon the inner surface of the abdominal wall as far as the lumbar region, where the colon is found; one may meet with coils of the small intestine and these may get in the way of the fingers but they may be recognized on account of their being entirely surrounded by peritoneum and are easily pushed aside; the fingers are allowed to glide from the posterior wall of the abdomen on to the descending colon which is traced downward until its continuation, the sigmoid flexure, is reached. The sigmoid is provided with a long mesentery as a rule, and can be drawn freely out of the abdominal incision. The loose sigmoid flexure is not used to form the artificial anus. On account of its lengthy mesentery it has a tendency to become very much prolapsed and this is undesirable. The sigmoid flexure is drawn out through the incision working upward until a portion of the bowel corresponding to the lowest part of the descending colon is secured. The portion of the bowel selected has a mesentery which is just sufficiently long to permit of a loop being drawn out of the incision. The rest of the bowel is then pushed back into the abdomen.

Corresponding to the middle of the incision a mattress suture of heavy silk is passed through all the layers of both edges of the incision, passing from one edge of the incision to the other and transfixing the mesentery in its course. This stitch is introduced with a large full curved Hagedorn needle. It is introduced about one inch away from the edge of the incision, penetrating all the layers and taking care to see that it takes a good bite in the peritoneal layer. It passes through the mesentery of the loop of bowel about one inch distant from the bowel and without wounding any of the vessels. The needle may be passed through the mesentery blunt end first and selecting a point free from blood-vessels. The suture then passes through all the layers of the opposite edge of the incision. It is passed back in the reverse order and through the same hole in the mesentery, and finally through the first edge of the incision emerging close to the point where it was originally introduced. This stitch is the suggestion of Ward. It does not

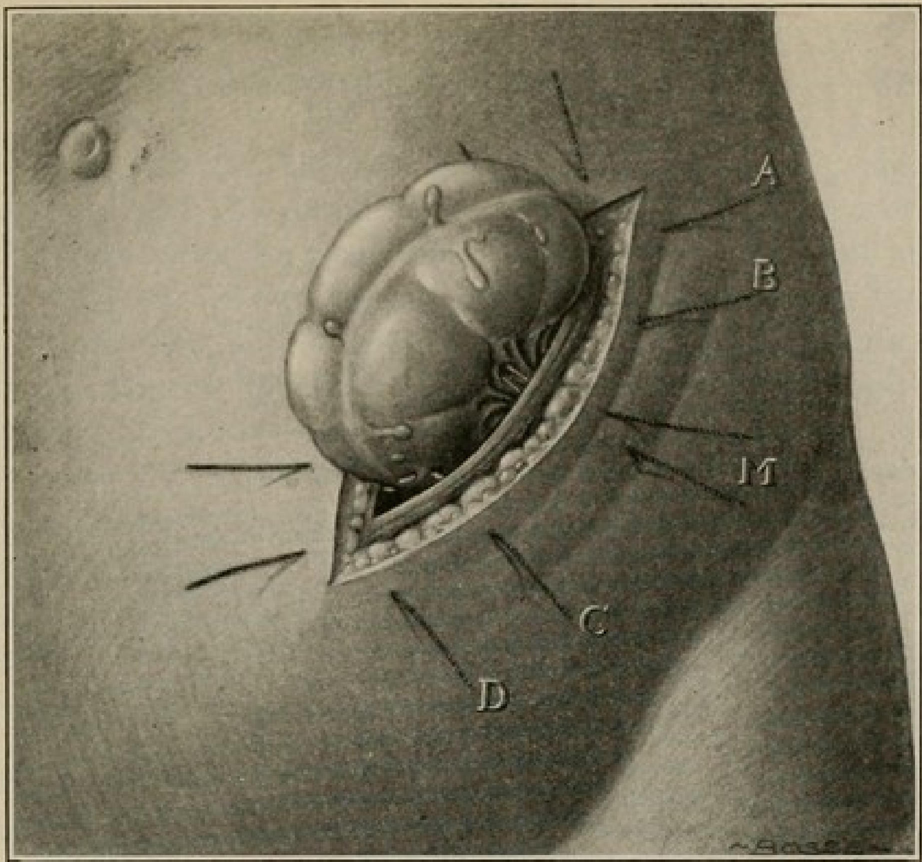

Fig. 217.—Colostomy. A loop of the intestine is drawn out through the incision. *A, D,* sutures that penetrate the skin and fat and the aponeurosis of the external oblique and serve to close the upper and lower ends of the incision. *B, C,* sutures that go through the peritoneum and transversalis fascia and pick up the bowel with several bites. They serve to close the incision in part and to secure the bowel as well. *M,* suture that penetrates all the layers of the abdominal wall and pierces the mesentery of the loop of bowel. It serves to bring the edges of the incision together in the middle.

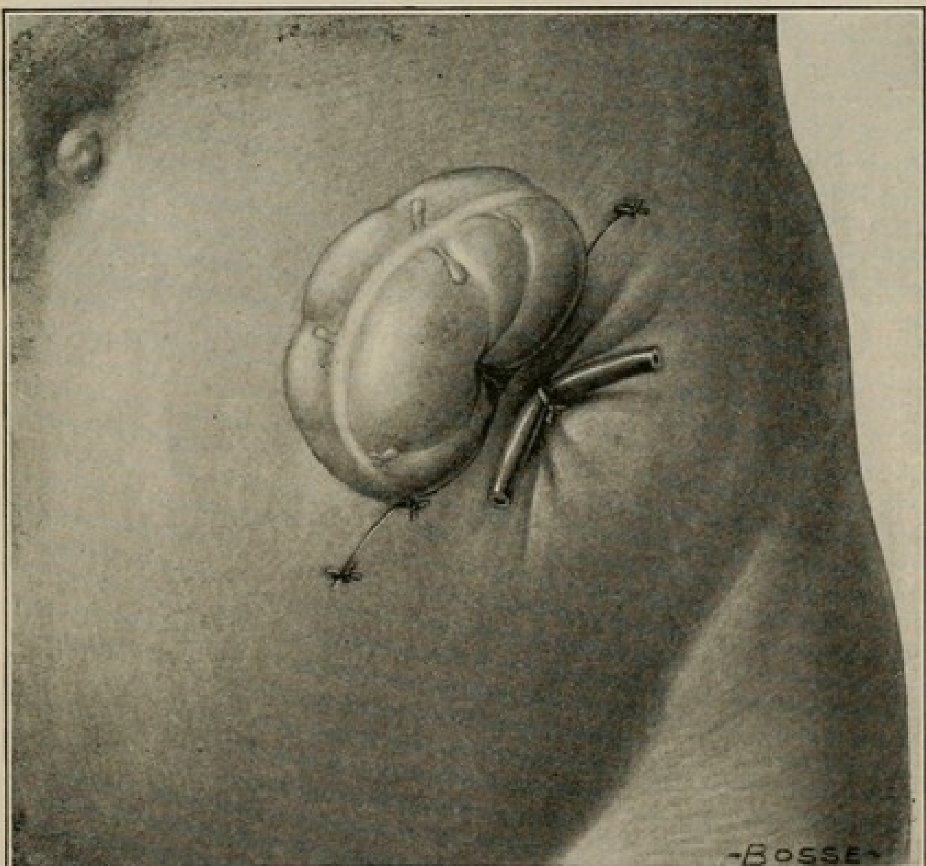

Fig. 218.—Colostomy. Sutures all tied. Mesenteric suture is tied upon a piece of rubber tubing on each side of the incision to prevent its cutting into the skin.

serve the purpose of suspending the loop of gut, but when drawn tight and tied it has the effect of bringing the two edges of the incision together in the middle, under the protruding loop of bowel, practically dividing the incision into two halves, an upper for the upper arm of the loop of gut and a lower for the lower arm. Before tying the mattress suture, additional sutures of silk are introduced, two in the upper end of the incision and two in the lower end. Of these sutures the uppermost and lowermost, *A* and *D*, penetrate the skin and fat and the aponeurosis of the external oblique only. These two sutures are of silk and serve simply to close the incision in part. The other two sutures, *B* and *C*, go through the peritoneum and transversalis fascia in the edges of the incision, and, as they pass across from one edge of the incision to the other, they pick up the wall of the bowel with one or two good broad bites, but without penetrating the entire thickness of the wall of the bowel. These sutures are of chromic catgut No. 1 and catch the wall of the bowel at a part corresponding to the line of one of the longitudinal muscular striæ—in this way insuring a very secure hold. The mattress suture is drawn tight and tied over a piece of rubber tubing in the loop upon either side of the incision in order to prevent the suture from cutting into the skin. The mattress suture brings the edges of the incision closely together in the middle with the mesentery of the sigmoid interposed between them, and obviates any danger of the loop of bowel becoming displaced or retracting back into the abdomen. The sutures *A* and *B*, and *C* and *D* are tied, thus closing the incision in part and fixing the bowel in the upper and lower ends of the incision.

This intramuscular method insures a fairly continent artificial anus. As the split muscles return to their natural position they grip the protruding loop of bowel pretty tightly and thus close the artificial anal opening.

Fatty appendices hanging from the loop of bowel are ligated and cut away.

A layer of rubber tissue is placed over the bowel to prevent sticking of the dressings.

The loop of bowel is opened by longitudinal incision with the knife or, better, with the cautery at a dull red heat after the lapse of several days, depending upon the urgency of the case. When the bowel is opened it will be seen that there are two openings separated by a partition or spur that prevents the entrance of material into the lower loop.

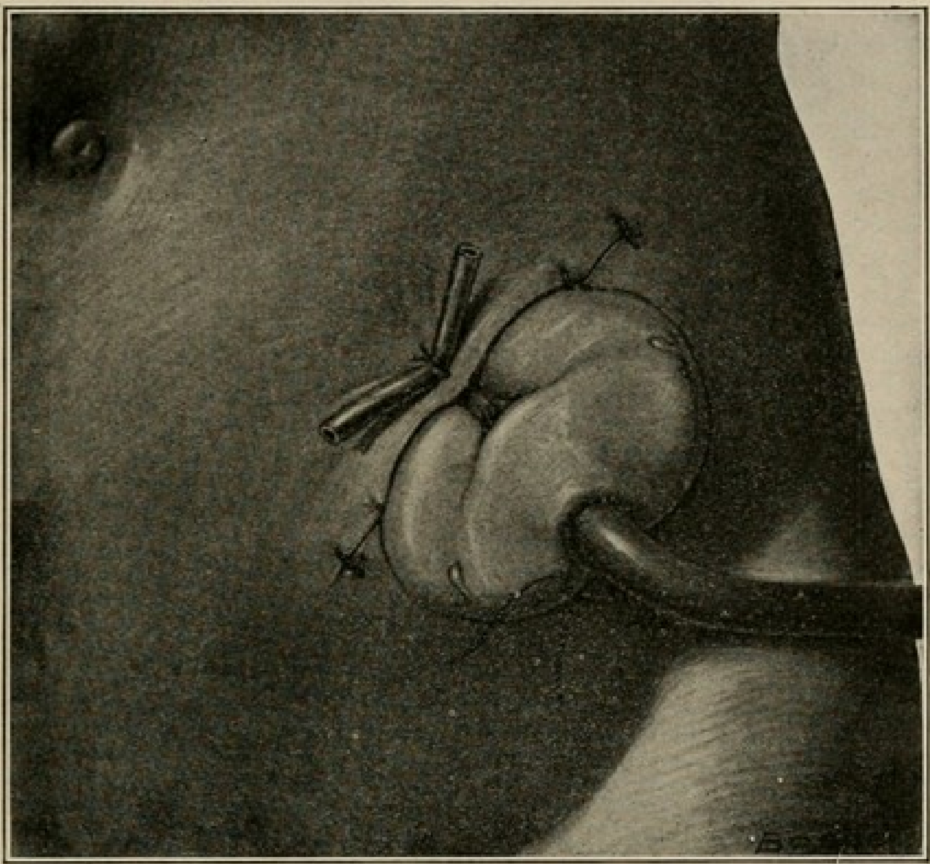

Fig. 219.—Colostomy. Rubber tube fixed in the loop of intestine with a purse-string suture.

If necessary to open the bowel immediately this may be done without danger of soiling by inserting a thick rubber tube or a Paul glass tube into the bowel. The loop of gut is emptied by stripping with the fingers and a rubber-sheathed holding clamp applied to the bowel to prevent re-entrance of contents until the tube has been secured in place. A purse-string of silk is introduced in the wall of the bowel and a small incision made. A small amount of intestinal contents that escapes is caught with a gauze wipe. The rubber tube or Paul's tube is introduced into the bowel and secured by tying the purse-string moderately tight around it.

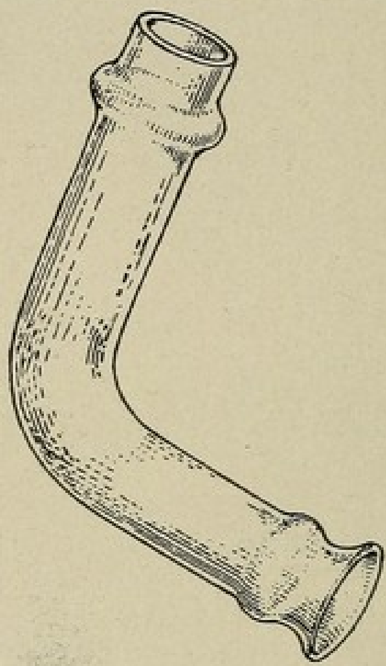

Fig. 220.—Paul's Tube. Used to drain the colon and intestine.

The holding clamps are removed. The tube will drain the bowel without the wound becoming soiled until adhesions have formed. If the rubber tube is used it is secured from becoming displaced by a suture that fixes it near the edge of the small incision in the bowel.

Right Iliac Colostomy.—If the growth—obstruction—involves the transverse or descending colon, the operation may be performed in a manner similar to that described above upon the right side of the body; in this case the lower part of the ascending colon is brought out through the incision and fixed.

Lateral Colostomy Without a Spur.—The colostomy with a spur just described is preferable. The incision is similar to that described in the preceding paragraphs. The edge of the peritoneum upon each side is fixed to the corresponding margin of the skin, near the middle, with two or three catgut sutures; this is done to prevent retraction of this layer of peritoneum. A silk stitch (*A*, Fig. 221) is passed through the edges of the upper part of the incision, through all the layers, including the skin and the edges of the peritoneum; a second similar suture (*D*, Fig. 221) is passed through the lower part of the incision. These two sutures are not tied until later. The lower part of the descending colon is sought

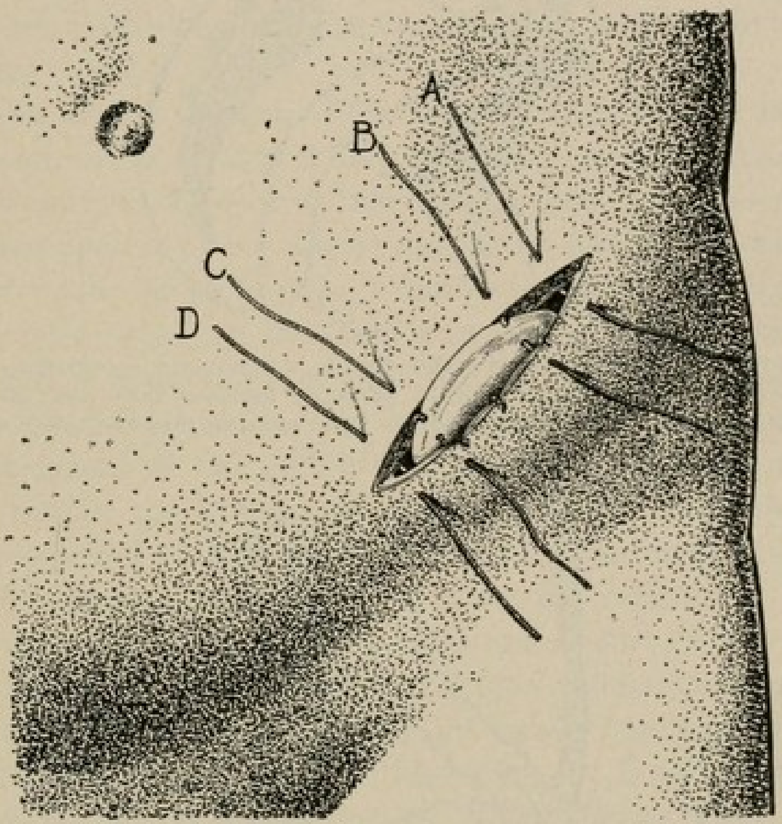

Fig. 221.—Colostomy. The wall of the descending colon drawn into the incision and fixed. *A*, *D*, stitches which pass through all the layers of the abdominal wall, including the peritoneum; *B*, *C*, stitches which pass through all the layers of the abdominal wall, including the peritoneum, but catch up the wall of the gut as well in their course.

for and drawn into the incision, and while the gut which has been selected is steadied in the wound a silk stitch (*B*, Fig. 221) in a curved surgeon's needle is passed through the upper part of one edge of the incision, through all the layers, care being taken to include the peritoneum; it then passes superficially through the wall of the gut, picking up its serous and muscular coats and taking a good, broad bite or several bites, along the line of the longitudinal muscular striæ, but not penetrating into its lumen, and finally is brought out through the opposite edge of the abdominal incision.

A second stitch (*C*, Fig. 221) is similarly introduced in the lower part of the abdominal wound, and this also catches the wall of the

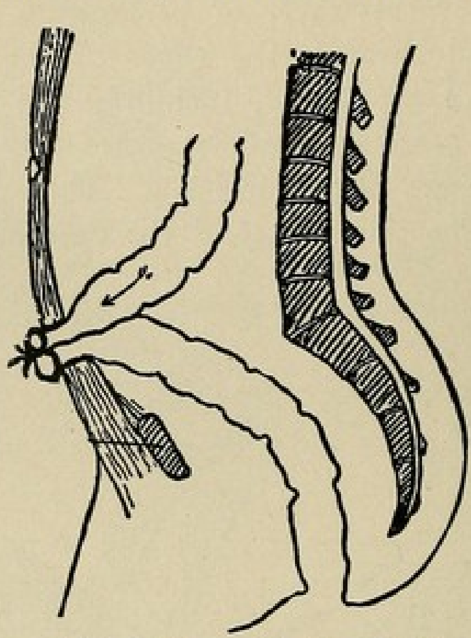

Fig. 222.—Colostomy. Shows the result of complete colostomy with spur. Two openings result with a spur or partition between them that prevents the contents from the upper segment of gut from passing into the lower segment.

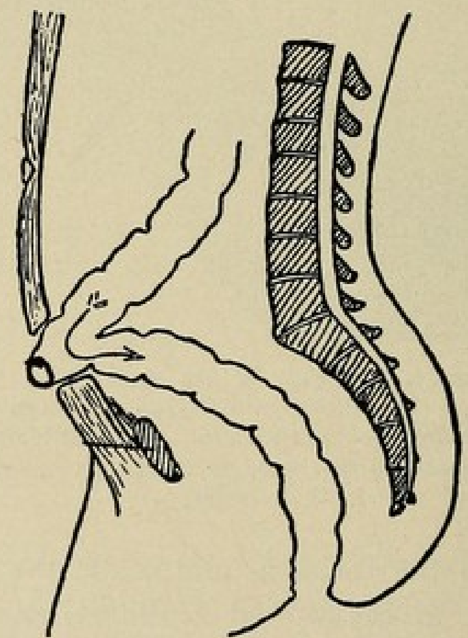

Fig. 223.—Colostomy. Shows the result of lateral colostomy. No spur is formed and contents from the upper segment may pass readily into the lower segment.

bowel on the way. These two stitches (*B* and *C*) should be about two inches apart and may now be tied, likewise the two stitches previously introduced through the edges of the wound, above and below, and the bowel is thus partially fixed in the abdominal incision. The bowel is still further fixed to the margins of the abdominal incision by three or four interrupted fine chromic catgut sutures on either side; each one of these secures the serous and muscular coats of the bowel and the edge of the incision in the abdomen, including the parietal peritoneum and skin. They may be introduced with a small, curved surgeon's needle.

If the condition is not very urgent the bowel had better not be opened until after the lapse of from twenty-four to forty-eight hours, or even longer, thus allowing time for adhesions to form and shut off the peritoneal cavity.

Resection of the Cæcum.—This may include, in addition to the cæcum, the whole or a part of the ascending colon and part of the ileum. For malignant disease, tuberculosis, and intussusception.

If, before operating, the disease can be located in this part of the gut or a tumor felt, the incision is probably best placed directly over the tumor penetrating through the outer part of the right rectus muscle. If the incision is made primarily for the purpose of exploration, the location of the tumor not having been previously ascertained, then it is usually placed in the middle line, reaching from the umbilicus downward, toward the symphysis; through this incision the cæcum may also be excised if found advisable. In either case the incision must be long enough to allow sufficient room for work.

If the incision is made through the outer part of the rectus it commences about one inch above the middle of Poupart's ligament and is carried in a direction upward to a point located midway between the umbilicus and the anterior superior iliac spine or, if necessary, it may be continued farther upward toward the tip of the tenth rib. It may vary from five to ten inches in length. We may find it necessary to separate some adhesions before the cæcum is exposed. This portion of the bowel together with the adjoining part of the ileum, is brought out of the incision upon the abdomen.

The cæcum being steadied outside the abdominal incision, is surrounded by gauze pads to protect the abdominal cavity and two strips of narrow tape are tied about the bowel beyond the part which is to be excised. Before tying the second piece of tape the segment of gut should be emptied by stripping it between the fingers.

The mesentery corresponding to the segment of gut which is to be excised is tied off in sections with catgut ligatures. The ligatures may be carried in the eye of a blunt ligature carrier or with a pointed-nosed artery forceps. Each ligature should be single and placed some distance away from the gut so as to leave space to cut between them and the gut. The segment of gut which is to be excised is detached by cutting its mesentery between the ligatures and the gut. One should take care to excise all of the gut whose mesentery has been tied off, because, if an end of the gut which has been deprived of its mesentery, and hence its blood-supply, is left, it is slow to unite and may become gangrenous. It remains to divide the gut above and below, thus removing the diseased segment. This is done with a long, straight scissors in one sweep, long clamps having been previously placed upon the gut to close the diseased segment in order to prevent the escape of its contents when it is cut.

Instead of proceeding as above, one may, after the tapes and compression clamps have been applied to the gut, divide the gut above and below the diseased area and then tie off the corresponding part of the mesentery in sections as described.

We are then ready for the final step of the operation, the restoration of the continuity of the alimentary canal by joining the ileum to the colon (ileo-colostomy), and this may be accomplished by:—

1. End-to-end anastomosis.

2. Lateral anastomosis with suture, clamps or McGraw's rubber ligature.

3. Lateral implantation with suture or Murphy button.

End-to-End Anastomosis.—This method may be employed if both ends of the gut which are to be united are of the same caliber. This condition at times exists, owing to the fact that the obstruction in the cæcum or at the ileo-cæcal opening may have caused a dilatation and hypertrophy of the ileum, the large intestine at the same time having become more or less diminished in caliber.

The anastomosis may be made with suture in a manner similar to that described in end-to-end anastomosis of the small intestine. If the two ends of gut are of unequal lumen the larger must be reduced by infolding a portion so that it will correspond in size with the smaller (see "End-to-end Anastomosis, Small Intestine").

Lateral Anastomosis. — This is a satisfactory method of restoring the continuity of the intestinal canal, particularly if the ends are of unequal size; for example, in joining the ileum to the cæcum or colon (see "Lateral Anastomosis, Small Intestine").

The cut edge of each segment of gut is inverted, a margin of from three-fourths to one inch being turned in and the opening closed with a continuous suture of chromic catgut which passes through the serous and muscular coats, always taking special care, particularly at the mesenteric border, to appose serous surfaces to each other. A second continuous silk suture is then introduced; this second suture also includes only the serous and muscular coats and serves to bury the first line of suture. After the ends of the bowel have been thus closed up they are placed side to side overlapping each other for a distance of about five inches and they are then united, surface to surface, for a distance of three or four inches with a continuous Lembert suture of fine silk. This line of suture forms the first half of the "outside serous ring," suture and when it has been introduced the needle with the thread left long is temporarily laid aside. An incision is made in each segment of the gut about three inches long but not so long as the line of the Lembert suture (one inch shorter) and at a distance of about one-fourth inch away from the line of the Lembert suture. The corresponding edges of these incisions are sewed together all around with a continuous overhand suture of chromic catgut which includes all the coats of the gut. After the edges of the openings have been thus united, the needle with which the first half of the "outside serous ring" suture was made is again taken up and the second half of the "outside serous ring," Lembert suture, inserted. The gut is kept free of contents during the operation, as usual, by constricting it with strips of narrow tape passed around each segment of gut beyond the site of the operation.

After the segments of the gut have been joined together and the anastomosis formed, the parts are wiped clean with a gauze pad wet with hot saline, any rent or opening remaining in the mesentery closed with several sutures of plain catgut and the parts returned to the abdomen.

The lateral anastomosis may also be made with the clamps, McGraw rubber ligature, Murphy button. The technique of these methods has been described elsewhere in the volume.

End-to-Side, Lateral Implantation.—The technique of this operation is analogous to that employed in Kocher's method of implantation of the end of the duodenum in the stump of the stomach (see "Pylorectomy"). The operation may be done with the suture or with the Murphy button. After the end of the large intestine has been inverted and closed by suture the end of the ileum is united to the edges of an opening which is made in the wall of the large intestine opposite its mesenteric border, corresponding to one of the longitudinal striæ.

Ileo-colostomy Without Resection of the Cæcum or Colon.—This operation may be done in cases of obstruction at the ileo-cæcal valve when the advisability of a more radical operation—resection—is doubtful. A lateral anastomosis may thus be made between the ileum and the ascending colon, or, if the obstruction is located in another part of the colon, the anastomosis may be made between the ileum and the sigmoid flexure. Care should be taken to secure a coil of small intestine as low down, near the cæcum, as possible; so that the nutrition of the patient may not be seriously interfered with. The details of the operation are similar to those described in the preceding paragraphs (see "Lateral Anastomosis").

Resection of the Sigmoid Flexure.—This operation is usually performed for malignant obstruction. This part of the large intestine is a favorite seat of malignant disease.

The incision is probably best made analogous to that for excision of the cæcum but upon the other side of the abdomen, through the outer part of the left rectus, commencing below, about one inch above the middle of Poupart's ligament. The sigmoid may also be resected through an incision in the linea alba, extending from the umbilicus downward to the symphysis pubis if such an incision has already been made for the purpose of exploration before the growth was definitely located.

The sigmoid, owing to its long mesentery, may be readily drawn out through the abdominal incision. It is surrounded by gauze pads to protect the abdominal cavity and after the mesentery which is usually quite long, has been tied off in sections, that part of the bowel which is to be resected is clamped off, cut free from its mesenteric attachment, and finally excised. The ends of the bowel are then united, end to end, by suture or with a large Murphy button, as described in resection of the cæcum, etc.

If the sigmoid is fixed and the neighboring parts already infiltrated, it may be better to make an artificial anus above the seat of obstruction and omit the radical operation.

Malignant disease is frequently encountered at the hepatic flexure of the colon, rather less commonly at the splenic flexure. When the disease is located at the hepatic flexure the gall-bladder and liver are usually already hopelessly involved in the disease.

The colon may be resected at the hepatic and the splenic flexures, the incision being made above, through the outer part of the corresponding rectus, or in the middle line, from the ensiform cartilage downward to or beyond the umbilicus. The continuity of the canal may be restored by any one of the methods described above, preferably the end-to-end with the suture.

OPERATIONS UPON THE VERMIFORM APPENDIX.

Appendicectomy.—Removal of the appendix.

As performed in cases of chronic relapsing catarrhal and recurrent appendicitis and in acute cases that have not yet gone on to suppuration—in all cases that are not complicated by abscess formation and that do not require drainage. In these cases the McBurney gridiron or the mid-rectus incision is used, and the incision is closed up immediately without drainage.

The McBurney Gridiron Incision.—This method obviates the likelihood of subsequent hernia and should be employed whenever possible. The skin is incised in an oblique direction from above, downward and inward. The incision is about three inches long. This incision may be lengthened later if it becomes necessary. In fat subjects it is well to make a liberal incision through the integument and fat. In penetrating through the aponeurosis and muscle, etc., the incision may be made as short as is compatible with the proper performance of the operation. The incision should be placed about one and one-half inches to the inner side of the anterior superior iliac spine, crossing, almost at a right angle, a line drawn from the anterior superior spine to the umbilicus and so arranged that one-third of the length of the incision is above the line and two-thirds below it. The aponeurosis of the external oblique is exposed and split by separating between its fibers, and then two broad, sharp retractors are introduced, and, retracting the skin and aponeurosis, the muscular fibers of the internal oblique are exposed; these are not cut, but are separated with the handle of the knife in the direction of the fibers, which is nearly at a right angle to the direction of the skin incision. The fibers of the transversalis muscle are next exposed and separated in a similar manner. With two blunt retractors the edges of the muscles are drawn apart and the transversalis fascia exposed. This layer is incised and finally the peritoneum. These last two layers are divided in the same direction as the internal oblique; *i. e.,* at right angles to skin incision. They are picked up with two mouse-toothed forceps and divided between these in order to avoid injuring the underlying gut which may lie close to the peritoneum or be adherent to it. The fascia and the peritoneum may be divided, each separately. Occasionally they lie in such intimate relation, one to the other, that they are divided as one layer.

The incision is closed by suturing the edges of the peritoneum and transversalis fascia together with a continuous stitch of plain catgut. The edges of the transversalis fascia are picked up and included with the peritoneum in order to give more security to this layer of suture. The edges of the muscles of themselves return to place and are secured by two or three interrupted catgut sutures. The aponeurosis of the external oblique is sewed with a continuous catgut suture from above downward and the skin closed with an intracuticular catgut suture.

The Mid-rectus Incision.—This is a most satisfactory incision. It is of especial value in those cases where there is doubt as to the presence of pus. It permits easy access to the appendix in simple catarrhal cases and likewise is adapted to those cases complicated with abscess and where drainage will be necessary. With proper closure there is no likelihood of subsequent hernia. The tubes and ovaries may also be reached through this incision and they are frequently found diseased when the abdomen has been opened for appendicitis.

A vertical incision about four inches long is made over the middle of the right rectus muscle. This incision penetrates through the skin and fat down to the aponeurosis of the external oblique. The lower two-thirds of this incision should be below a line which is drawn from the anterior superior spine to the umbilicus. The aponeurosis, which really forms the anterior layer of the sheath of the rectus, is divided with the scissors. The operator penetrates between the fleshy fibers of the rectus bluntly with the fingers or the end of the blunt scissors. The deep epigastric artery and vein are seen passing across the bottom of the incision beneath the fascia transversalis. They must be drawn to one side or clamped and ligated.

In closing the incision, the several layers must be sutured separately—first, the peritoneum, and, included with this layer, the fascia transversalis and posterior layer of the rectus sheath with plain catgut. The edges of the rectus muscle are approximated with several interrupted sutures of plain catgut. The edges of the aponeurosis of the external oblique (anterior layer of the sheath of the rectus) are united with a continuous suture of chromic catgut, No. 2, and, finally, the edges of the skin are united with an intracuticular suture of plain catgut.

After the abdomen has been opened by either of the methods described above, we may proceed with the next step of the operation, the search for the appendix. At times it may be found presenting at once in the wound, more or less changed, thickened, etc., or, occasionally being bound down and fixed within the abdomen by adhesions, it does not come into view and then it will be necsesary to search for it.

The apendix may be directed downward and may dip into the pelvis, or, with its hip pointed upward, it may lie to the outer or to the inner side of the cæcum. It may be more or less confined in any of these positions by its mesentery or by adhesions. If difficulty is experienced in finding the appendix, the cæcum may be brought out of the incision to serve as a guide. The cæcum is the

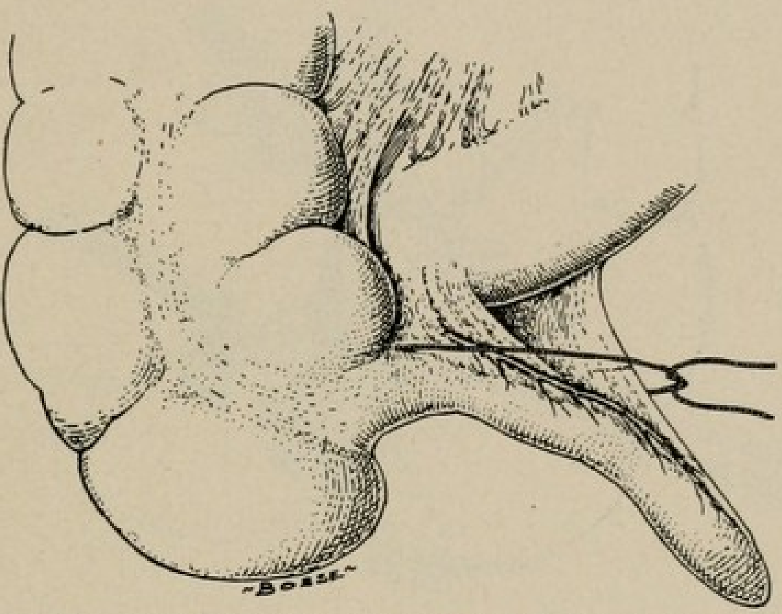

Fig. 224.—Appendicectomy. Ligature passed around the meso-appendix ready to tie.

guide to the appendix and is identified by its sacculation, by the little fatty processes attached to it and by its longitudinal, white striæ, two of which can usually be seen: if these striæ are followed they will be found to lead down to the point where the appendix is given off. Occasionally the appendix is applied directly against the wall of the cæcum, covered over by the serous layer that invests the cæcum. In order to remove it, it would be necessary to incise the peritoneal layer that covers it and peel it out of its bed.

The appendix is gently liberated from its adhesions with the fingers,—there is no danger of hemorrhage in this procedure,—and gradually it is brought out of the incision, the cæcum being at the same time returned into the abdomen. Care should be exercised to detach the appendix all the way back as far as its root.

After the appendix has been sufficiently freed it is drawn out through the incision and its mesentery is tied off. This is done by transfixing the mesentery close to the appendix and near its root with a ligature carrier or with a needle carrying a piece of No. 2 plain catgut. This ligature is tied and the appendix then cut away from the mesentery, cutting between the appendix and the ligature with the scissors. If the mesentery is unusually broad several ligatures may be used, taking the mesentery in several bites. The appendix having been thus cut away from its mesentery all the way back to its root, we are ready to proceed with the final

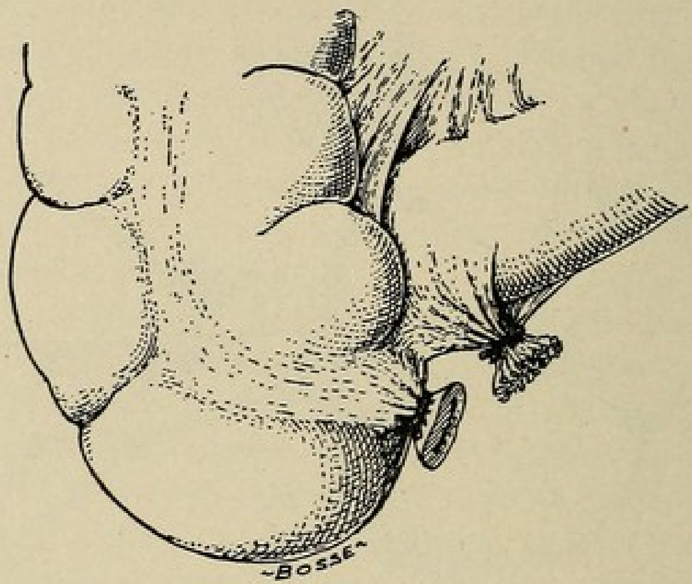

Fig. 225.—Appendicectomy. Mesoappendix has been ligated. Ligature tied around root of appendix and the organ amputated. The stump has not been inverted.

step of the operation,—the removal of the appendix. This may be done in one of several ways.

1. Ligature Without Inversion.—After the mesentery has been tied off and cut away from the appendix with the scissors, a catgut ligature (No. 2) is tied securely around the appendix about one-fourth inch distant from its root; the ends of this ligature are left long to serve as a temporary tractor. The appendix is seized with an artery clamp upon the distal side of the ligature to prevent leakage when it is cut, and with a straight scissors it is amputated between the clamp and ligature. While the stump of the appendix is steadied by making traction with the ligature which was left long intentionally for that purpose, the raw end of the stump is

touched with pure carbolic acid on a small probe or else it is cauterized with a pointed Paquelin. The ligature is cut short and the stump of the appendix allowed to drop back into the abdomen. This is a safe way of dealing with the appendix stump and is especially satisfactory in cases where unusual difficulty would be experienced in inverting it, etc.

2. Inversion of the Stump of the Appendix with Purse-string (Dawbarn).—After the mesentery has been ligated and cut free from the appendix, the latter is steadied and a purse-string

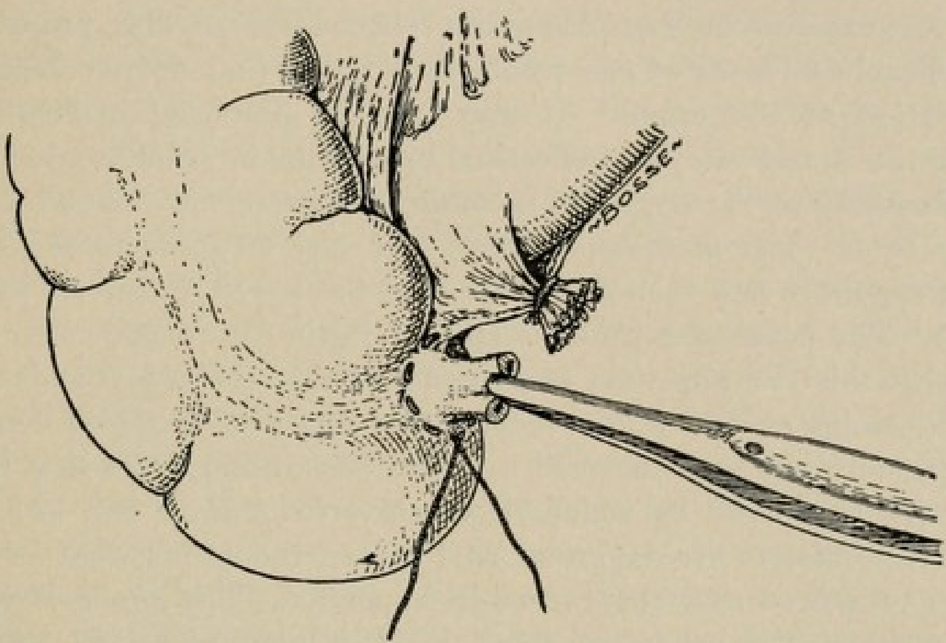

Fig. 226.—Appendicectomy. Mesoappendix has been ligated and a purse-string suture has been introduced around the root of the appendix, and the organ amputated. The stump is seized with a forceps preliminary to inverting it into the cæcum.

suture of No. 1 chromic catgut introduced in the wall of the cæcum so as to surround the root of the appendix at a distance of about one-fourth inch all around. This suture should include only the serous and muscular coats of the cæcum; yet, even at the risk of penetrating into the lumen of the bowel, it should take a good, secure bite with each stitch. The purse-string suture is not drawn tight nor tied, but the first loop of a surgeon's knot is taken. Then, without applying any ligature around its root the appendix is seized with an artery forceps and cut away with the scissors, leaving a stump about one-quarter inch long. The stump does not bleed. The cut end of the stump is seized with a thumb forceps without teeth and inverted into the cæcum; it is turned "outside in" like a reversed glove finger. The forceps is withdrawn and at the same time the purse-string is drawn tight, thus leaving the inverted stump presenting into the cæcum and closing the opening in the cæcum. Occasionally there is some difficulty in inverting the stump on account of the narrowness of the lumen. This is overcome by dilating the lumen by using a narrow-bladed artery forceps like a glove-stretcher.

This is a very convenient and safe method of disposing of the stump of the appendix.

3. Inversion of the Appendix (Edebohls).—This procedure is applicable to cases of catarrhal appendicitis that do not demand amputation of the organ. It may also be practiced incidentally during the course of other abdominal operations in order to preclude the possibility of the appendix becoming a source of trouble at some future time. The meso-appendix is first tied off close to the root of the appendix and then cut away from the appendix for its whole length. The point of a probe is applied to the tip of the appendix, and with this the appendix is turned "outside in" into the lumen of the cæcum as one would reverse the finger of a glove. After the appendix has been inverted into the cæcum and while it is thus held with the probe by which it was inverted one or two stitches of chromic catgut are taken so as to close the orifice that corresponds to the root of the turned-in appendix. The probe is then withdrawn and if necessary another stitch may be taken. After the mesentery has been ligated it should be trimmed away very close to the appendix in order to diminish the bulk of the organ and facilitate the process of inverting it into the cæcum. The stitches that unite the margins of the orifice that corresponds to the root of the turned-in appendix serve to retain the appendix in its new inverted condition; they are of chromic catgut and, of course, are non-penetrating.

After the appendix has been amputated, stump turned in, etc., the cæcum is mopped off with a gauze wipe wet in hot saline and returned to the abdomen. The incision in the abdomen is closed as indicated above without drainage.

Operation for Appendicular Abscess.—Cases that go on to suppuration, resulting in the formation of a localized intraperitoneal abscess which is shut off from the general peritoneal cavity by adhesions between immediately adjacent peritoneal surfaces. The abscess should be opened and drained and the appendix removed.

The incision in cases where an abscess has been previously diagnosticated is made over the middle of the right rectus muscle. This incision is three or four inches long and may be increased if necessary to allow a proper exposure, etc. The incision crosses the line drawn from the anterior superior iliac spine to the umbilicus, one-third of the incision above the line and two thirds below the line. The incision is carried through the abdominal wall layer by layer. The cut through the skin and fat exposes the aponeurosis of the external oblique (anterior layer of the sheath of the rectus). This layer is incised and split for the full length of the incision with the scissors. The operator penetrates bluntly with the fingers or blunt-pointed scissors between the fibers of the rectus muscle. The deep epigastric artery and vein are seen in the bottom of the incision,; they are clamped double, cut between and ligated. The transversalis fascia (posterior layer of the sheath of the rectus) and the peritoneum are next incised. They are picked up with two mouse-toothed forceps and incised between these. In some cases, especially in thin people with little or no subperitoneal fat, these two layers are incised as one. In fat people they will usually be incised as two separate layers. Care is exercised, in incising the peritoneal layer, not to injure the underlying bowel. The gut may be adherent to the peritoneum or may float up against the peritoneum so as to lie directly underneath it. In some cases the incision may be placed somewhat differently from that just described in order to better expose the inflammatory tumor mass; it may be placed rather nearer the outer border of the rectus muscle or lower down, rather nearer Poupart's ligament.

The location of the abscess varies in different cases. In some it is located anterior to the cæcum within a mass of matted guts and, under these circumstances, may be opened as soon as the incision is carried through the peritoneal layer. In other cases the abscess is situated behind the cæcum, reaching upward toward the kidney and liver. In still other cases the abscess is found to the outer or to the inner side of the cæcum, reaching upward toward the liver or downward into the pelvic cavity. In some cases the abscess lies almost entirely within the pelvic cavity and causes symptoms due to pressure on the bladder and rectum and may be detected through the vagina. Occasionally there is more than one collection, and care should be exercised that such a condition does not escape our attention at the time of operation.

In most cases, after the abdomen has been opened, we expose a mass consisting of the cæcum and coils of small intestine adhered and matted together and within this mass the appendix and abscess are inclosed. The fingers introduced into the abdomen can be passed freely in all directions between the inflammatory mass within which the abscess is located and the anterior abdominal wall; inward toward the umbilicus, upward toward the liver, and downward into the pelvis. Having exposed the inflammatory mass, we are ready to evacuate the abscess. Before doing this, however, gauze pads are tucked into the space between the mass and the anterior abdominal wall in order to block it off so that, when the abscess is opened, the entrance of pus into the general peritoneal cavity will be prevented.

The abdominal incision is held open with retractors. The appendix is not seen, being buried within the mass of matted guts. We can locate the point where the appendix comes off from the cæcum by following down along the course of the longitudinal striæ and the abscess is opened by gently, with the fingers, working between the adhesions until the abscess is reached. As the pus escapes it is swabbed away with gauze wipes. The abscess cavity is wiped out dry with pieces of folded gauze carried on holders.

After the pus has been evacuated and the abscess cavity wiped dry the attempt to find and remove the appendix may be made.

The search for and effort to free the appendix, especially in the hands of inexperienced operators, should be carried on in a careful manner and without violence, and it may be wise in exceptional cases, where unusual difficulty is experienced in locating and separating the appendix, to drain the abscess cavity and leave the appendix to take care of itself or to be removed later after suppuration has ceased, thus giving the patient the best chance for relief from his immediate danger. To leave the diseased appendix subjects the patients to prolonged suppuration and the danger of fecal fistula. There is no question, therefore, as to the desirability of removing the appendix at the time that the abscess is opened and an earnest effort should be made to accomplish this. If the appendix is situated to the inner side of the cæcum or behind the cæcum there is more difficulty in separating and removing it than if it is located to the outer side of the cæcum. Occasionally the appendix has no mesentery, it is applied directly against the wall of the cæcum, covered over by the peritoneal layer that invests the cæcum. Under these circumstances it may be necessary to shell the appendix out of its bed against the wall of the cæcum after incising or tearing through the serous layer that covers it. In those cases where the mesentery of the cæcum is very short so that the cæcum cannot be drawn into the incision or out through the incision, the location and separation of the appendix present more than ordinary difficulty. This difficulty can be partially overcome by mobilizing the cæcum by carefully tearing the serous, mesenteric layers that bind it to the posterior wall of the abdomen and that resist the efforts to deliver it through the abdominal incision. The manipulation required to detach and remove the appendix will, in many cases, necessitate breaking up the protecting adhesions, but this is without serious consequence if the abscess has been previously thoroughly emptied and the cavity swabbed out dry with gauze wipes on holders. At times, after the pus has been evacuated, the appendix is found to be fairly accessible and may be felt or seen in the abscess cavity; so that, by farther separating the adhesions with the fingers, it may be easily reached and removed. A fecal concretion which may have escaped from a perforated appendix should not be overlooked.

In many cases the appendix can be brought up so that its mesentery may be ligated as described in the non-suppurative cases. In others, in order to get the appendix out, it will have been necessary to tear it away from its narrow mesentery or to shell it out of its serous envelope, especially in those cases where the appendix has no mesentery and is applied directly against the wall of the cæcum. In many of these cases there is little or no bleeding, the vessels being thrombosed to a considerable extent. Individual bleeding points must be clamped and ligatured.

As to the treatment of the appendix after it has been detached it suffices in many cases to simply tie a catgut ligature around the appendix close to its root, say, one-quarter inch distant from the cæcum, and amputate it with the scissors or Paquelin. The stump which is steadied with the ligature left long for the purpose, may be sterilized, if the appendix has been amputated with the scissors, with a drop of pure carbolic acid on a probe or with the Paquelin. If conditions permit, however, it is preferable to amputate the appendix and invert the stump into the cæcum, securing it with a purse-string suture of chromic catgut as described for the non-suppurative cases.

These abscess cases should be drained. For the purpose of drainage a cigarette drain of plain strip gauze encased in rubber tissue or gutta-percha tissue is the most satisfactory. It emerges through the lower end of the incision. If the suppurative process involves the connective tissue behind the colon reaching up toward the kidney, the question of a counter-opening in the loin should be considered. The writer has not seen the necessity for this additional counter-drainage.

The abdominal incision is closed, except below where the drain emerges, layer by layer. The first line of suture of plain catgut No. 2 unites the edges of the peritoneum and should include the edges of the transversalis fascia to give a more secure hold. The edges of the split rectus muscle are next united with several interrupted sutures of plain catgut. The edges of the aponeurosis of the external oblique are brought together with a continuous suture of chromic catgut and finally the edges of the skin are approximated with a sufficient number of interrupted sutures of silk-worm gut. The incision is thus closed except for the small opening left at the lower end where the cigarette drain emerges.

The drain should be pulled out for part of its length—an inch or two—at the end of forty-eight hours. On the third day the drain is pulled out altogether and replaced by a thin strip of iodoform gauze.

Operations for Appendicitis Accompanied by General Peritonitis or Peritoneal Infection due to acute gangrene or perforation or sloughing of the appendix before adhesions have been formed; or to rupture or leakage of an appendicular abscess. In these cases the appendix should be removed and an attempt made to prevent or check the general peritoneal infection.

These are the so-called fulminating cases of appendicitis and are frequently overlooked, and may go unrecognized until the general systemic poisoning has reached a degree which is in itself fatal in spite of any remedial measures that may be undertaken by the surgeon. These patients frequently do not complain of pain; they may insist that they are feeling better, and in many cases they exhibit no elevation of temperature, nor acceleration of the pulse rate. These patients, however, look sick. There is tenderness over the region of the appendix, the tongue is coated, the breath foul, and there is almost certain to be the characteristic obstipation that is not relieved by either laxatives or enemas. These are the cases where delay in operating is very likely to occur and where delay is most fatal. They must be operated upon before the heart is overwhelmed by the poison.

The incision is made through the rectus muscle in a manner similar to that just described above, and should be sufficiently long—four to six inches.

After the abdomen has been opened the appendix is at once sought and removed. The appendix is amputated and the stump inverted and secured with a purse-string suture of chromic catgut. If the condition of the appendix is such that it would be difficult or impossible to invert the stump after amputation, it will suffice to tie a catgut ligature around the root of the appendix, close to the wall of the cæcum, amputate the appendix and touch the stump with carbolic on a probe followed by alcohol.

The fluids in the neighborhood of the appendix are swabbed out with pieces of folded gauze. Fluids in other adjacent and remote parts of the abdomen are likewise swabbed away. The pelvis, where fluids are especially apt to gravitate and collect, is emptied by repeated swabbing with gauze wipes on holders. The writer does not approve of irrigating or flushing the peritoneal cavity in these cases. If the intestines are coated with flaky exudate and matted together by fresh adhesions it is advisable to separate carefully with the fingers between the matted coils of gut in order to discover and evacuate any isolated collections of purulent fluid.

For the purpose of drainage a cigarette drain of strip gauze, wrapped in rubber tissue or gutta-percha, is introduced into the abdomen, reaching well down into the pelvis, and another similar drain is introduced which reaches down to the region of the appendix stump.

The incision in the abdomen is closed preferably, layer by layer, as described in the preceding operation, leaving the lower end open to an extent just sufficient for the drains to emerge. Where haste is required the incision may be closed with a sufficient number of interrupted sutures of silk or silk-worm gut. These sutures are introduced after the edges of the peritoneum, including the edges of the transversalis fascia, have been united with a continuous suture of catgut. The interrupted silk sutures include all the other layers of the abdominal wall—the skin, aponeurosis, and muscle—but not the transversalis fascia or peritoneum.

Appendicostomy.—The establishment of a fistulous opening through the appendix into the cæcum.

This plan of utilizing the appendix was suggested by Wier for the purpose of introducing medicated fluids, solutions of nitrate of silver, etc., into the bowel in the treatment of inflammatory disease of the large intestine, ulcers, etc.

The apendix is reached in the usual way through the McBurney incision. It is drawn up into the incision and secured there by several chromic catgut sutures which fix its mesentery to the edges of the peritoneum and transversalis fascia. The tip of the appendix is secured to the edges of the skin with one or two sutures of fine chromic catgut. The tip of the appendix is amputated and a probe introduced to discover whether the lumen is patent or can be dilated. If this examination shows that the canal is free a catgut ligature is tied around the open end of the appendix in order to shut it off for one or two days until adhesions will have been formed.

If the lumen of the appendix is obstructed or obliterated and does not permit the passage of the probe the appendix may be amputated and its stump inverted and a fistula established into the cæcum according to the plan of Gibson, employing the procedure of Witzel, as described in gastrostomy for this purpose. A rubber tube is embedded in the wall of the cæcum, the end of the tube penetrating the wall of the bowel through a small incision.

THE LIVER AND GALL-BLADDER.

The Surgical Anatomy of the Liver.—The liver is a solid glandular organ almost completely invested by the peritoneum, suspended in the upper right portion of the abdomen (right hypochondrium) and extending beyond the middle line into the left side (left hypochondrium). It is situated under cover of and protected by the ribs, except in the epigastric region. Behind and toward the right the liver is thick, gradually becoming thin toward the front and left. From side to side it measures eleven inches; from before backward, eight inches; and its posterior border has a thickness of two and one-half inches.

Above, the diaphragm separates the liver from the pleura and pericardium; below it are the gall-bladder, hepatic flexure of the colon, the first part of the duodenum, the pylorus and stomach (which it overlaps), and the right kidney and suprarenal capsule.

The superior surface of the liver looks forward as well as upward, and is in relation with the diaphragm and with the ribs and costal cartilages from the fifth or sixth to the tenth. The lower limit of this surface corresponds to the free border of the ribs (costal cartilages). This upper surface of the liver is smooth, and presents a fold of peritoneum running from the anterior border backward, the suspensory ligament. This serves to suspend the liver to the diaphragm, and is the continuation of the falciform fold of peritoneum, which is thrown around the round ligament from the anterior abdominal wall and which extends from the umbilicus to the anterior edge of the liver. The suspensory ligament divides the upper surface of the liver into the larger right lobe and the smaller left lobe; the latter overlaps the stomach and reaches to the left beyond the middle line. Toward the posterior border of the liver the folds of the suspensory ligament spread out right and left, and, still passing between the liver and the diaphragm, form the anterior layer of the coronary ligament.

The posterior border of the liver, really a surface, is thick, gradually becoming thin toward the left, and is not covered by peritoneum; the peritoneum which covers the upper surface of the liver upon reaching its posterior border is reflected upward to the diaphragm as the anterior layer of the coronary ligament, and that which covers the under surface upon reaching the posterior border of the liver is reflected on to the posterior abdominal wall (diaphragm), forming the posterior layer of the coronary ligament. The coronary ligament, at either end, forms the right and left lateral ligaments of the liver. The posterior border of the liver, to the left of the middle line, presents a notch which corresponds to the œsophagus and which marks the division of the liver into its right and left lobes. The posterior border of the liver is in relation with the diaphragm and lower ribs, with the vertebral column, tenth and eleventh dorsal, the aorta, vena cava inferior, etc. The œsophagus is received in the notch above mentioned.

The anterior border is thin and in many patients may be palpated through the abdominal wall. It reaches just below the free border of the ribs (costal cartilages), and corresponds to a line drawn from the tip of the right tenth to the tip of the left eighth costal cartilage, where this joins the cartilage of the seventh. In women the anterior edge of the liver is found well below the free border of the ribs (costal cartilages).

The under surface of the liver is irregular and marked by grooves and impressions for the colon, gall-bladder, kidney, etc., and is covered by the peritoneum, which is reflected downward at the transverse fissure, as the lesser omentum, as far as the lesser curvature of the stomach, where its folds separate to include the stomach between them.

Besides the right and left lobes, the under surface of the liver presents three smaller lobes: the quadrate, caudate, and the lobus Spigelii. The large right lobe is marked by the transverse fissure, which passes from right to left and is situated rather more than half-way back from the anterior border.

At this fissure, the vessels, ducts, lymphatics, and nerves pass in and out of the liver. These structures descend in the right free border of the lesser omentum, between its two folds, the common bile-duct to the right, the hepatic artery to the left, and the portal vein between and behind these two. The hepatic duct, which is formed by the junction of the right and left bile-ducts, emerges from the right end of the transverse fissure and descends between the folds of the lesser omentum, where it is joined by the cystic duct to form the common bile-duct, ductus choledochus.

If we examine the under surface of the liver as this organ lies in its normal position in the abdomen, through a vertical incision made in the abdomen from the tip of the ninth costal cartilage, we note, in sweeping across the surface from right to left, two well-marked grooves, or depressions, into which the finger sinks; the first, that toward the right, corresponding to the tip of the ninth costal cartilage, lodges the gall-bladder; the second, nearer the middle line, corresponds to the round ligament (fœtal umbilical vein).

The Surgical Anatomy of the Gall-bladder and Bile-ducts.—The gall-bladder is a pear-shaped, hollow-receptacle. Its wall is fairly thick and is composed of muscle and mucous membrane. The serous coat (peritoneum) invests the under surface of the body and all of the fundus of this organ, binding it to the under surface of the liver. The peritoneum is reflected downward from the neck of the gall-bladder to the duodenum presenting a sharp free edge. The cystic duct in its course to reach the common duct lies between the folds of this reflection of peritoneum a short distance away from its free edge. The gall-bladder lies in direct relation with the under surface of the liver, in the fossa of the gall-bladder, the apposed surfaces of the gall-bladder and liver being joined to each other by loose connective tissue.

The fundus of the gall-bladder is directed downward, forward, and to the right, usually appearing below the anterior thin edge of the liver, opposite the tip of the ninth costal cartilage. Sometimes it does not reach quite as far as the anterior edge of the liver, and is then concealed underneath the liver. The edge of the liver, corresponding to the fundus of the gall-bladder, is sometimes marked by a slight notch.

The gall-bladder is three to four inches long and has a capacity of about one and one-half ounces. The fundus rests upon the transverse colon, and the neck upon the first part of the duodenum. To the outer side of the gall-bladder—*i.e.*, to the right—is the hepatic flexure of the colon; to the left of the gall-bladder is the pyloric end of the stomach. The neck of the gall-bladder is bent upon itself like the letter "S" before being continued into the cystic duct.

The cystic duct is about one-twelfth inch in diameter and rather more than one inch in length. Its lumen has such an irregular, spiral, twisted shape that the passage of a probe through it is difficult or impossible. The duct curves downward between the layers of the peritoneal fold that is reflected downward from the neck of the gall-bladder to the duodenum and just above the first part of the duodenum it joins with the hepatic duct to form the common bile-duct. The cystic artery, a branch of the right bifurcation of the hepatic passes upward and toward the right to reach the neck of the gall-bladder. In its course to reach the neck of the gall-bladder the cystic artery (with its accompanying veins) lies above and to the left of the cystic duct.

The hepatic duct is one-sixth inch in diameter and two inches long; it is formed by the junction of the bile-ducts from the right and left lobes of the liver. The right bifurcation of the hepatic artery in its course to reach the right lobe of the liver passes to the right, behind the hepatic duct, just above the point where the cystic duct joins the hepatic to form the common duct.

The common bile-duct, ductus communis choledochus, varies in length: it is usually three inches long and one-fourth inch in diameter; it continues the course of the hepatic duct, descending between the folds of the lesser omentum, lying near its right free edge—the ligamentum hepatico-duodenale. In this situation it lies in front of the portal vein with the hepatic artery on its left side; continuing downward it passes behind the first part of the duodenum, and finally behind and to the inner side of the second part of duodenum, between it and the head of the pancreas. The upper part of the common duct is known as the supraduodenal portion and is rather wider than the lower part, which is known as the retroduodenal portion. The lower part of the common duct is imbedded in and surrounded by the substance of the pancreas. Pathological processes affecting the head of the pancreas, chronic pancreatitis, tumors, etc., might cause obstructive jaundice by compressing the common duct. The common duct perforates the wall of the second part of the duodenum upon its inner side, running very obliquely in the wall of this part of the gut for a distance of from one-half to three-fourths inch. That portion of the duct which thus obliquely traverses the wall of the duodenum is called the intramural part of the duct. The orifice of the duct upon the

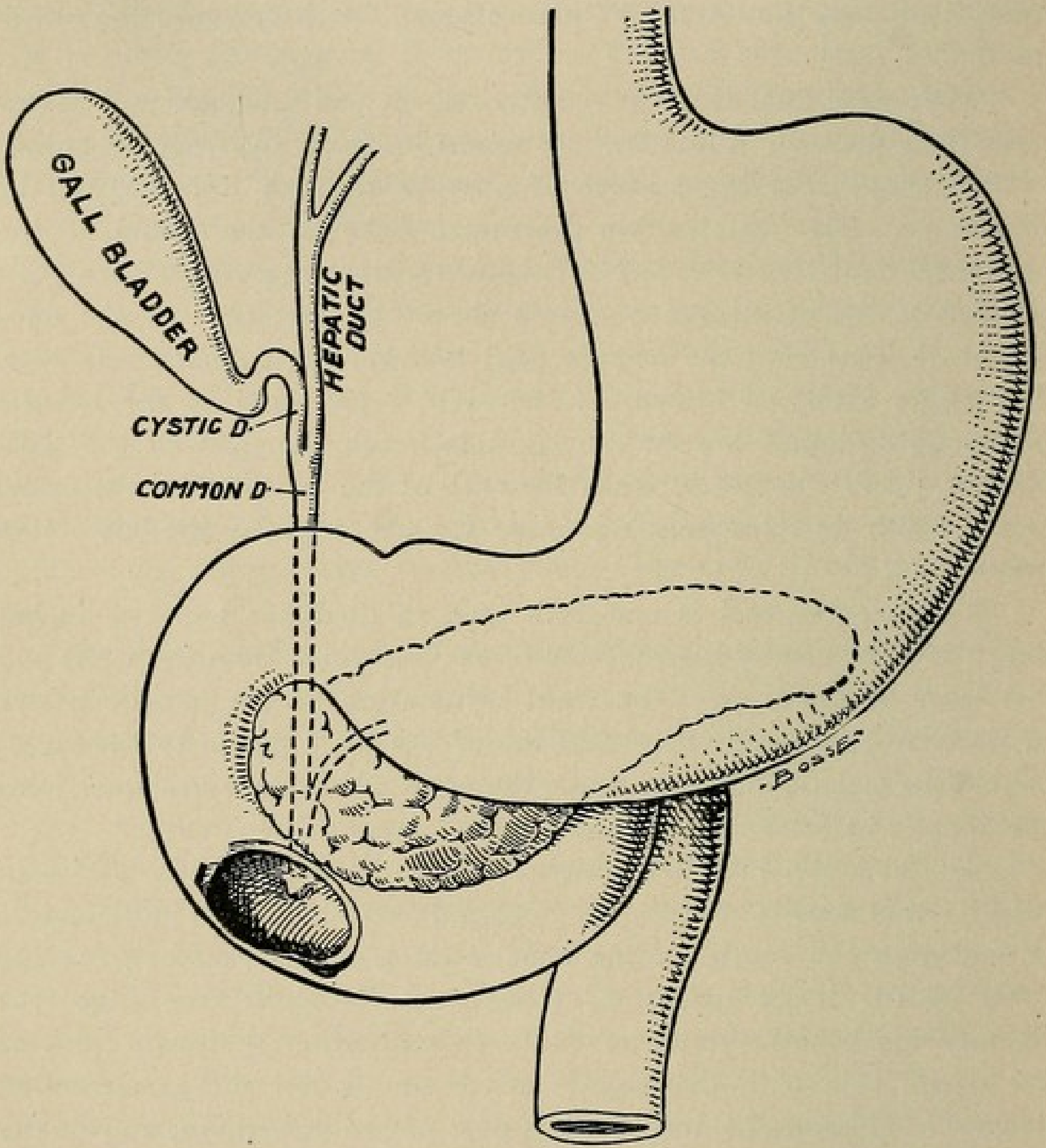

Fig. 227.—Bile Ducts, etc. A hole cut in the duodenum to show the papilla and orifice of the common duct, etc. The pancreas is outlined behind the stomach.

inner surface of the gut is marked by a papilla, which, as a rule, is readily recognizable by the sense of touch and is situated about three inches distant from the pylorus. The orifice or mouth of the common duct is very small, permitting the introduction of only a fine probe, 2 mm. in diameter, so that a stone that has succeeded in traversing the whole length of the common duct may become impacted at the orifice. Just above its orifice the common duct is dilated, pouched, and this dilated portion is known as the ampulla of Vater.

Usually the pancreatic duct terminates in the ampulla of Vater. Under these conditions the pancreatic duct and the common bile-duct have the same common opening into the duodenum. Less commonly the pancreatic duct opens into the duodenum, not through the ampulla of Vater, but independently, through a separate orifice upon the summit of the papilla that marks the orifice of the common bile-duct.

Attention has been directed by Morison to the space in the upper part of the abdomen behind the liver, into which the gall-bladder presents. It is bounded above and anteriorly by the right lobe of the liver; below by the upper or ascending layer of the transverse mesocolon; externally by the abdominal parietes covered by the parietal peritoneum; posteriorly by the layer of the transverse mesocolon which covers the upper part of the right kidney and ascends upon the posterior abdominal wall. Internally, the space is bounded by the peritoneum which is reflected over the bodies of the vertebræ, aorta, etc. From this space, following down along the gall-bladder and cystic duct, one can pass the fingers, behind the common duct, etc., through the foramen of Winslow, into the lesser cavity of the peritoneum, *i.e.,* into the peritoneal space behind the stomach.

OPERATIONS UPON THE LIVER.

Hepatotomy.—Incision of the liver for abscess, hydatid cyst, etc.

For Abscess.—The incision, when the disease involves the right lobe, is placed along the outer border of the rectus muscle, extending from the tip of the ninth costal cartilage downward for a distance of from three to five inches or the incision may be made below and parallel with the free border of the ribs.

At times it may be desirable to place the incision elsewhere in order that it may correspond with the prominence of the tumor if one is present; for example, if the abscess is located in the left lobe of the liver, then the incision is better placed in the middle line, linea alba. The incision is carried through the integument, fascia, etc., down to the peritoneum and after the hemorrhage has been controlled the parietal peritoneum is incised between two mouse-tooth forceps. We may find the tumor adherent to the parietal peritoneum and in this case, after aspirating to discover the nature of its contents, the abscess is incised and evacuated. The finger is introduced into the abscess cavity to explore and break up septa, etc. The cavity is finally packed with strip gauze. Under these circumstances the operation is very simple and there is no danger whatever of infecting the general peritoneal cavity.

In some cases after incising the peritoneum, it will be found that the tumor is not adherent to the parietal peritoneum, *i.e.*, we can pass the hand freely between the liver surface, tumor, and the parietal peritoneum; there are no protecting adhesions. Under these conditions we must take measures to prevent contamination of the general peritoneal cavity by the contents of the abscess cavity while the cavity is being evacuated by carefully tucking the gauze pads in and about the incision before opening the abscess; or else the operation may be done in two stages.

Occasionally, after the liver has been exposed, there will be found no external signs, softening or swelling or prominence of the liver surface to indicate the site of the abscess. At times the abscess is situated deep in the substance of the liver. Under these circumstances it will be necessary to resort to puncture and aspiration to locate the abscess. It may be necessary to make repeated punctures before the abscess is discovered. A fairly large needle should be used. The pus from a liver abscess is of a peculiar dirty reddish color and one should not fail to recognize it or mistake it for blood.

After the abscess has been located we may proceed in one of two ways. Either pack down to the surface of the liver with strip gauze, after suturing the edges of the peritoneum to the edges of the skin in the abdominal incision and wait for two or three days until adhesions have formed before opening into the abscess; or else, after placing the gauze pads to protect the peritoneal cavity, incise and evacuate the abscess at once. This latter method is probably the preferable one.

If it is decided to open immediately the gauze pads are carefully arranged so as to protect the peritoneal cavity from contamination, and a small incision made with the knife into the abscess cavity. The pus is wiped away as fast as it escapes. The finger is introduced into the abscess cavity to explore and break up septa and to remove any solid pieces of necrotic material that may be present. At times there are more than one abscess present. They may be discovered and opened by the examining finger during the operation; at times they are overlooked until their presence is indicated later by a continuation of the symptoms, etc.

The abscess cavity is wiped dry with gauze pads and finally packed with a plug of strip gauze. The gauze pads that were placed to protect the peritoneal cavity are removed, and the incision in the abdomen closed, layer by layer, except where the gauze drainage plug emerges.

For Hydatid Cyst.—Operation consists in evacuation and drainage of the cyst cavity. Care to prevent entrance of any of the contents of the cyst into the abdominal cavity during the course of the operation.

Evacuation and drainage may be done in one or two stages.

The abdomen is opened by a vertical incision corresponding to the position of the tumor. If the operation is to be done in two stages the incision is packed with strip gauze which is tucked in between the liver (tumor) and the parietal peritoneum. After waiting for three or four days for adhesions to form between the liver and peritoneum that will serve the purpose of shutting off the peritoneal cavity, the cyst is opened and contents evacuated, the lining membrane of the cyst is peeled out and the cavity packed.

If the operation is done in one stage then, after the liver (tumor) has been exposed, the peritoneal cavity is carefully packed off by gauze pads which are tucked into the incision and the cyst emptied as nearly completely as possible with the aspirator or trocar. The cyst is then incised and the remaining contents completely evacuated and the lining membrane of the cyst removed. The edges of the incision in the cyst are sutured to the edges of the peritoneum and transversalis fascia in the abdominal incision, and the cyst cavity packed with strip gauze.

Transpleural Route.—The liver may be exposed through an opening which is made in the lower part of the chest incising the two layers of the pleura (that which lines the inner aspect of the chest wall and that which covers the surface of the diaphragm) in order to expose the diaphragm for incision. This route is sometimes selected for the purpose of draining subphrenic or hepatic abscess, hydatid cyst, etc.

Corresponding to the line of the ribs which are to be resected —the seventh and eighth, or eighth and ninth, or ninth and tenth— an incision is made. This incision is three or four inches long and placed in the intercostal space between the two ribs which are to be resected. As to the ribs which are to be resected, the selection will depend upon the results of exploration with the aspirating needle, percussion, etc. These means determine the location of the pus, etc. The middle of the incision will correspond, as a rule, to the axillary line, maybe further forward or more toward the back, according as the puncture with aspirator indicates the location of the pus, etc.

The edges of the skin, etc., are retracted and the ribs exposed by an incision which passes along the length of each of the two ribs for a distance of two or three inches, and which penetrates through the periosteum down to the surface of the bone. With the periosteum elevator, the soft parts, including the periosteum, are peeled off the surface of the ribs working close to the bone and carefully around the upper and lower borders and posterior surface. Two or three inches of each of the two ribs is resected. If the intercostal vessels corresponding to the upper and lower borders of the ribs are injured and bleed, they are clamped and ligated. Resection of a portion of one rib will suffice in many cases.

The intercostal structures (muscles) are incised, spurting vessels clamped and ligated and the pleura thus exposed. In order to prevent the entrance of pus, blood, etc., into the pleural cavity, it will be necessary to suture the two layers of the pleura (that which lines the inner surface of the chest wall to that which covers the diaphragm) together before opening the abscess, etc. This is done with a continuous suture of plain catgut.

The diaphragm is finally incised and the pus, fluids, evacuated, and a drain of strip gauze introduced.

Hepatectomy.—Excision of a portion of the liver. Portions of the liver have been excised when involved primarily or by extension from growths of the gall-bladder and ducts either by means of the Paquelin cautery or by blunt dissection (enucleation) with the finger. The control of hemorrhage is the essential part of the problem.

If the Paquelin cautery is used it should be at á dull red heat dividing the tissues very slowly. With the Paquelin used in this manner there is not overmuch hemorrhage.

According to the method of Kousnetzoff and Pensky, the diseased portion which is to be excised may be isolated by introducing a line of through-and-through connecting sutures of thick, plain catgut which are placed well beyond the outermost limits of the part which is to be excised. These sutures are tied before the diseased portion is excised. A long piece of catgut, double, is used for the sutures, which are introduced with a long, straight or curved, blunt-pointed needle. After the sutures have been introduced the loops are cut, making a corresponding number of individual sutures. The sutures are tied very slowly and not sufficiently tightly to cut through.

According to the plan of Payr and Martina, the hemorrhage may be controlled and the walls of the defect, which is left after excision of the diseased portion of liver, approximated by the use of penetrating mattress sutures which are supported by being carried through perforated magnesium plates. The plates are placed on either side of the edges of the defect which is left in the liver after the diseased portion has been removed. The sutures when drawn tight exert a distributed compression and serve to control

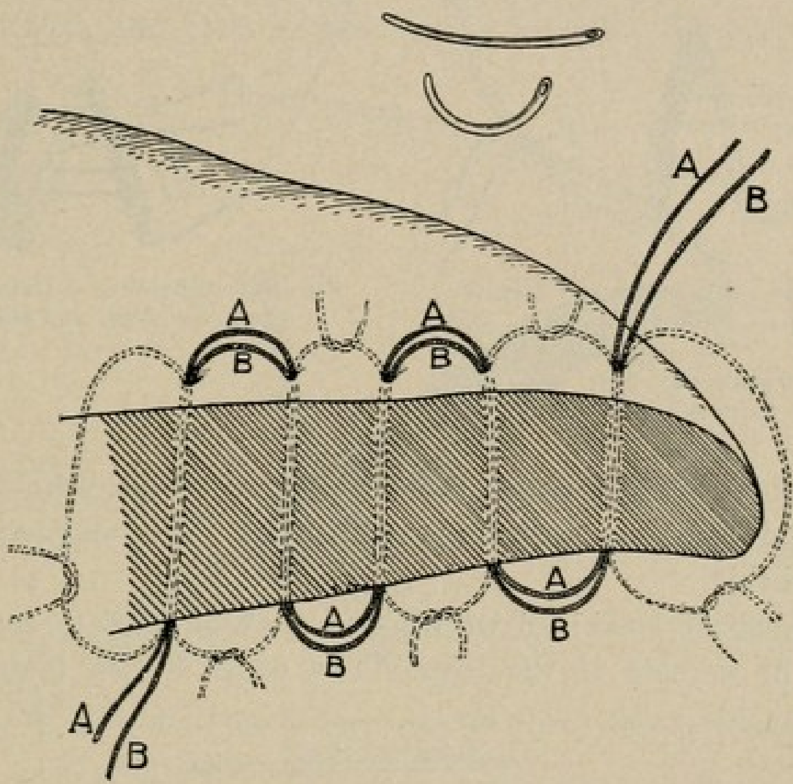

Fig. 228.—The Kousnetzoff and Pensky Suture. For control of hemorrhage from the liver. The loops *A* and *B* of the sutures are cut to make the separate ligatures which are tied alternately upon the upper and lower surface of the liver. The *A* loops are cut upon the upper surface and the *B* loops upon the lower. The blunt-pointed needles for passing the sutures are shown in the upper part of the picture.

the hemorrhage and approximate the edges of the wound. In excising the diseased portion of liver the section can be made wedge shape by cutting into the liver tissue so that the upper and lower edges of the remaining raw space in the liver are overhanging and can be brought together with suture and thus do away with the raw surface that would otherwise remain. The plates may be applied and sutures introduced before excising the diseased portion. The plates are placed opposite each other upon the upper and lower surfaces of the liver, and the sutures introduced and drawn tight, thus compressing the liver tissue between the plates and preventing hemorrhage.

The plates are approximated only sufficiently tight to control the venous hemorrhage. Individual spurting arterial points are secured and ligated with catgut. If too great pressure is made upon

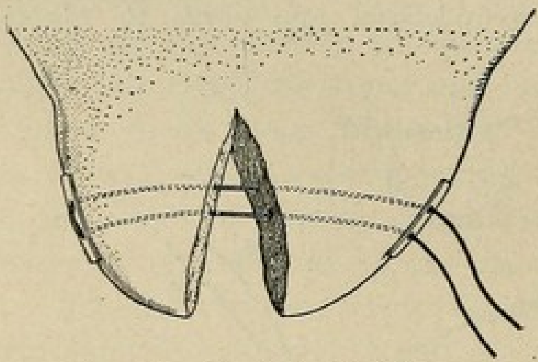

Fig. 229.—Control of Hemorrhage from the Liver (*Payr* and *Martina*). The mattress suture passed through the liver and supported by the magnesium plates.

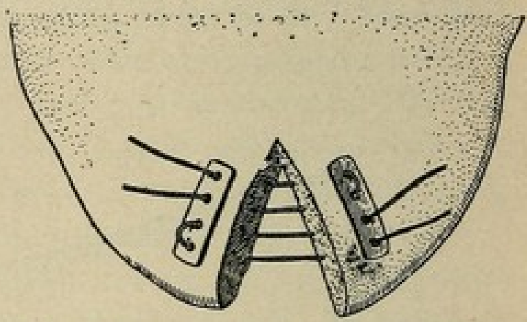

Fig. 230.—Control of Hemorrhage from the Liver (*Payr* and *Martina*).

the liver between the plates there is danger of necrosis of the liver tissue, and resulting pulmonary embolism. The magnesium plates are absorbable.

Tamponade combined with suture may be used to control hemorrhage in wounds of the liver. The edges of the bleeding space

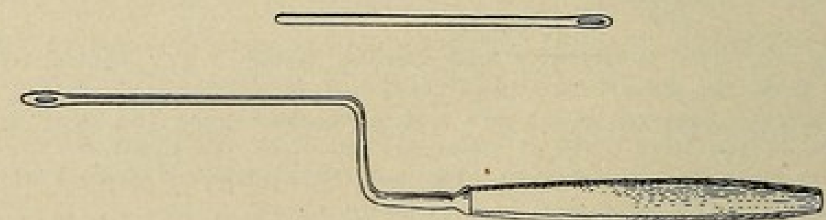

Fig. 231.—Ligature Carrier and Needle (*Payr* and *Martina*).

in the liver are approximated with a sufficient number of interrupted sutures of catgut, the space itself being packed with a plug of plain strip gauze.

During the course of operations or in wounds of the liver, large individual bleeding points may be ligatured. The finger is placed upon the bleeding point to control the hemorrhage temporarily, and a ligature carried around it in the substance of the liver with a curved needle. The ligature is carefully and slowly drawn tight and tied. Hemorrhage from individual bleeding points may also be checked by direct application of the cautery at a dull red heat.

Injuries of the Liver.—The liver may be lacerated by blows upon the abdomen, oftentimes without external signs of injury or violence or by fractured ribs, or by bodies causing penetrating wounds. These injuries may be accompanied by free hemorrhage. On account of the solid structure of the liver large venous channels cannot collapse, and thus hemorrhage is favored. Hemorrhage may

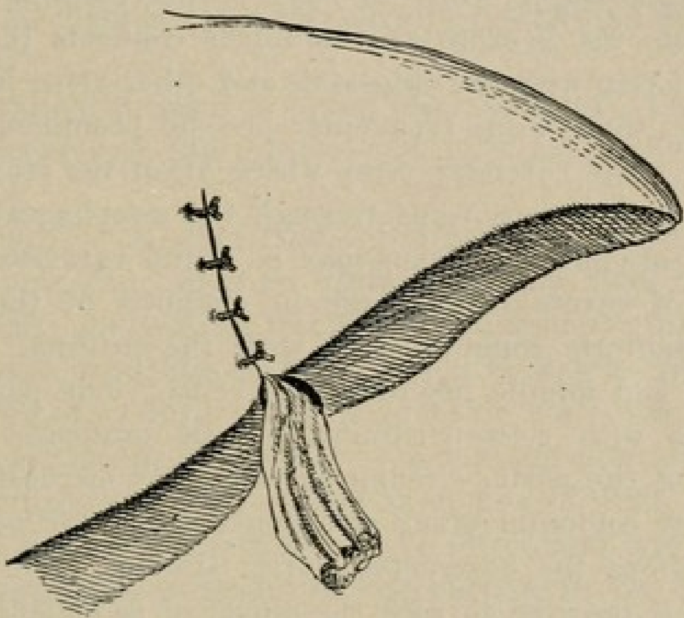

Fig. 232.—Control of Hemorrhage from the Liver. Suture and gauze pack combined.

be controlled by the cautery or by packing, or by packing combined with suture of the edges of the tear in the liver. The several plans for the control of hemorrrhage from the liver are described in the preceding paragraphs. Hemorrhage from wounds in parts of the liver which are inaccessible for suture, etc., may be controlled by gauze pack.

Omentopexy (Talma).—This operation consists in attaching the omentum to the parietal peritoneum. It is performed for the purpose of establishing compensatory anastomosis between the portal and general venous systems. In addition to fixing the omentum to the parietal peritoneum it is desirable at the same time to induce adhesions between the liver and spleen and the corresponding peritoneal surface opposite these organs.

The operation is recommended for the relief and cure of ascites due to cirrhosis of the liver, and if one may judge from the limited number of cases that have been reported it certainly offers a prospect of relief, especially if undertaken in properly selected cases. The operation should not be done in those cases where the pathological changes in the liver have progressed to an extreme degree.

Normally the portal and general venous systems communicate through small branches that are located in the subperitoneal connective tissue between the layers of the hepatic ligament; these connect branches of the portal vein with the radicles of the phrenic vein and azygos major veins. A large branch running in the round ligament from the liver to the umbilicus connects the left branch of the portal vein with the epigastric and other veins in the abdominal parietes; these veins frequently become prominent in cirrhosis of the liver. The coronary veins which drain the stomach communicate with both azygos veins through the œsophageal plexus; the veins of the œsophageal plexus may be found varicosed and may be the source of severe hemorrhage in cirrhosis of the liver. The inferior mesenteric communicates with the internal iliac through the inferior and middle hemorrhoidal veins. The pancreatic veins communicate with retro-peritoneal venous branches. In case of obstruction of the portal circulation caused by cirrhosis of the liver the means of communication mentioned above are not sufficiently ample to relieve the obstructed portal system. The operation of omentopexy is resorted to with the object of establishing new channels of communication through the venous branches that are formed in the adhesions between the attached omentum and liver and spleen (portal system) and the peritoneum (general venous system). It may be observed after omentopexy that the superficial veins of the abdomen and about the umbilicus become very prominent and smaller veins that are usually invisible are plainly to be seen.

Incision is made from the ensiform process to the umbilicus in the linea alba or to the right of the middle line, penetrating between the fibers of the rectus muscle. When the abdomen is opened the chief bulk of the fluid escapes and the rest is swabbed out with gauze wipes. In this manner the abdominal cavity is emptied.

The hand is introduced into the abdomen and the parts examined, especially the liver and spleen. The upper surface of the liver, and the outer surface of the spleen and the corresponding portions of the parietal peritoneum, that covering the diaphragm opposite the liver and that of the abdominal wall opposite the spleen, are vigorously rubbed with a rough piece of gauze until there is a slight tendency to oozing. The parietal peritoneum for a considerable distance upon either side of the abdominal incision is treated in a similar manner. The great omentum is then sutured to the peritoneum that lines the anterior abdominal wall for some distance upon each side of the incision. The attachment of the omentum to the anterior abdominal wall should be sufficiently extensive so as to give a good, broad area for adhesions to form. Chromicized catgut should be used for suture material.

Some surgeons recommend suturing the omentum into a pocket made for the purpose between the parietal peritoneum and the transversalis fascia.

The abdominal incision is closed layer by layer; the peritoneum with plain catgut and the other layers with interrupted sutures of chromic catgut.

THE QUESTION OF DRAINAGE.—Drainage has been resorted to to prevent reaccumulation of fluid during the time that the adhesions are forming, etc., and for this purpose it would be of great advantage; but, on the other hand, the drainage opens the way to fatal peritoneal infection. The other plan which is probably the better one in most cases, is to omit drainage and resort to tapping after the operation, as often as necessary to prevent reaccumulation of fluid. If drainage is employed a glass or rubber tube may be introduced into the abdomen through a small incision made for the purpose in the lower part of the abdomen in the middle line.

OPERATIONS UPON THE GALL-BLADDER.

Aspiration of the Gall-Bladder.—Drawing off the contents of the gall-bladder, usually for purposes of diagnosis. This operation may be resorted to in order to determine the nature of a tumor which can be felt through the abdominal wall. The needle is introduced over the most prominent part of the tumor, usually below the tip of the ninth costal cartilage, and some of the contents withdrawn. The needle should be of small caliber.

This is a dangerous procedure and one to be condemned, even if the needle and skin are made aseptic, because some of the contents is very apt to escape through the puncture in the wall of the gall-bladder upon withdrawing the needle, especially if the needle used is not of fine caliber.

Cholecystotomy.—Incision of the gall-bladder for the purpose of removing stones. The incision in the gall-bladder is closed immediately after stones, etc., have been removed—the "Ideal Operation" of Bernays. This is an operation which is not to be recommended except in occasional cases where the operator is quite certain that the mucous membrane of the gall-bladder is healthy and that the bile-ducts—hepatic, cystic and common—are patent and unobstructed. Otherwise the incision which is made in the gall-bladder should be left open and the gall-bladder drained—cholecystostomy.

An incision is made which reaches from the tip of the ninth costal cartilage vertically downward for a distance of four inches. It penetrates between the fibers of the rectus near its outer border. It may be necessary in stout people to make the incision longer. Instead of the vertical an oblique incision may be used, one finger's breadth distant from and parallel with the free border of the ribs, the middle of the incision corresponding to the tip of the ninth costal cartilage. This incision is usually four to five inches long. The vertical incision is the preferable one.

After the abdomen has been opened the sharp anterior edge of the liver is seen in the upper part of the incision and the transverse colon in the lower part. The gall-bladder may also be seen, more or less distended, projecting beneath the anterior border of the liver, or it may be small and concealed beneath the edge of the liver. Occasionally in order to expose the fundus of the gall-bladder and bring it into the incision, it is necessary, with the finger, to break up some adhesions that bind the gall-bladder to the neighboring organs. If stones are present they may, in many cases, be felt through the wall of the gall-bladder before it is incised.

Before opening the gall-bladder the hepatic, cystic and common ducts should be examined for stones, etc. Occasionally the gall-bladder may be found distended to such a degree and forms such a large tumor that it will be necessary to empty it with the trochar before a satisfactory examination of the ducts can be made. The common duct may be palpated between the two fingers of the left hand introduced into the foramen of Winslow and the thumb opposed anteriorly. A normal common duct may not be made out readily by palpation, but one containing a stone or stones and especially if it is dilated and its wall inflamed and thickened, may be easily recognized.

After the examination of the ducts, etc., has been completed, the fundus of the gall-bladder is seized with two sharp-nosed artery clamps for the purpose of steadying it. Gauze pads are tucked into the abdominal incision and around the gall bladder in order to protect the peritoneal cavity against leakage. A trochar is thrust into the fundus of the bladder and the fluid contents drawn off as nearly completely as possible. The organ is then held up and steadied with the artery clamps and its fundus incised and any remaining fluid contents swabbed out with gauze wipes. Stones that are present may be removed with a scoop or forceps and the finger introduced in order to explore the interior of the organ. Care must be exercised that stones impacted in the neck of the gall-bladder or in the cystic duct are not overlooked. They can, in some cases, be forced back into the bladder and removed. If the cystic duct has been obstructed, as soon as the obstruction is relieved there is apt to be a copious flow of bile from the cystic duct into the gall-bladder.

After the gall-bladder has been emptied and its interior swabbed out dry with gauze wipes, it may be temporarily tamponed with strip gauze and the bile-passages, hepatic, cystic, and common ducts, again carefully examined for stone, etc.

After the operator has satisfied himself that the ducts are unobstructed and if the contents of the gall-bladder were not purulent, the incision in the gall-bladder is closed with a double row of sutures. The first row of plain catgut, includes all the layers of the wall of the gall-bladder except the mucous membrane.

This first line of suture is reinforced by a row of silk Lembert sutures which include only the serous and muscular coats of the gall-bladder; these serve to bury the first row and bring the adjoining serous margins of the incision into accurate apposition. The incision in the abdomen is closed layer by layer; first, the parietal peritoneum and transversalis fascia are united with a continuous catgut suture, then the edges of the muscle are brought together with several interrupted catgut sutures, the edges of the aponeurosis are united with a continuous suture of chromic catgut and finally the edges of the skin with a catgut suture.

Cholecystostomy.—The establishment of a fistulous opening in the gall-bladder; for the removal of calculi and for the purpose of draining the gall-bladder and liver. The incision which is made in the gall-bladder for the removal of the calculi is left open in order to provide drainage.

The incision in practically all operations upon the gall-bladder and bile-ducts is at the beginning, exploratory. It may be enlarged afterwards as the necessity presents itself. A sand-bag placed under the lower dorsal region is of distinct advantage in those cases where it is necessary to gain good access to the deeper bile structures, cystic and common ducts, etc.

The incision commences at the tip of the ninth costal cartilage and passes downward for a distance of four inches; it penetrates between the fibers of the rectus near its outer border. In stout people the incision in the skin and fat layers may be made considerably longer to permit better access to the deeper layers. If more room is required the incision may be extended according to the plan of Robson upward and inward toward the ensiform cartilage. This, however, is rarely necessary unless for extensive work upon the ducts, etc.

After the abdomen has been opened the gall-bladder is sought and examined. It may be distended and more or less enlarged and present into the incision, or it may be small and contracted and concealed up underneath the liver. It is often necessary to free the gall-bladder from adhesions that bind it to adjacent organs, transverse colon, duodenum, stomach, etc. The adhesions are at times very dense, completely bury the gall-bladder and require much patience to separate them. By gentle manipulation this can be accomplished even in cases that at first sight appear almost hopeless. Roughness in this step of the operation might result in tearing one of the adjacent hollow vicera.

Gauze pads are arranged in and about the incision to protect the parts and catch escaping fluids, blood, etc. One pad should be carefully packed under the gall-bladder and liver, down into the right kidney space.

When the gall-bladder ducts have been freed from adhesions, the gall-bladder, cystic, hepatic and common ducts and head of the pancreas are carefully examined. For the purpose of palpation of the common duct, etc., two fingers of the left hand are introduced into the foramen of Winslow, behind the free edge of the lesser omentum, and, with the thumb opposed anteriorly, the entire length of the common and hepatic ducts can be satisfactorily examined. In some exceptional cases it may be necessary to enlarge the abdominal incision in order to get better access to the bile-ducts.

After the examination of the bile-ducts has been completed the gall-bladder is brought up into the incision and secured by catching its fundus with two sharp-nosed artery clamps, one on each side. The trochar is thrust into the gall-bladder between the two clamps and the bladder emptied as nearly completely as possible. If a piece of rubber tubing is attached to the end of the trochar the contents of the gall-bladder may be conducted over the side of the table and thus avoid soiling the field of operation. When the bladder collapses stones may be felt within it.

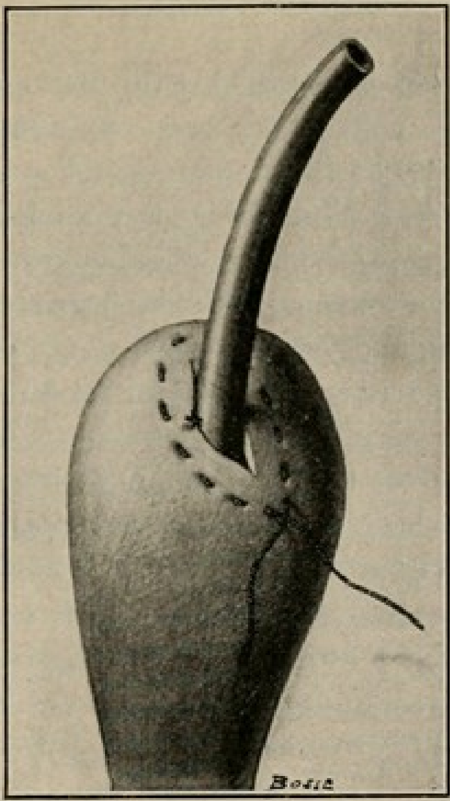

Fig. 233.—Cholecystostomy. Purse-string to close incision in fundus of gall-bladder around the drainage tube has been introduced.

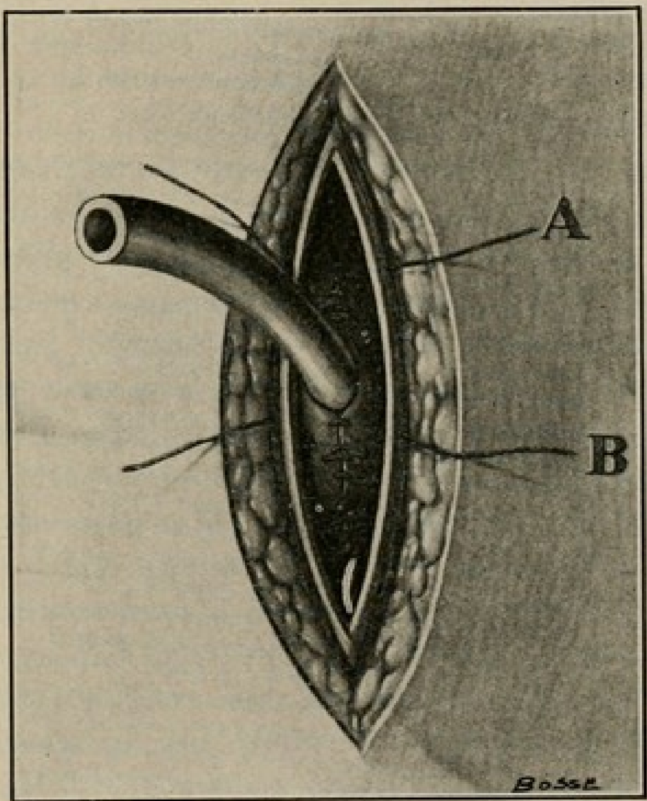

Fig. 234.—Cholecystostomy. The purse-string suture has been tied and the incision in the fundus of the gall-bladder closed "water-tight" around the tube. Two sutures, *A* and *B*, have been introduced in the wall of the gall-bladder. They catch the edges of the peritoneum and deep fascia on either side of the incision, and, when tied, serve to suspend the gall-bladder close to the abdominal wall.

While the bladder is steadied with the clamps an incision is made in the fundus sufficiently large to remove the stones and permit the introduction of the finger for the purpose of exploration.

The clamps are then removed and re-applied so as to catch the edges of the opening in the gall-bladder and the stones are removed with the stone scoop or forceps. Stones impacted in the neck of the gall-bladder or cystic duct may be dislodged and forced back into the bladder by manipulation of the neck of the gall-bladder. They can then be removed with the scoop or seized with the forceps. If unsuccessful in the effort to dislodge stones impacted in the neck of the gall-bladder, etc., it would be necessary to resort to cholecystectomy, removing the gall-bladder together with the stone impacted in its neck, etc., or, if impacted in the cystic duct, to incise the duct and remove the stones (see "Cysticotomy"). At times, stones which are overlooked and left remaining in the neck of the gall-bladder and cystic duct become dislodged spontaneously, especially if the bladder is drained (large-calibre tube) and washed out occasionally with sterile olive oil, after operation.

After all the stones have apparently been removed the bladder is packed temporarily with a strip of gauze and the cystic and common duct again carefully palpated to make certain that no stones are left remaining in these passages.

The gauze strip is removed from the bladder and the final step of the operation, provision for drainage, proceeded with. A purse-string suture of chromic catgut No. 1 is applied around the edge of the incision in the gall-bladder. This suture may penetrate the entire thickness of the wall of the gall-bladder. It is placed fairly close to the edge of the incision and takes a good secure bite with each thrust of the needle. The individual stitches of the purse-string should be rather long—about one-third inch apart, so that it will draw the edges of the opening in the gall-bladder very tight around the tube which is introduced. The drainage tube is of rubber, of large calibre—one-third to one-half inch in diameter. The tube is introduced into the gall-bladder and secured with a single suture of plain catgut, which passes through the tube and the edge of the incision in the gall-bladder. The tube has an opening in the end and another large opening in the side near the end. Not more than one and one-half inches of the length of the tube is inserted into the gall-bladder in order that its end may not impinge against the wall and thus become blocked. When the purse-string is pulled tight and tied it closes the incision in the gall-bladder "water-tight" around the drainage tube.

The abdominal pads are now removed and the parts cleansed with a gauze wipe wet in hot saline. If the bladder, carrying the drainage tube, can conveniently and without too much tension be brought up into the abdominal incision, it is fixed to the edges of the same with two chromic catgut sutures which secure the wall of the gall-bladder, one above and the other below the place where the drainage tube emerges. These two sutures are used to suspend the gall-bladder to the edges of the abdominal incision. They are introduced through the edges of the peritoneum and transversalis facia, and pick up the wall of the gall-bladder as they pass across the incision from one edge to the other. They take one or more good bites in the wall of the gall-bladder, but do not penetrate into the mucous membrane layer. They are left long and are not tied until after the suture that is used to unite the edges of the peritoneum has been introduced.

If the sandbag under the dorsum has been used this is removed before beginning the closure of the abdominal incision. The suture that is used to approximate the edges of the peritoneum and transversalis fascia (the transversalis fascia is included in the peritoneal suture in order to give a better hold) is a continuous stitch of plain catgut. It commences in the upper end of the incision and is continued downward as far as the point where the drainage tube emerges, where it is tied. Another similar suture commences in the lower end of the incision and is continued upward as far as the point where the tube emerges and is there tied. The two sutures that suspend the gall-bladder are then tied. The edges of the split rectus muscle are approximated with several sutures of plain catgut. The edges of the aponeurosis (anterior sheath of the rectus) are united from above downward as far as the drainage tube, and from below upward as far as the tube, with a continuous stitch of chromic catgut. Finally the skin is sutured. In very fat patients it is well to add a number of heavy silk sutures for extra support. These are introduced after the peritoneum and deep fascia have been sutured and the stitches that suspend the gall-bladder have been tied. They are placed about one-half inch apart and pierce all the layers of the abdominal wall except the peritoneum and deep fascia. These extra supporting sutures are not tied until after the several layers of the incision have been sutured as described above.

In some cases it is not feasible to suspend the gall-bladder to the edges of the abdominal incision as described above, owing to the fact that it cannot be brought up into the incision without undue tension. In these cases the gall-bladder carrying the drainage tube may be dropped back into the abdomen. This may be safely done, especially if the opening in the bladder has been carefully sutured, "water-tight" around the drainage tube. A strip of plain gauze packing is introduced into the abdomen, down alongside the drainage tube as far as the fundus of the gall-bladder in order to provide drainage in the event of leakage.

Cholecystectomy.—Extirpation of the gall-bladder.

The gall-bladder is excised in cases of rupture due to traumatism, falls, blows, run-over. Gall-bladders that are affected with malignant disease; gangrenous or perforated as the result of acute inflammatory processes; shrunken, contracted, bound down and buried beneath dense adhesions; those that cannot be utilized for drainage of the liver on account of torsion, kinking or stricture of the cystic duct; where calculus cannot be dislodged from its position in the neck of the gall-bladder or in the cystic duct; where a biliary fistula persists on account of stricture, obstruction, etc., of the cystic duct. Under any of the conditions above enumerated the gall-bladder should be extirpated.

In those cases where the gall-bladder is excised the operator should be certain that the common duct is patent.

In operations upon the common duct where drainage of the liver is desirable, the gall-bladder, if the cystic duct is patent, can be utilized for this purpose with very satisfactory results. The gall-bladder and unobstructed cystic duct form an excellent drainage tract from the liver. If drainage of the liver is required and at the same time it is necessary to remove the gall-bladder on account of disease, then the drainage of the liver must be provided by immediate, direct drainage of the common duct.

The incision is, in the beginning, exploratory, and is made from the tip of the ninth costal cartilage downward, as described in cholecystostomy. The primary incision is supplemented by extending it upward and inward parallel with the free border of the ribs toward the ensiform cartilage. A sandbag is placed under the lower dorsal region. By these means the deeper bile structures are brought up nearer to the abdominal incision and the abdominal viscera tend to gravitate toward the lower part of the abdominal cavity.

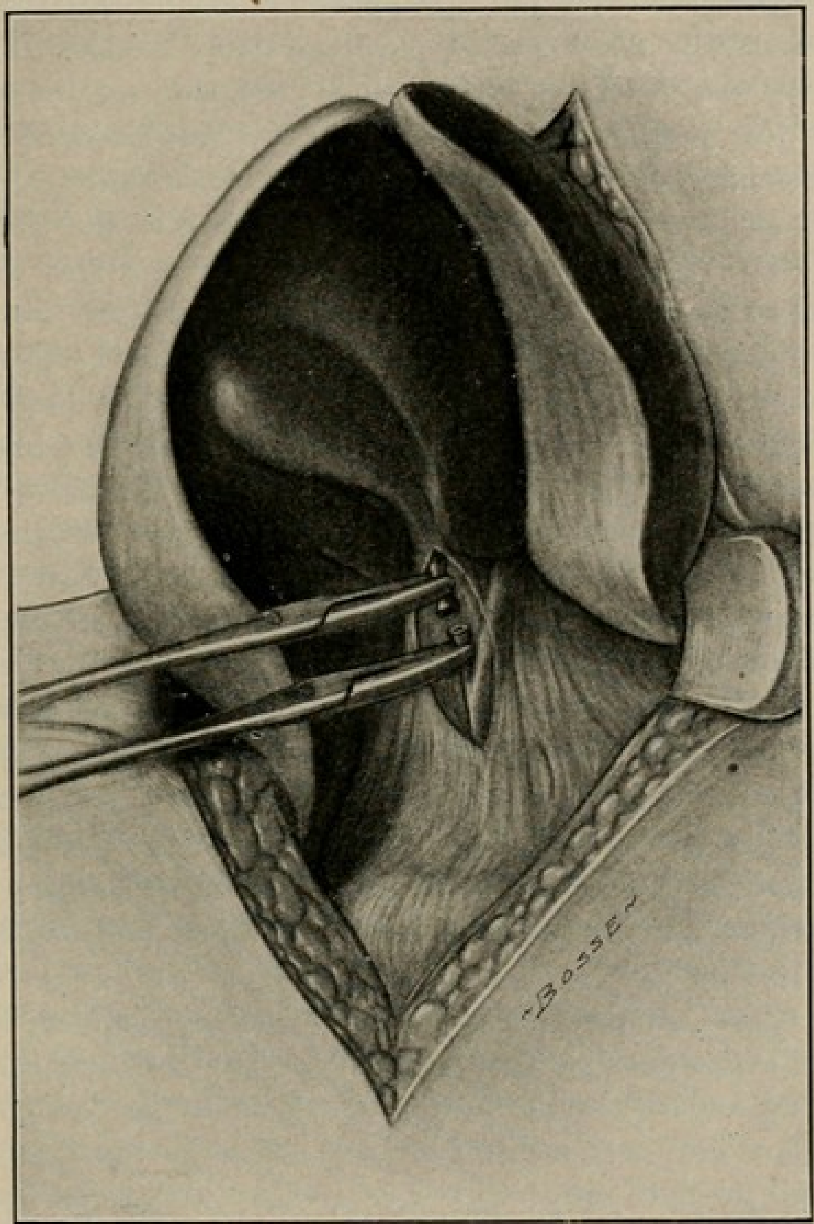

Fig. 235.—Cholecystectomy. The liver has been drawn out of the incision. The peritoneum has been incised and the cystic duct clamped double and divided between the clamps.

After the abdomen has been opened the gall-bladder is sought and examined. It may be distended and present into the incision or it may be small, shrunken, contracted, concealed up under the liver and buried in dense adhesions. It is necessary to separate the adhesions that bind the gall-bladder to the adjacent organs, transverse colon, great omentum, duodenum, stomach. At times the adhesions are very extensive and dense and require much care and patience to separate them and free the gall-bladder.

The gauze pads are properly placed so as to protect the adjoining parts, one packed down under the liver into the right kidney space. The liver and with it the gall-bladder is drawn down from under the ribs out through the incision, and the liver rotated, so that the gall-bladder comes to look forward and upward. The parts are then readily accessible for examination. The gall-bladder and the gall-ducts, cystic, common, hepatic, and the head of the pancreas are carefully palpated and inspected as far as possible, for the presence of stones, malignant disease, etc. With two fingers of the left hand introduced into the foramen of Winslow, and the thumb apposed anteriorly, the entire length of the common and hepatic ducts can be palpated.

The gall-bladder may be separated from the under surface of the liver and removed by either of two methods. Commencing anteriorly at the fundus and working backward, tying the cystic duct and the cystic artery and vein as the final step of the procedure; or else commencing behind, first clamp and divide the cystic duct and ligate the cystic artery and vein and then work forward toward the fundus.

The second method is the preferable one, especially in those cases where the cystic duct is fairly accessible. The liver and gall-bladder are held up and the cystic duct, where it joins the common, clearly recognized. The peritoneal layer that encloses the cystic duct is incised and the duct seized with a long clamp within one-half inch of its termination in the common. A second clamp is applied to the duct a short distance from the first and between the two clamps the duct is divided. The stump of the duct is ligated with chromic catgut and the clamp removed. The cystic artery and vein are next found above and to the left of the duct. Two clamps are applied and the vessels divided between them and the ends of the vessels ligated with catgut and the clamps removed.

The stump of the cystic duct is steadied with the ligature which was left long for this purpose, and sterilized with a drop of carbolic on a probe or with the Paquelin and the ligature cut short. The stump of the duct is buried beneath the peritoneum, which is sewed over it with several fine chromic catgut sutures.

The gall-bladder is enucleated with the finger from its bed upon the under surface of the liver. The peritoneal layer which corresponds to the serous coat of the gall-bladder, and which holds the gall-bladder in its position against the under surface of the liver, is split with the scissors as the enucleation proceeds. As much of the peritoneal covering of the gall-bladder as possible is preserved to be used later for the purpose of covering over the raw surface of the liver which is left after the gall-bladder has been removed. There may be some hemorrhage from the raw surface of the liver. This is controlled usually by pressure with a very hot, wet, gauze pad.

The free, hanging edges of the peritoneum which are left after the bladder has been removed are united with a continuous suture of plain catgut, and thus the raw surface of the liver is covered over.

The separation of the gall-bladder from the under surface of the liver may be commenced anteriorly at the fundus. Snipping the fold of peritoneum that is reflected from the under surface of the liver over to the fundus of the gall-bladder, the finger is introduced and the gall-bladder detached from the under surface of the liver backward toward the neck of the gall-bladder and cystic duct. The fold of peritoneum that covers the gall-bladder is incised with the scissors as the separation of the gall-bladder proceeds. The bladder finally hangs by its pedicle, which consists of the cystic duct and the cystic artery and vein. The pedicle is seized with two clamps and divided between them. The stump is ligated with chromic catgut, the clamp removed, and the end of the cystic duct treated with carbolic on a probe or with the Paquelin. The peritoneum is sewed over the stump as described in the preceding operation, and the raw surface of the liver covered by uniting the free hanging edges of the peritoneal layer, which are left after enucleating the gall-bladder, with a continuous catgut suture.

If drainage is not necessary the abdominal incision is closed layer by layer.

If desirable to drain the site of the operation a plug of strip gauze is left in the abdomen. It may be fixed to the stump of the pedicle with a single, fine, plain catgut suture. The incision is closed except for the small opening left for the drainage plug to emerge. The drain is usually removed after two or three days.

If it is desirable to drain the liver, cholangitis, the stump of the cystic duct is not ligated. The clamp is removed and the stump of the cystic duct is split down as far as its junction with the hepatic, an opening being made large enough to admit a rubber tube, one-third to one-half inch in caliber. The tube is passed through the split stump of the cystic duct upward into the hepatic duct for about one inch and is secured near the edge of the incision in the duct by a single catgut suture. This suture catches the wall of the duct a short distance away from the edge of the incision which admits the tube. A plug of gauze is packed down alongside of the drainage tube to the incision in the duct in order to provide drainage in the event of leakage around the rubber tube.

Cholecyst-enterostomy.—The establishment of a fistulous communication between the gall-bladder and the intestinal canal. The operation is indicated in cases of inoperable obstruction of the common duct, as for example, new growths in the common duct or head of the pancreas. A communication is established that permits the bile to escape from the gall-bladder into the intestinal canal. The operation would likewise be indicated in case of persistent biliary fistula provided the reason for the non-closure of the fistula were due to some inoperable obstruction of the common duct.

The communication may be established between the gall-bladder and the duodenum, jejunum or large intestine.

The cystic duct must, of course, be patent so that the bile can find its way into the gall-bladder.

Cholecysto-duodenostomy.—The formation of a fistulous opening between the gall-bladder and the duodenum. The upper part of the duodenum, that which adjoins the gall-bladder is used for the purpose. This operation has an advantage over those that establish communication with the jejunum and colon in that it permits the bile to enter the upper part of the duodenum where it may be used to good purpose in the process of digestion.

The operation may be made with the suture, clamp, Murphy button, McGraw rubber ligature, etc.

Suture Method.—A vertical incision four to six inches long is made from the tip of the ninth costal cartilage, downward, through the outer part of the rectus muscle. If necessary to get more room the incision may be extended upward and inward, toward the ensiform cartilage.

Having cut through the abdominal wall the liver is drawn down and out of the incision and rotated so that the gall-bladder comes into view. Gauze pads are properly placed in the incision and about the gall-bladder to protect the parts and the gall-bladder emptied with the trochar as nearly completely as possible, and then opened through a small incision in its fundus. Through this incision stones are removed and the interior of the gall-bladder, patency of the cystic duct, are investigated. The gall-bladder is wiped out dry and packed with strip gauze to prevent leakage during the subsequent steps of the operation. The duodenum is located and drawn into the incision. It may be necessary to partly detach the duodenum (see mobilization of the duodenum, "Gastro-duodenostomy," Kocher, page 438) before it can be brought up with sufficient freedom into the incision to permit of easy union with the gall-bladder. The duodenum is cleared of its contents by gentle stripping and a clamp with elastic rubber-sheathed blades applied in order to prevent re-entrance of contents.

The gall-bladder is sutured to the wall of the duodenum with a continuous, non-penetrating stitch of silk for a distance of one and one-half to two inches in a manner similar to that described in "Gastro-jejunostomy, Suture," page 442. This line of suture forms the posterior half of the "outside serous ring" suture. The needle still carrying the thread is laid aside until needed later to introduce the anterior half of this "outside serous ring" suture. The gall-bladder and duodenum are incised. The incisions are made parallel with and about one-quarter inch distant from the suture line. The edges of the incisions are sewed to each other all around with a continuous suture of plain catgut. Finally the needle with which the posterior half of the "outside serous ring" suture was introduced and still carrying the silk thread, is again taken in hand and with it the anterior half of the non-penetrating suture, "outside serous ring," is applied, and this step of the operation thus completed. The clamp is removed from the duodenum.

The incision in the fundus of the gall-bladder is closed layer by layer as described in cholecystotomy. The first line of suture, of plain catgut, includes all the layers except the mucous membrane and serves to close the opening. A second line of suture of silk—a continuous Lembert suture—which secures the serous and muscular layers only is applied and serves to bury the first catgut suture line and bring the serous margins of the incision into accurate apposition. It may be desirable in some cases to leave the incision which was made in the fundus of the gall-bladder open in order to provide drainage temporarily until the communication between the gall-bladder and duodenum has become established. In order to accomplish this purpose a rubber drainage tube is secured "water-tight" in the incision in the gall-bladder, and the bladder disposed of as described in cholecystostomy.

The incision in the abdomen is closed for part of its extent or completely according as the gall-bladder is drained or not.

With Clamps.—The cholecysto-duodenostomy may be made with the assistance of the holding clamps in a manner analogous to that described in "Gastro-jejunostomy" and "Lateral Intestinal Anastomosis, Clamp Method."

With Murphy Button.—A small button is used. This method

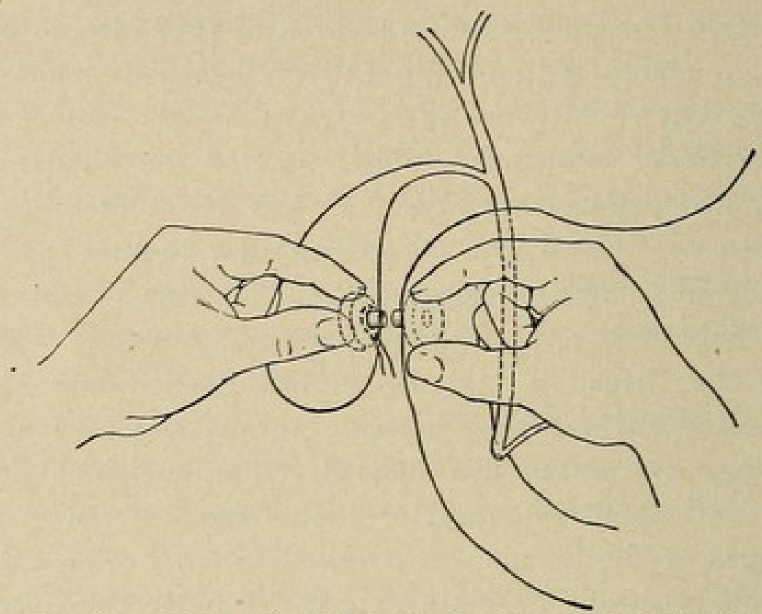

Fig. 236.—Cholecysto-duodenostomy with Murphy Button.

has the advantage of being quick and comparatively simple. It is of value in those cases where, owing to adhesions, disease, etc., the parts are not so easily accessible, not sufficiently movable as to permit of the manipulation necessary in making the anastomosis with the suture.

The incision is similar to that described in the operation in the preceding paragraphs. The abdomen is opened and the gauze pads properly arranged to protect the parts and the gall-bladder emptied with the trochar. The duodenum is emptied of its contents by stripping it between the fingers, and a clamp with elastic, rubber-sheathed blades applied to prevent the re-entrance of contents. It may be necessary to mobilize the duodenum in order to bring it and the gall-bladder into close contact (see page 438). With a straight needle a chromic catgut suture is introduced in the wall of the gut in the fashion of a purse-string. Each leg of this suture should include about one and one-half inches of the length of the gut and be in a straight line; it is made with three punctures of the needle, each bite including about one-third inch and passing through the entire thickness of the wall of the gut; the second limb of the suture is made with the same thread in the reverse direction parallel with the first and distant from it about one-half inch, finally terminating along side of where the needle first entered in commencing the suture. Corresponding to the point where the thread turns back to form the second half of the suture a little slack, or loop, should be left. With the ends of this running stitch the first loop of a surgeon's knot is taken. The gut is incised between the two rows of suture for a distance corresponding to two-thirds the length of the diameter of the button to be used (No. 1 or 2 preferable), the incision thus made being shorter than the suture line. The method of applying the purse-string suture is similar to that employed in "Lateral Intestinal Anastomosis" (Fig. 203). The male half of the button is slipped into the incision in the gut and the purse-string drawn tight about it and tied. A similar purse-string suture is introduced in the wall of the gall-bladder at a convenient point near the fundus, and an incision made and the female half of the button introduced into the gall-bladder and the purse-string drawn tight and tied. The two halves of the button are then carefully and steadily forced together.

It may have been necessary to make an incision in the fundus of the gall-bladder to remove stones; to investigate the interior of the bladder, etc. The gall-bladder is disposed of as described in the preceding operation.

If the bladder is not drained the incision in the abdomen may be closed, layer by layer, as described in cholecystotomy.

Cholecysto-jejunostomy—Suture Method.—A fistulous opening is made between the gall-bladder and jejunum in those cases where the duodenum is unavailable on account of its being too firmly fixed, involved in the disease, etc., to permit of its being brought up into apposition with the gall-bladder.

A vertical incision, four to six inches long, is made through the outer part of the right rectus muscle and commencing above, just below the free border of the ribs at the tip of the ninth costal cartilage. If more room is required the incision may be extended upward and inward toward the ensiform cartilage.

Having cut through the abdominal wall the distended gall-bladder is usually found presenting in the incision. Gauze pads are placed about the parts to protect the peritoneal cavity, and the gall-bladder emptied as nearly completely as possible with the trochar and then incised, the incision being made in the fundus and sufficiently large to remove stones if present and to permit investigation of its interior, etc. The gall-bladder is swabbed out dry with gauze wipes and packed temporarily with strip gauze to prevent leakage during the subsequent steps of the operation.

A loop of the jejunum about twenty inches away from its commencement (see "Gastro-jejunostomy") is secured and brought up, in front of the great omentum and transverse colon, into the incision in the abdominal wall. The loop of gut is emptied of its contents by stripping between the fingers and two pieces of narrow tape are placed about it to prevent re-entrance of contents. With a straight needle and fine silk the gall-bladder, at a convenient point near its fundus, and the gut, opposite its mesenteric border, are united to each other. This stitch takes a good, broad bite, including the serous and muscular coats, but does not pierce the whole thickness of the wall of either organ. The gall-bladder and jejunum are joined together in this way for a distance of one and one-half to two inches. This suture forms the posterior half of the "outside serous ring." The needle still carrying the thread is temporarily laid aside and an incision, one to one and one-half inches long, made in the gall-bladder and in the intestine. These incisions are made parallel with and about one-quarter inch away from the line of suture. The edges of the openings are sewed to each other all around with a continuous suture of plain catgut, and thus the communication between the two organs is effected. The first needle carrying the fine silk thread with which the first half of the "outside serous suture" was made, is again taken up and the second half of this "outside serous suture" is introduced.

The incision which was made in the fundus of the gall-bladder for the purpose of emptying it and removing stones, etc., is disposed of as described in the operations in the preceding paragraphs; it may be left open and drained or closed with a double row of sutures.

The incision in the abdomen is closed in part or completely according as the gall-bladder is drained or not (see "Cholecystostomy").

This anastomosis may also be effected with the clamps, Murphy button, McGraw rubber ligature, etc.

Cholecysto-colostomy.—The establishment of a fistulous communication between the gall-bladder and colon. This operation has been done in cases of inoperable obstruction of the common duct so as to provide an exit for the bile to escape. The technique of this operation is quite similar to that of the operations just described. The suture method, clamps, Murphy button, etc., may be used to make the junction between the gall-bladder and large intestine. The transverse colon is found immediately adjacent to the gall-bladder and the anastomosis between the gall-bladder and it is easily effected. It is claimed that the functions of the patient do not suffer from thus diverting the bile away from the small intestine. The objection has been made against this operation that the gall-bladder and secondarily the liver are more apt to become infected from the large intestine, colon bacillus, etc.

OPERATIONS UPON THE GALL-DUCTS.

Occasionally the cystic and hepatic ducts, but more frequently the common duct, are the object of surgical operation; for the purpose of removing stones that have become impacted or to establish a new orifice of communication between the obstructed or obliterated ducts and the bowel.

Cysticotomy.—Incision into the cystic duct for the purpose of removing stones impacted therein.

In many instances calculi impacted in the neck of the gall-bladder or in the cystic duct can be dislodged and forced back into the gall-bladder by manipulation and massage of the neck of the bladder and then removed through an incision in the bladder. Occasionally, however, stones become so tightly fixed in the neck of the gall-bladder or in the cystic duct that they cannot be dislodged by this means. In these cases extirpation of the gall-bladder including the stone impacted in the neck or in the cystic duct would be the most satisfactory procedure; or the impacted stone might be left undisturbed in the cystic duct and the gall-bladder drained, using a large drainage tube, three-quarters inch in caliber, in the hope that the stone may become dislodged spontaneously or through the assistance rendered by frequent irrigation subsequent to operation with soap, olive oil, etc.

Stones impacted in the neck of the gall-bladder or cystic duct may be removed through incision made through the neck of the gall-bladder or cystic duct down upon the stone. The incision which is thus made should be closed with a row of non-penetrating sutures of fine chromic catgut and the gall-bladder drained (Cholecystostomy.)

In order to gain access to the cystic duct an abdominal incision and measures similar to those described in cholesystectomy are necessary.

Hepaticotomy.—Incision of the hepatic duct, for the purpose of removing impacted stones. Calculi may be present in the hepatic duct and may become impacted there. As a rule they can be stripped with the fingers into the gall-bladder and removed through an incision in the gall-bladder; or they may be stripped down into the common duct and removed through an incision in the common duct. When the stone is firmly impacted it becomes necessary to cut down upon the stone through the wall of the hepatic duct in order to remove it.

When the stone is lodged in the lower part of the hepatic duct (just above the point where the hepatic is joined by the cystic to become the common duct), the steps of the operation for its removal are quite similar to those described in choledochotomy.

The upper part of the hepatic duct is very inaccessible and calculi impacted in this part of the duct may be very difficult to reach. A free abdominal incision is required and it may be necessary to break the cartilages of the seventh and eighth ribs at their junction with the ribs to gain more room. The liver is drawn out of the incision and rotated and one or two fingers introduced into the foramen of Winslow in order to steady the hepatic duct and draw it up into the abdominal incision. The incision in the hepatic duct through which the stone is removed is not closed. A rubber drainage tube, 6-8 mm. in diameter, is introduced through the incision and pushed up into the duct as described in detail in choledochotomy.

Stones impacted in the hepatic duct may be removed by splitting the cystic duct (with or without extirpation of the gall-bladder) down as far as its junction with the common. Through the opening thus made the stones may be removed from the hepatic duct.

Choledochotomy. — Incision into the common bile-duct. This operation is performed for the purpose of removing calculi which have become lodged in the duct. Calculi may become impacted in any part of the common duct, in the upper supraduodenal part, in the lower retroduodenal part or in the lower end of the duct, in the intramural portion or in the ampulla of Vater—the dilated part of the duct just before it opens into the duodenum. There may be only one calculus, frequently there are several or they may be very numerous. They may be lodged loosely in the common duct being thus able to change their position from time to time and permitting the bile to flow past them,

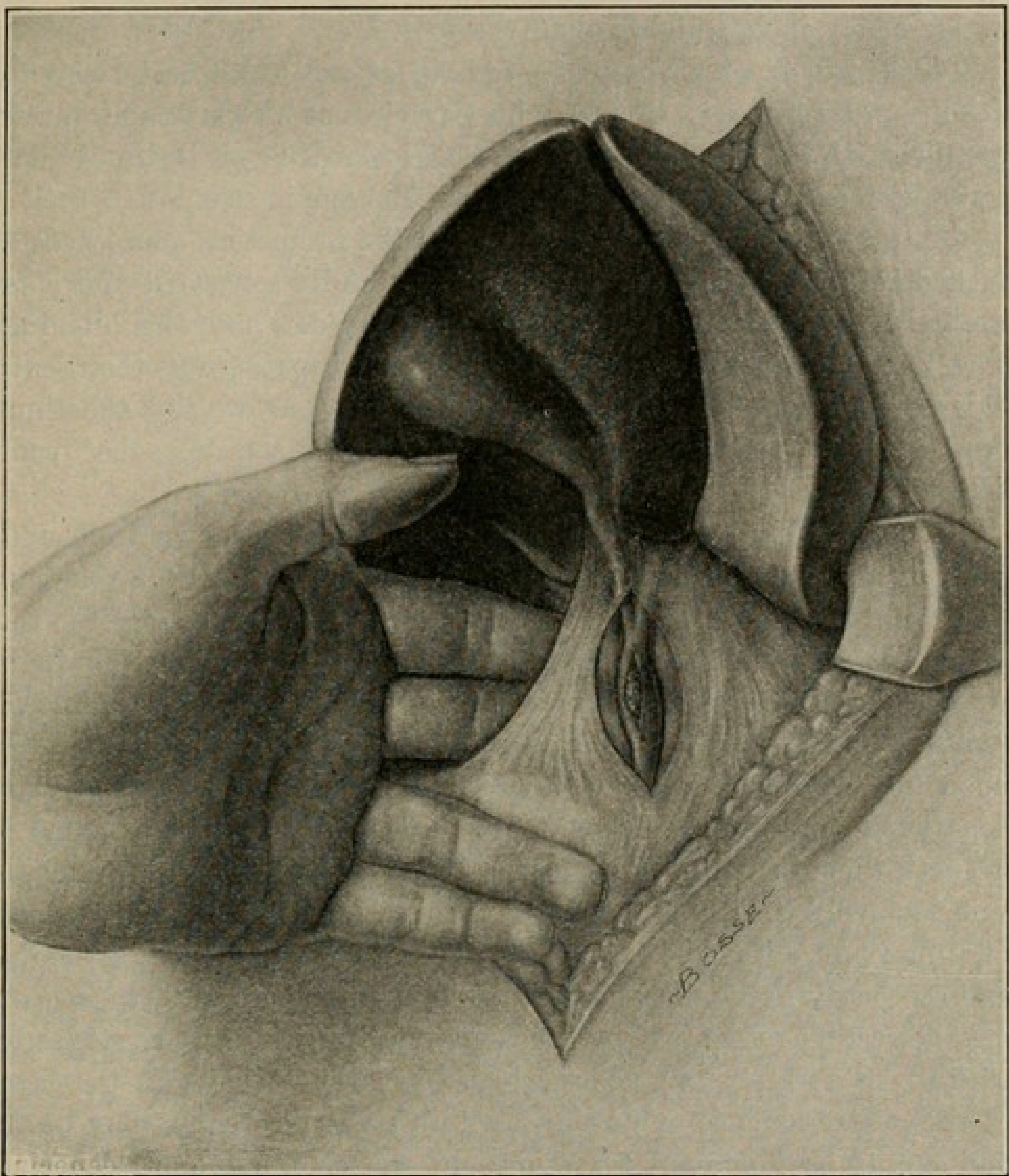

Fig. 237.—Choledochotomy. Two fingers have been passed into the foramen of Winslow and the common duct lifted forward into the abdominal incision. An incision has been made through the wall of the common duct down upon a stone contained within.

or they may be impacted so snugly in the duct that they obstruct the flow of bile completely and cause symptoms accordingly.

Supra-duodenal Choledochotomy. — A sand-bag is placed under the lower dorsal region and the table inclined so that the head is five or six inches higher than the foot.

The primary incision from the tip of the ninth costal cartilage (cholecystostomy), is enlarged by carrying it upward and inward, parallel with the free border of the ribs, toward the ensiform cartilage, for a distance of two or three inches—Robson incision.

After the abdomen has been opened the protecting gauze pads are tucked into the incision and adhesions carefully separated and a preliminary examination made of the gall-bladder and the bile-ducts. The ducts are palpated, the common and hepatic, for their entire length, with two fingers in the foramen of Winslow and the thumb opposed. Calculi that are present in the ducts, may be readily detected.

The liver and with it the gall-bladder is drawn down from under the ribs and out through abdominal incision and the liver rotated so that the gall-bladder comes to look forward and upward and the common duct is brought up nearly to a level with the incision in the abdomen and may be examined and palpated with precision. The common bile-duct with the portal vein behind it and the hepatic artery upon its left side is situated between the folds of the lesser, gastro-hepatic, omentum, near its right, free border, and may be palpated for its entire length with two fingers of the left hand in the foramen of Winslow and the thumb opposed anteriorly. The normal common duct may not always be recognized but if there are stones in the duct and especially if the duct has become dilated and its wall thickened it may be readily recognized by the examining fingers and the stones felt within. Several lymph nodes which are situated between the layers of the gastro-hepatic omentum near its right free edge, may be felt and might be mistaken for stones in the common duct, especially as they are, at times, found enlarged and indurated as a result of disease of the gall-ducts or of the adjacent organs.

Before proceeding to the removal of the stones from the common duct, the gall-bladder should be incised, after being first emptied with the trochar; any stones that are present in the gall-bladder are removed and its interior swabbed out dry with gauze wipes. The gall-bladder is then packed temporarily with strip gauze to prevent any leakage during the subsequent steps of the operation.

The protecting gauze pads are again properly arranged, one packed carefully down under the liver into the right kidney space and the operator proceeds to remove the stones from the common duct. Two fingers of the left hand are introduced, behind the common duct, into the foramen of Winslow and the duct drawn forward toward the abdominal incision and it and the stone within thus steadied while an incision is made through its wall, cutting directly down upon the stone. The incision is just large enough to permit the extraction of the stone. When the stone is removed bile may escape and is wiped away as fast as it flows. The finger is introduced into the duct or a probe, if the duct is too small to admit the finger, and search is made for any remaining stones. The finger is passed upward and downward in the duct in examining for additional stones. At times calculi are impacted low down in

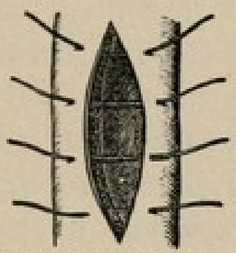

Fig. 238.—Method of Suturing Incision in the Common Duct. The sutures appear in the edges of the incision just short of the mucous layer. They do not penetrate the entire thickness of the wall of the duct—they do not present within the lumen of the duct.

the duct and may be dislodged and worked upward into the upper part of the duct and removed through the incision.

The incision in the common duct may be closed with a continuous or several interrupted sutures of fine chromic catgut. These sutures enter and exit close to the edges of the incision, but they must surely not penetrate the mucous layer—they must not appear within the lumen of the duct—they appear in the edges of the incision just short of the mucous layer. As to the advantage of closing the incision in the duct there is considerable difference of opinion. If the incision is closed a drain made of strip gauze wrapped in rubber tissue may be left in the abdomen, reaching down to the suture line in the common duct.

Some surgeons leave the incision in the duct unsutured and introduce a rubber tube into the duct for drainage; especially should this be done if there have been symptoms of septic liver infection—cholangitis. If the duct is to be drained a rubber tube is passed through the incision and upward into the duct for about one inch and fixed in position by a single catgut stitch that passes through the tube and picks up the wall of the duct, but without penetrating its entire thickness, close to the edge of the incision. If the incision is larger than is necessary to accommodate the tube a sufficient number of fine chromic catgut sutures are taken to close the incision tightly around the tube. These sutures enter and exit close to the edges of the incision, appearing in the edges of the incision just short of the mucous layer. They must not penetrate the mucous coat. A drain of strip gauze rolled and wrapped in rubber tissue is left in the abdomen, reaching alongside the rubber drainage tube down to the suture line in the duct.

The sandbag is removed from under the back and the abdominal incision carefully sutured, layer by layer, except the space that is left open for the exit of drainage tubes, etc. The peritoneum and transversalis fascia are sewed together with a continuous suture of plain catgut; the edges of the muscles with several interrupted sutures of plain catgut; the edges of the aponeurosis with a continuous suture of chromic catgut, and finally the skin.

Retro-duodenal Choledochotomy.—Incision of the retroduodenal portion of the common duct for the purpose of removing calculi impacted there. This part of the common duct is embedded in the head of the pancreas, in some instances completely surrounded by pancreatic tissue. At times it is very difficult to expose the lower part of the duct and incise it without dividing the pancreatic tissue which surrounds it, and possibly wounding the duct of Wirsung which lies in close proximity to the lower part of the common duct. In some cases a stone impacted in the lower part of the common duct can be dislodged and massaged upward into the supraduodenal portion and removed through an incision in this part of the duct, as indicated in the operation described in the preceding paragraphs.

The preliminary steps of the operation, incision, etc., are similar to those described in supraduodenal choledochotomy.

In order to expose the lower part of the common duct the peritoneal layer is incised along a line parallel with and less than an inch to the outer side of the second part of the duodenum, and this part of the intestine is detached from the posterior abdominal wall and turned over toward the left so that its posterior surface is exposed. The lower part of the common duct is sought. The calculus can be felt distinctly within and another effort should be made to dislodge it and force it up into the supraduodenal part of the duct, where it can be easily removed. If this effort is not successful an incision is made through the wall of the duct cutting directly down upon the stone and it and any additional calculi removed. The incision in the duct is closed with several non-penetrating sutures of fine chromic catgut in a manner similar to that described in supraduodenal choledochotomy, and the displaced duodenum returned to its natural position. A strip of gauze rolled and wrapped in rubber tissue is left in the abdomen reaching down into the incision which was made in the peritoneal layer alongside of the duodenum.

It is necessary to provide a temporary outlet for the bile while the incision in the lower part of the duct is healing, either by direct drainage of the common duct by means of a rubber tube introduced through an incision made for the purpose in its supraduodenal part, or else by draining the gall-bladder (cholecystostomy) if it is certain that the cystic duct is unobstructed.

Removal of Calculi from the Common Duct through the Duodenum.—For calculi which are impacted low down in the duct at or near the point where it enters the duodenum. "The Transduodenal Choledochotomy" of McBurney, "The Transduodenal Choledochoduodenostomy" of Kocher.

The preliminary steps of the operation, sand-bag under the lower dorsal region, upper end of table raised and the abdominal incision are similar to those described in "Supraduodenal Choledochotomy."

After the abdomen has been opened the gall-bladder and bile ducts are examined and the stone recognized in the lower part of the common duct. An effort should be made to dislodge the stone and force it upward into the supraduodenal part of the duct where it can readily be removed, or possibly into the duodenum. This failing we proceed to remove it through the duodenum. The duodenum may be made more accessible, if necessary, by loosening it from its attachment, "mobilizing" it, according to the method of Kocher.

The mobilization of the duodenum is effected by making a vertical incision through the posterior peritoneal layer, about one finger's breadth to the outer side of the second part of the duodenum. This incision exposes the anterior surface of the right kidney. Into the opening thus made the finger is introduced and the second part of the duodenum, together with the head of the pancreas, separated and lifted away from the posterioı wall of the abdomen up into the abdominal incision and steadied there during the succeeding steps of the operation. The impacted stone within

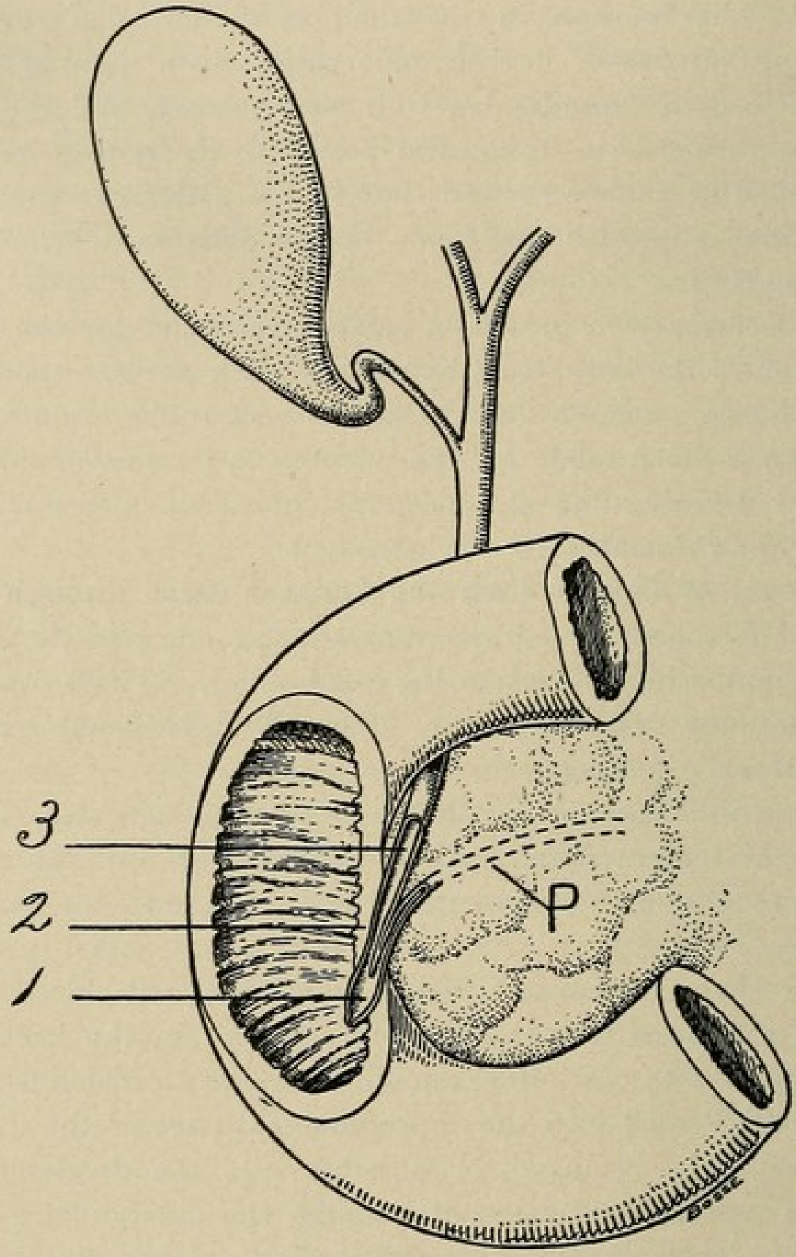

Fig. 239.—Lower Part of Common Duct. Portion of the wall of the duodenum removed to show the point where the common duct opens into the duodenum. 1. Ampulla of Vater. 2. Intramural portion of common duct. 3. Portion of duct just above the intramural portion. *P*, Pancreatic duct.

the common duct can be felt through the wall of the duodenum and may be fixed between the fingers that support the duodenum.

The gauze pads are arranged to protect the adjacent peritoneal surfaces and the duodenum incised, making an opening either longitudinal or transverse in direction, and from one to one and one-half inches long. Material from the incised duodenum is wiped away as fast as it escapes.

The calculus may be impacted in the ampulla of Vater, the dilated portion of the duct immediately above the orifice, and may be seen presenting into the intestine through the orifice; or it may be impacted higher up, just above the ampulla of Vater, in the intramural portion of the duct. The stone is extracted with the forceps through the orifice. It may be necessary to stretch or incise the orifice before this can be done. The orifice of the duct is incised by snipping with the scissors in an upward direction. If the stone is impacted above the ampulla of Vater, in the intramural portion of the duct, it may be necessary to extend the incision from the orifice, upward, for a distance of one-half to three-quarters of an inch before the stone can be extracted.

Occasionally the stone is impacted still higher up in the duct (above the intramural portion of the duct), and cannot be seized and delivered through the orifice. Under these circumstances it becomes necessary to cut down upon the stone in order to remove it. This incision goes through the entire thickness of the wall of the duodenum and through the wall of the common duct. The contiguous edges of the opening which is thus made from the duodenum into the common duct are sewed to each other with several interrupted sutures of fine chromic catgut and thus there is established a fistulous communication between the common duct and duodenum (Choledocho-duodenostomy Interna). Owing to the inflammatory process that accompanies stone impaction of the common duct the adjoining walls of the common duct and duodenum are usually found already adherent to each other, so that the stitches might safely be omitted. It is better, however, to suture the edges as described.

After the stone has been removed a thick probe on the finger is introduced through the orifice or incision into the duct and search made for additional calculi.

The incision in the duodenum is closed with a non-penetrating Lembert suture of silk. The incision in the abdomen is closed layer by layer as in the operations described above unless the common duct or the gall-bladder is drained (see "Supraduodenal Choledochotomy").

THE PANCREAS.

Surgical Anatomy of the Pancreas.—The pancreas is an elongated glandular organ from six to eight inches long, its breadth equal to about one-fourth its length; it is about one-half inch in thickness

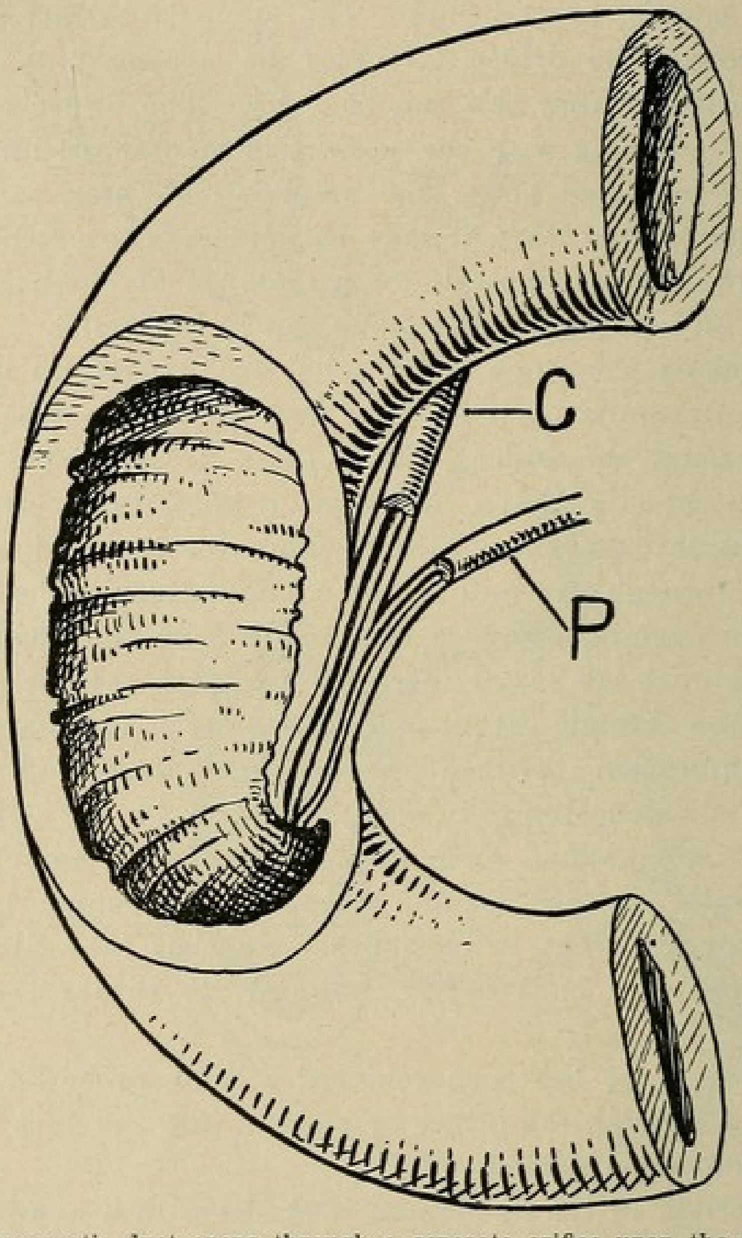

Fig. 240.—Pancreatic duct opens through a separate orifice upon the summit of the papilla into the duodenum. *C*, Common duct; *P*, Pancreatic duct.

from before backward. It is placed transversely in the upper back part of the abdominal cavity, lying behind the stomach across the body of the second lumbar vertebra. It consists of a head, body and tail, the tail abutting against the spleen.

The head lies to the right of the vertebral column, resting upon the inferior vena cava, right crus of the diaphragm and right renal vessels and separated from the inner border of the right kidney by the second part of the duodenum. The common bile-duct is located between the second part of the duodenum and the head of the pancreas more or less completely surrounded by pancreatic tissue.

The body of the pancreas lies opposite the second lumbar vertebra upon the crus (left) of the diaphragm, aorta, thoracic duct, etc. To the left of the vertebral column it is in relation with the renal vessels and left kidney. In front of the pancreas are the peritoneum, stomach and transverse colon. The splenic artery and vein run along its upper border. Its lower border is in relation with the third part of the duodenum, and passing forward between this part of the duodenum and the lower border of the pancreas are the superior mesenteric artery and vein.

The tail of the pancreas projects to the left as far as the spleen, to which it is connected by a fold of peritoneum, ligamentum pancreatico-lienale.

The pancreas is covered by the peritoneum upon its anterior surface only. The transverse mesocolon passes backward, and upon reaching the pancreas its layers separate; the upper layer passes upward, covering the front surface of the pancreas, and lines the back wall of the upper part of the abdomen (lesser peritoneal sac).

The pancreatic duct, duct of Wirsung, courses through the entire length of the organ from left to right and empties into the second part of the duodenum. The duct penetrates the inner wall of the duodenum very obliquely and in close relationship with the common bile-duct and usually terminates by opening into the lower dilated part of the common bile-duct: the ampulla of Vater. The orifice of the common duct is marked by a papilla which is situated upon the inner wall of the second part of the duodenum from three to four inches below the pylorus. In some cases the pancreatic duct does not terminate in the ampulla of Vater, but opens into the duodenum independently of the common bile-duct through a separate orifice upon the summit of the papilla.

A calculus lodged in the ampulla of Vater may compress the end of the pancreatic duct and cause obstruction to the escape of the pancreatic juice into the duodenum or, as pointed out by Opie, in those cases where the pancreatic duct opens into the ampulla of Vater a small stone obstructing the duodenal orifice of the ampulla of Vater might serve to divert the stream of infected bile from the common bile-duct into the pancreatic duct (see Fig. 239) and thus lead to serious disease of the pancreas—hemorrhagic pancreatitis and gangrene.

In addition to the pancreatic duct already described, that of Wirsung, there is a second one normally present, the duct of Santorini. The orifice of the duct of Santorini can usually be demonstrated upon the inner wall of the duodenum about one inch nearer the pylorus than the papilla that marks the opening of the common bile-duct and duct of Wirsung. Within the pancreas the duct of Santorini usually anastomoses with the duct of Wirsung. In some exceptional cases the duct of Santorini is larger than the duct of Wirsung and may functionate for the latter.

The induration that results from chronic inflammatory processes that involve the head of the pancreas and which are frequently associated with cholelithiasis and the passage of gall-stones through the common bile-duct, may cause symptoms of obstructive jaundice by compression of the common duct; malignant growths involving the head of the pancreas may have a similar effect upon the common duct.

OPERATIONS UPON THE PANCREAS.

The operative treatment of diseases of the pancreas forms a comparatively new chapter in surgery. As the functions of the organ and the pathological processes that affect it become better understood the results of surgical interference become more satisfactory.

Operative procedures are undertaken for the purpose of treating injuries, inflammatory conditions, and new growths in the shape of cysts and solid tumors.

Fat Necrosis.—Injuries and inflammatory conditions that are accompanied by a destruction of the tissue of the pancreas are very likely to be complicated by necrosis of the fatty tissue in and about the pancreas and in the mesentery, omentum, subperitoneal connective tissue, etc. This phenomenon of fat necrosis is caused by the direct action of the pancreatic secretion that escapes from the injured gland. Langerhans and Flexner have demonstrated a ferment in the pancreatic juice which is capable of reducing the living fat into its fatty acid and glycerin, and this is, no doubt, the active agent in producing the peculiar condition of fat necrosis. After the fat has been split up in this manner the glycerin is absorbed and the fatty acid remaining combines with lime salts and thus there are produced little, opaque areas of a dull white or yellow color in place of the fatty tissue that has been broken up. When the abdomen is opened the omentum, etc., are found studded with these areas. These spots are flat, and vary in size from a pin-head to a pea or larger and stand out in marked contrast to the bright, glistening yellow of the normal fat. Recognition of this condition of fat necrosis during the course of operation is of the greatest significance to the surgeon and should direct his attention at once to the pancreas as the seat of grave disease or injury.

Incisions to Obtain Access to the Pancreas.—The pancreas is situated very deep in the upper back part of the abdomen. It is usually approached from in front, the incision being placed above the umbilicus in the middle line or to one or the other side of the middle line, penetrating between the fibers of the rectus muscle. After the abdomen has been opened, it will be necessary, in order to reach the pancreas, to enter the lesser peritoneal sac. This may be accomplished through an opening which is made for the purpose in the lesser omentum, gastro-hepatic ligament, or through an opening corresponding to the lower border of the stomach which is made in the gastro-colic ligament. Access to the pancreas may also be gained through a rent torn in the transverse mesocolon; the transverse colon and the great omentum are reflected upward and the mesocolon penetrated from below bluntly in order to avoid injury of the arteria colica media. The head of the pancreas may be exposed by penetrating between the duodenum and pancreas after the peritoneum which is reflected over its anterior surface has been incised.

The pancreas has also been exposed through an oblique incision commencing near the tip of the twelfth rib and passing forward toward the umbilicus; or beginning below the tip of the twelfth rib the incision may be carried forward, running below and parallel with the free border of the costal cartilages.

By a Retroperitoneal Method.—The pancreas may be approached through an incision in the lumbar region. The incision is placed along the outer border of the erector spinæ muscle commencing at the twelfth rib and carried downward or downward and outward. This route may be employed for the purpose of evacuating cysts, abscesses, etc., if the head or tail of the organ is the part chiefly affected and if the tumor occupies a position well to one side or the other of the middle line. A cyst, etc., under favorable conditions, may be thus emptied without entering the peritoneal cavity.

Drainage should be provided in all operations where the pancreas is found injured or diseased so as to prevent as far as possible the entrance into the peritoneal cavity of pancreatic juice, etc., in the event of leakage.

For Injuries.—Owing to its protected position, the pancreas is seldom the seat of injury without adjacent important organs being seriously involved. In stab and gunshot wounds of the stomach the pancreas is frequently found injured as well. In severe non-penetrating traumatisms of the abdomen, run-over, kicks, etc., where the pancreas is injured, the intestine, duodenum, is likely to be ruptured. In operations for wounds of the abdominal viscera, especially if the stomach or duodenum is involved, the condition of the pancreas should always be carefully investigated. The pancreas may be reached by entering the lesser peritoneal cavity through an opening which is made for the purpose in the gastro-colic ligament. This is detached for a sufficient extent from the lower border of the stomach.

Wounds of the pancreas are to be closed with deep and superficial sutures of catgut in order to control the hemorrhage and to prevent as far as possible the leakage of pancreatic secretion into the peritoneal cavity. The presence of this material in the peritoneal cavity is capable of setting up a fatal peritonitis and is the cause of the fat necrosis. Owing to the friable nature of the pancreatic tissue, difficulty may be experienced in getting the sutures to hold. If the tail of the pancreas is the part involved the injured portion may be tied off and excised. Proper drainage should be provided in all of these cases. A plug of strip gauze is introduced through the opening in the gastro-colic ligament down to the site of the wound in the pancreas, its free end emerging through the abdominal incision near the umbilicus.

Needless to say, accompanying wounds of the stomach, intestine, spleen, kidneys, etc., should be properly disposed of. The abdomen is wiped dry and the incision closed for part of its length.

For Cysts.—The exact nature of the origin of all pancreatic cysts is not known. A considerable number are, no doubt, caused by occlusion of the larger or smaller ducts by calculi or they may be caused by stenosis of the smaller ducts due to chronic inflammatory processes seated in the pancreas itself or extending from adjacent organs. The cysts usually first make their presence known in the shape of a palpable tumor occupying, as a rule, the upper part of the abdominal cavity.

The abdominal incision is placed above the umbilicus, in the linea alba or to one or the other side of the middle line. When the abdomen is opened the cyst may be found presenting forward through the gastro-hepatic ligament, above the stomach, pushing the stomach down or else—and this is more common—it may present below the stomach, between it and the transverse colon, forcing the stomach upward toward the liver and the transverse colon downward. In still other cases the cyst may dissect its way forward between the layers of the transverse mesocolon pushing the transverse colon in front of it or it may grow downward and forward so as to present below the transverse colon.

The cyst may be emptied and drained or an attempt may be made to extirpate it.

Evacuation and Drainage.—After the cyst has been exposed its contents are evacuated as nearly completely as possible with the trochar, and then it is incised. The edges of the incision are sutured to the peritoneum and deep muscle in the abdominal incision. The abdominal incision is closed for part of its extent with interrupted silk sutures and a large drainage tube surrounded with strip gauze is introduced down into the bottom of the cyst.

Without preliminary evacuation, the cyst may be fixed to the edges of the abdominal incision and opened later, after adhesions have had time to form.

If the cyst is small and cannot be brought up into the abdominal incision a purse-string suture may be applied about the margin of the opening in the cyst and a large rubber tube introduced. The purse-string is drawn tight, thus closing the edges of the opening securely about the tube. The tube may be fixed to the margin of the incision in the cyst with a catgut suture in order to make certain that it will not become displaced. Strip gauze is packed around the drainage tube down to the site of the incision in the cyst. The abdominal incision is closed for part of its extent with interrupted silk sutures.

An additional counter-opening with the object of providing still better drainage may be made in the lumbar region, or after the diagnosis has been made the anterior abdominal incision may be closed and the cyst drained exclusively through a lumbar incision.

In some cases following this plan of treatment a fistula persists for a long time, but, as a rule, it closes ultimately.

Extirpation.—Extirpation of a pancreatic cyst either partial or complete is seldom advisable. The adhesions are frequently found to be very extensive and firm and under such conditions extirpation would be difficult and dangerous.

In some cases the adhesions are of such a character that the tumor can be isolated by blunt dissection, working with the fingers very close to the wall of the cyst and occasionally doubly ligating and dividing bands of adhesions. After the cyst has been entirely separated the pedicle that joins the cyst to the pancreas must be secured. This is ligatured and clamped before it is divided in removing the cyst. In these cases also drainage should be provided.

The abdominal incision is closed in part.

For Acute Pancreatitis.—The process which has been described as acute hemorrhagic pancreatitis is probably caused by a retrograde infection extending along the pancreatic duct either from the duodenum or common bile-duct. Opie says that a small calculus blocking the duodenal orifice of the ampulla of Vater in those cases where the pancreatic duct opens into the ampulla, and not independently upon the wall of the duodenum, may cause the stream of infected bile to be diverted into the pancreatic duct and thus set up just such an infectious inflammatory process. The condition is accompanied by destruction of pancreatic tissue, and as a result the pancreatic juice is able to escape into the substance of the pancreas and into the peritoneal cavity, producing the peculiar phenomena of necrosis of the fatty tissue with which it comes in contact in and about the pancreas and in the omentum, mesentery, subperitoneal connective tissue, etc. This secretion also carries septic agents to the peritoneal cavity and is capable of setting up a peritonitis which is fatal unless it can be controlled by the surgeon. The diagnosis in these cases is usually not made until after the abdomen has been opened.

The incision is best placed in the middle line above the umbilicus. When the abdomen is opened the peritoneal cavity is usually found containing blood-stained, purulent fluid and the omentum, etc., marked by small patches of fat necrosis varying in size from a pin-head to a pea or larger. These appearances are of peculiar significance and should direct the attention of the operator at once to the pancreas. After the abdominal cavity has been wiped dry the lesser peritoneal cavity should be entered. An incision is made for this purpose in the gastro-colic ligament. Occasionally, and especially if the condition has existed for a longer time, the foramen of Winslow will have become occluded and the lesser peritoneal sac will be found converted into a large abscess cavity filled with bloody, purulent fluid.

Instead of proceeding as indicated above, the medium exploratory incision may be closed and the abscess cavity opened and drained through an incision in the left lumbar region; or through an incision that commences in the left lumbar region near the tip of the twelfth rib and which is carried forward parallel with and a short distance away from the free border of the ribs.

In all cases after evacuating the abscess and wiping the cavity dry, drainage should be provided in the shape of a plug of strip gauze. The incision is closed for part of its extent.

For Tumors.—New growths affecting the pancreas primarily are comparatively rare. Carcinoma, adenoma, and sarcoma have been described. Carcinoma usually affects the head of the organ and may cause obstructive jaundice by compressing the common bile-duct. Tumors involving the tail of the pancreas may be treated by resection of the affected portion of the organ. Diseased portions of the pancreas have been resected during the course of operations upon the stomach.

The abdomen is opened through an incision in the middle line and the pancreas reached through an opening in the gastro-hepatic or gastro-colic ligament or transverse mesocolon. Drainage should be provided in all these cases.

THE SPLEEN.

The Surgical Anatomy of the Spleen.—The spleen is a solid organ located in the upper left part of the abdomen in close relation with the fundus of the stomach, to which it is attached by the gastro-splenic ligament (omentum), being suspended from the diaphragm by the phrenico-splenic ligament, its lower end resting upon the phrenico-colic ligament. The spleen is rather ellipsoidal, although its shape may vary. It measures usually about 12 cm. in its long diameter, 8 cm. in breadth, and 3 cm. in thickness. Its size may vary considerably.

Its outer surface is smooth and rounded, and looks outward, upward, and backward toward the diaphragm, which separates it from the pleura and the edge of the lung and the ninth, tenth, and eleventh ribs. Its inner surface consists of two areas: the anterior, the gastric surface, which is the broader, looks inward and forward, and lies close to the posterior surface of the fundus of the stomach; the posterior portion of the inner surface is in contact with the upper and outer part of the left kidney and the tail of the pancreas. Between these two areas the inner surface presents the hilum, where the vessels and nerves pass in and out of the organ.

The lower end of the spleen is in relation with the splenic flexure of the colon, and rests upon the phrenico-colic ligament, which supports it. The anterior border is rather sharp, and marked by a varying number of notches, usually one. Oftentimes when the organ is enlarged the anterior notched edge can be made out by palpation through the abdominal wall. The posterior border is rounded and thick.

The splenic artery is a branch of the cœliac axis, and in its course to the hilum of the spleen runs along the upper border of the pancreas, lying above the splenic vein. The splenic vein is as large around as one's finger—twice as large as the splenic artery. It emerges in several branches from the hilum of the spleen, runs along the upper border of the pancreas, and after receiving the inferior mesenteric vein joins with the superior mesenteric to form the portal vein.

The spleen is almost completely invested by the peritoneum, which is intimately blended with the firm capsule proper of the organ. The spleen is fixed to the stomach by the gastro-splenic ligament (omentum) and to the diaphragm by the phrenico-splenic ligament, the suspensory ligament. Its lower end rests upon the phrenico-colic ligament.

The gastro-splenic ligament, or omentum, is the fold of peritoneum which is reflected from the fundus of the stomach over to the spleen, and between its layers the splenic vessels pass to and from the hilum of the spleen and the vasa brevia to the fundus of the stomach. The phrenico-splenic ligament, or suspensory ligament, is the fold of peritoneum which is reflected from the diaphragm to the spleen.

OPERATIONS UPON THE SPLEEN.

Splenotomy.—Incision of the spleen for the purpose of evacuating and draining an abscess or an hydatid cyst.

The abdominal incision may vary according to the location of the tumor, if one can be made out. A vertical incision through the middle or outer part of the left rectus muscle and extending from the costal cartilages downward for a distance of four or five inches may be employed; or an oblique incision below and parallel with the left costal arch may be made. The operation may be performed in one or two sittings.

In One Sitting.—After the spleen has been exposed, if it is found adherent to the parietal peritoneum it may be incised at once and packed with strip gauze. If the spleen is not adherent to the abdominal parietes it should be drawn into the incision and steadied there while gauze pads are packed into the incision and about the spleen to protect the peritoneal cavity from soiling. Fluid under tension should be drawn off as nearly completely as possible with the aspirator so as to avoid flooding when the organ is incised. The spleen is freely incised and the edges of the opening thus made are sutured to the edges of the abdominal incision. The abscess or cyst cavity is packed with strip gauze and the abdominal incision closed in part.

In Two Sittings.—After the spleen has been exposed as described above it is fixed to the edges of the abdominal incision with several catgut sutures. Each suture pierces the capsule and the substance of the spleen superficially and includes the parietal peritoneum, fascia transversalis and deep muscle layers in the abdominal incision. Strip gauze is packed through the incision down to the surface of the spleen and the abdominal incision closed in part. It is not necessary in all cases to suture the exposed spleen to the edges of the abdominal incision. It suffices for the purpose of inducing adhesion between the spleen and abdominal wall to pack strip gauze down through the incision to the spleen.

After the lapse of two or three days, adhesions having formed between the exposed surface of the spleen and the abdominal wall, the abscess or cyst may be incised and drained.

Splenorrhaphy.—Suturing of wounds, lacerations, of the spleen for the purpose of controlling hemorrhage. Sutures of catgut are used and should take a broad deep bite. They tear through if much tension is made. Hemorrhage from the spleen may be controlled by methods similar to those described for control of hemorrhage from the liver. It would probably be well in some cases of hemorrhage to extirpate the spleen.

Splenopexy.—Fixation of, or anchoring, the spleen. This operation is performed for "wandering" or "floating" spleen. If the "floating" spleen is more than twice the normal size or if diseased it should be extirpated rather than anchored. One method of fixation has been described by Rydygier and another by Bardenheuer.

Rydygier's Method.—The abdomen is opened through an incision in the middle line, commencing near the ensiform cartilage and reaching to or beyond the umbilicus; or an incision may be made through the middle of the left rectus muscle. Corresponding as nearly as possible to the normal position of the spleen, ninth to eleventh ribs, a pocket is formed in the parietal peritoneum by making a transverse, slightly curved incision with the convexity upward in the parietal peritoneum and then tearing the peritoneum loose from the abdominal wall to an extent sufficient to make a pouch that will accommodate the lower half of the spleen. The spleen is placed in the pouch thus formed and secured there by several interrupted sutures that unite the free edge of the peritoneal pouch to the gastro-splenic omentum. In order to prevent further separation of the peritoneum and the spleen from sinking farther into the peritoneal pouch one or two silk sutures are introduced through the parietal peritoneum and the deep abdominal muscles. These sutures are applied from within the abdomen and are placed just below the bottom of the peritoneal pocket. The free, serous surface of the spleen and opposite parietal peritoneum may be vigorously rubbed with a gauze wipe to induce additional adhesions. The abdomen is closed without drainage.

Bardenheuer's Method.—The incision commences near the iliac crest and extends upward in the mid-axillary line almost as far as the tenth rib—about 10 cm. long. From the upper end of this incision a second one is made, about the same length, extending backward along the lower border of the tenth rib. The incision penetrates all the layers of the abdominal wall down to, but not through, the parietal peritoneum. The angular flap thus outlined is reflected downward and the parietal peritoneum, unopened, is exposed. A small incision is made in the peritoneal layer and the spleen secured and drawn out through it edgewise and the edges of the opening in the peritoneum fixed all around to the pedicle of the spleen, gastro-splenic omentum. with interrupted sutures of silk. A silk thread is then passed over the tenth rib and through the lower pole of the spleen, but this is not tied until later. Corresponding to the lower end of the spleen several silk sutures are introduced joining the deep fascia of the reflected abdominal flap to the subperitoneal connective tissue in order to prevent the spleen, later, from sinking further downward between the peritoneum and abdominal wall. The suspensory suture which was thrown over the tenth rib is then tied.

The abdominal flap is replaced and sutured accurately layer by layer with catgut. The suture may be reinforced with a number of interrupted silk sutures that penetrate through the skin, fascia, and divided muscle.

Splenectomy.—Extirpation of the spleen.

The operation is done for wounds, rupture, prolapse; tumors—cystic, hydatid, and solid, sarcoma; wandering spleen if much enlarged or diseased; idiopathic hypertrophy; primary tuberculosis.

Incision must be sufficiently large. It may be placed in the middle line, reaching from near the ensiform process downward to or beyond the umbilicus. As a rule, better access is had through an incision penetrating through the left rectus muscle. It may be necessary, if the spleen is very large, to make an additional transverse cut outward toward the flank or inward through the body of the left rectus muscle toward the middle line. Some surgeons advise an oblique incision passing downward and backward below and parallel with the left costal arch.

After the abdomen has been opened the spleen is sought for and recognized. If adhesions are present these are broken up bluntly with the fingers or if they are thick and vascular they may be ligated doubly and cut. In freeing the spleen the operator must avoid injuring its capsule, otherwise there may be much troublesome hemorrhage.

After the spleen has been separated from adhesions it is drawn well forward into the incision. This effort is resisted by the normal peritoneal folds that connect the spleen with the stomach, gastro-splenic omentum, and, with the diaphragm, phrenico-splenic ligament. The pedicle of the spleen, which consists practically of the gastro-splenic omentum (including the splenic vessels), may be transfixed, through its middle, with a curved, blunt-pointed ligature carrier, provided with a long strand of strong, plain catgut. After this ligature has been placed it is cut so as to make two, and these are then tied, one including the upper half of the pedicle and the other the lower half. The tail of the pancreas should not be included in tying these ligatures. If the phrenico-splenic ligament is not already included in the ligatures placed as described, this structure may now be ligated and in a similar manner. The ligatures are tied very tight and left long to serve as tractors in order to pull the stump of the pedicle into the wound for final inspection after the spleen has been cut away.

The pedicle is cut close to the spleen and the organ removed; the stump of the pedicle may be drawn gently forward and an effort made to isolate and ligate the splenic artery and vein, each separately. If the pedicle is properly secured there is little danger of subsequent hemorrhage. After the spleen has been removed care should be taken to secure any remaining bleeding points.

The incision in the abdomen is closed without drainage, layer by layer.

OPERATIONS UPON THE SPINAL COLUMN.

Laminectomy.—Resection of the laminæ of the vertebræ for the purpose of relieving compression of the cord due to traumatism or disease, depressed or displaced bone, extravasated blood, pus, tuberculous products, Pott's disease, tumors, etc. Tumors may grow from the vertebræ, meninges, or cord proper.

The patient is placed prone upon the table with an inflated rubber cushion under the ribs to give the back a slight curve. The head should be upon a lower level than the part of the back which represents the site of operation. A long incision is made, in the middle line, through the soft parts down to the tips of the spinous processes. The middle of this incision should correspond to the probable location of the injury or disease.

The soft parts—muscles, etc.—upon either side of the middle line are then freely separated with a periosteum elevator so as to expose the laminæ of from three to five vertebræ.

Hemorrhage should be controlled, oozing, by temporary packing with a hot gauze pad, and spurting points by clamps and ligatures. The spinous processes are snipped off at their bases with the cutting bone-forceps, the blades of which may be conveniently bent at an obtuse angle.

While the soft parts, detached muscles, etc., are well retracted, the laminæ, if not already fractured by a traumatism, are divided and then removed.

The laminæ that are to be resected should first be stripped bare of their periosteum and any remaining soft parts with the sharp-edged periosteum elevator, and then divided as close as possible to the transverse processes, first on one side and then on the other. The division of the laminæ may be accomplished with the chisel and mallet or with the rongeur forceps or with the cutting bone-forceps. The laminæ of the vertebra which corresponds to the middle of the wound are resected first and then those of the vertebræ above and below. The laminæ of the first vertebra attacked may be divided with the chisel and mallet. In this way an opening is made into the spinal canal and through it the laminæ above and below can be readily gouged away with the rongeur forceps.

The dura mater proper may be exposed by tearing with a blunt director through the loose connective tissue that overlies it. In thus exposing the dura mater, there may be considerable hemorrhage from the venous plexus that is located in the posterior part of the vetebral canal between the bony wall and the dura, but this is readily controlled by a few minutes' compression with a hot gauze pad. After the spinal canal has been opened the immediate cause of the symptoms may present itself and the condition may be remedied without opening the dura; for example, a dislocated vertebra, tuberculous granulation tissue, extradural tumor, etc. Prominent angular deformity of

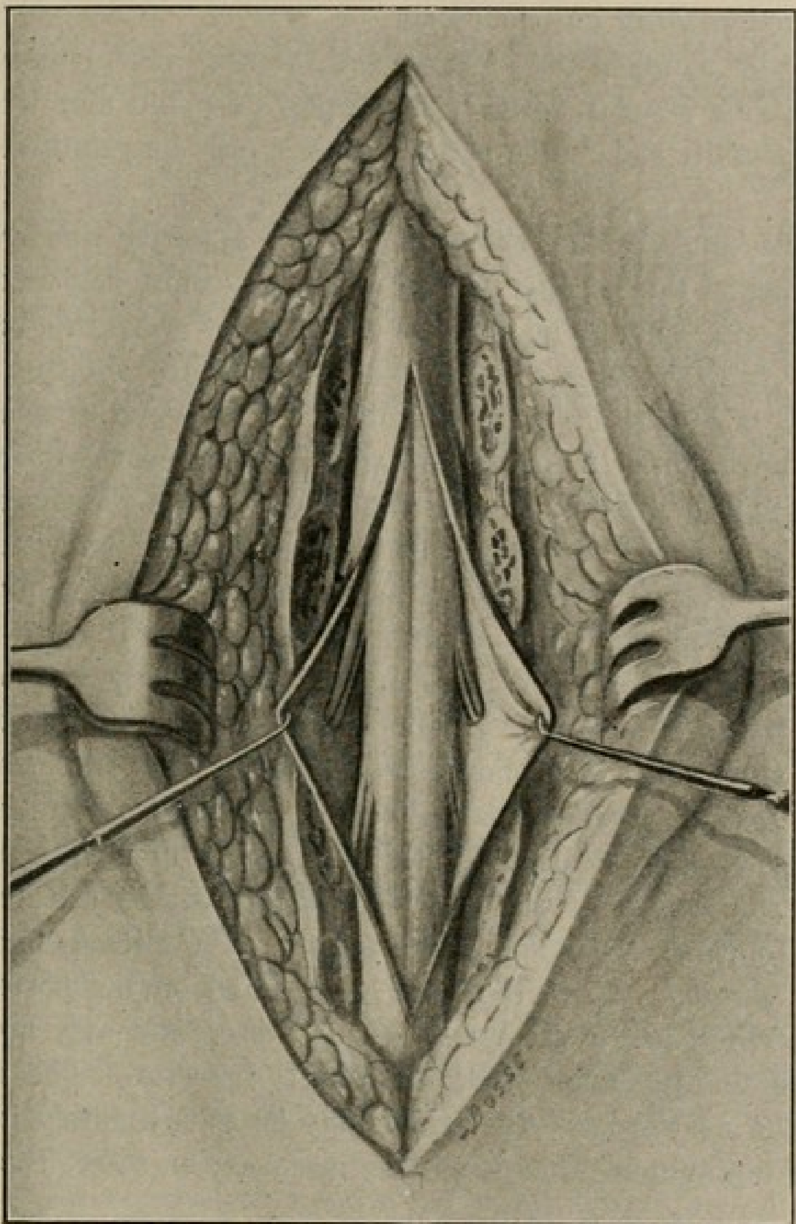

Fig. 241.—Laminectomy. The laminæ have been cut away and the spinal canal opened. The dura mater has been incised, showing the spinal cord and the nerve-roots as they perforate the dura.

the anterior wall of the spinal canal due to fracture, dislocation, Pott's disease, should be corrected by reduction or by chiseling or gouging away the offending process of bone; carious bone may be curetted and sequestra removed and the cavity which remains filled with melted paraffin and iodoform.

In order to reach the anterior wall of the canal, it may be necessary to divide several nerve-trunks upon one side and lift the cord partly out of its bed. The severed nerves may be reunited afterward by suture.

If the cause of the symptoms is not apparent the dura should be laid open. Before opening the dura, its color, degree of bulging, pulsation, etc., should be noted. Bulging of the dura and lack of pulsation indicate pressure, and is a reason for incising the dura. The dura is picked up with a toothed forceps and a small opening made in the middle line, and through this opening the dura is incised upon a grooved director to any requisite length. When the dura is incised there is an escape of cerebro-spinal fluid, and, may be, pus or blood. Precautions should be taken to prevent the cerebro-spinal fluid from escaping in too great quantity. It may be dammed back with a gauze pad. The upper part of the body, the head, should be low. If there are any adhesions present between the dura mater and the arachnoid, they should be gently broken up. The edges of the dura may be then well retracted and the cord carefully examined. A bent probe may be used for the purpose of investigating the sides and anterior aspect of the cord. A tumor within the dura may be exposed to view. Usually of the nature of a glioma, endothelioma, fibroma, gumma. More likely to be situated on the posterior aspect or side of the cord, is frequently encapsulated and may be enucleated by gentle manipulation with the blunt dissector. The tumor may involve the nerve-roots—the latter may be so intimately incorporated with the tumor mass that it will be necessary to resect them with the tumor.

If the symptoms indicate the presence of a tumor and none is found, it is advisable to resect the laminæ of several vertebræ higher up in further search for the cause of the trouble If the tumor is found to be irremovable the posterior nerve-roots may be divided above and below the site of the tumor in order to relieve pain.

In closing the wound the edges of the dura are brought together with interrupted catgut sutures placed about one-eighth inch apart, and the edges of the muscles and skin approximated with interrupted sutures of silkworm gut. For the purpose of drainage, a narrow strip of gauze is introduced into the bottom of the wound, its extremity emerging through the lower end of the skin incision. The wound usually heals by first intention.

The parts may be immobilized, if necessary, by incasing the patient in a plaster-of-Paris jacket or by the use of a proper extension apparatus.

DIVISION OF THE POSTERIOR NERVE-ROOTS, for uncontrollable pain, usually involving the nerves of the upper extremity. Amputation may already have been done for this condition without relief. The posterior nerve-roots may also be divided in cases of inoperable, irremovable tumor of spinal cord in order to afford relief from pain. Laminectomy is done and the dura opened. The posterior nerve-roots are picked up upon a blunt hook in their course from their origin at the side of the cord to the foramina in the dura, through which they escape and are divided or a section may be removed. Owing to the fact that a given area is supplied by fibers derived from different sources—from several segments of the cord—it is necessary to divide, in addition, the roots of one or two nerves above and below the nerve which corresponds directly to the site of pain. The proper nerve-roots may be identified by stimulating the anterior motor roots and observing which muscles respond, etc.

Lumbar Puncture.—J. Leonard Corning, of New York, in 1885 reported experiments of injecting solutions of cocain into the spinal canal through a puncture in the dorsal region for the purpose of inducing analgesia, etc.

Quincke, of Kiel, in 1891, practiced lumbar puncture for the purpose of drawing off fluid to diminish intracranial pressure in cases of hydrocephalus. With this object in view he drew off as much as 100 c.c. in some cases.

Bier in 1889 reported a number of cases which had been operated upon painlessly under the influence of cocain introduced into the subarachnoid space through a lumbar puncture.

Tuffier in 1899 brought the matter prominently before the general profession, and since then the method has been practiced by many operators with much success, especially in cases where the administration of a general anæsthetic would be dangerous. Lumbar puncture is also practiced for the purpose of withdrawing the cerebro-spinal fluid for examination to assist in diagnosing cases of suspected cerebro-spinal and tuberculous meningitis, suspected intracranial hemorrhage, fracture of the base of the skull, etc., and also for the purpose of introducing therapeutic agents, antitoxin in tetanus, etc., into the subarachnoid space. The necessary instruments consist of a needle and syringe. The needle may be made of steel or, better, of iridium-platinum, 9 to 10 cm. long, with a diameter of 1 mm., and provided with a stylet. A needle without a stylet may be used, but this may become plugged. It has the advantage, however, of showing just as soon as it enters the subarachnoid space by the escape of cerebro-spinal fluid. A shorter needle—4 or 5 cm.—may be used for children. A syringe with a capacity of 2 c.c. and capable of being sterilized by boiling—preferably all glass—is employed.

The puncture is usually made between the laminæ of the fourth and fifth lumbar vetebræ or between the third and fourth or the fifth and first sacral. The puncture between the laminæ of the fourth and fifth seems to be preferred by most surgeons.

Krause advises introducing the needle in the middle line, just under the spinous process of the second lumbar vertebra.

The patient should be seated upon the side of the table with his back to the operator, his trunk bent forward, and his elbows resting upon the thighs. The tips of the spinous processes should form a straight line from above downward, deviating neither to the right nor left. It may be necessary to make the puncture with the patient in the recumbent position. Under these circumstances the patient lies upon the side with the body bent and the knees drawn up to the abdomen. The skin is wiped with alcohol and then painted with iodine.

To locate the tip of the spinous process of the fourth lumbar vetebra, which is usually the guide in performing the operation, a line may be drawn across the back from the highest point of one iliac crest to a corresponding point upon the other. The tip of the spinous process of the fourth lumbar will be found to correspond to this line. The patient being bent forward causes the space between the laminæ of the fourth and fifth lumbar vertebræ to become wider. The index finger of the left hand is placed upon the lower part of the tip of the spinous process of the fourth lumbar vertebra, and with the right hand the needle is introduced; it is entered just below and about 1 cm. to the right of this point (tip of the spine of the fourth lumbar). The skin may be anæsthetized and a small incision made with the point of the knife in order to permit the easy passage of the needle through this structure, which is sometimes pretty tough and difficult to penetrate. The needle is then pushed slowly and deliberately forward and inward through the soft parts, entering the spinal canal in the middle line between the laminæ of the fourth and fifth lumbar vertebræ. After the needle has passed through the ligament between the laminæ, ligamentum subflavum, and the dura mater into the subarachnoid space there is felt a sense

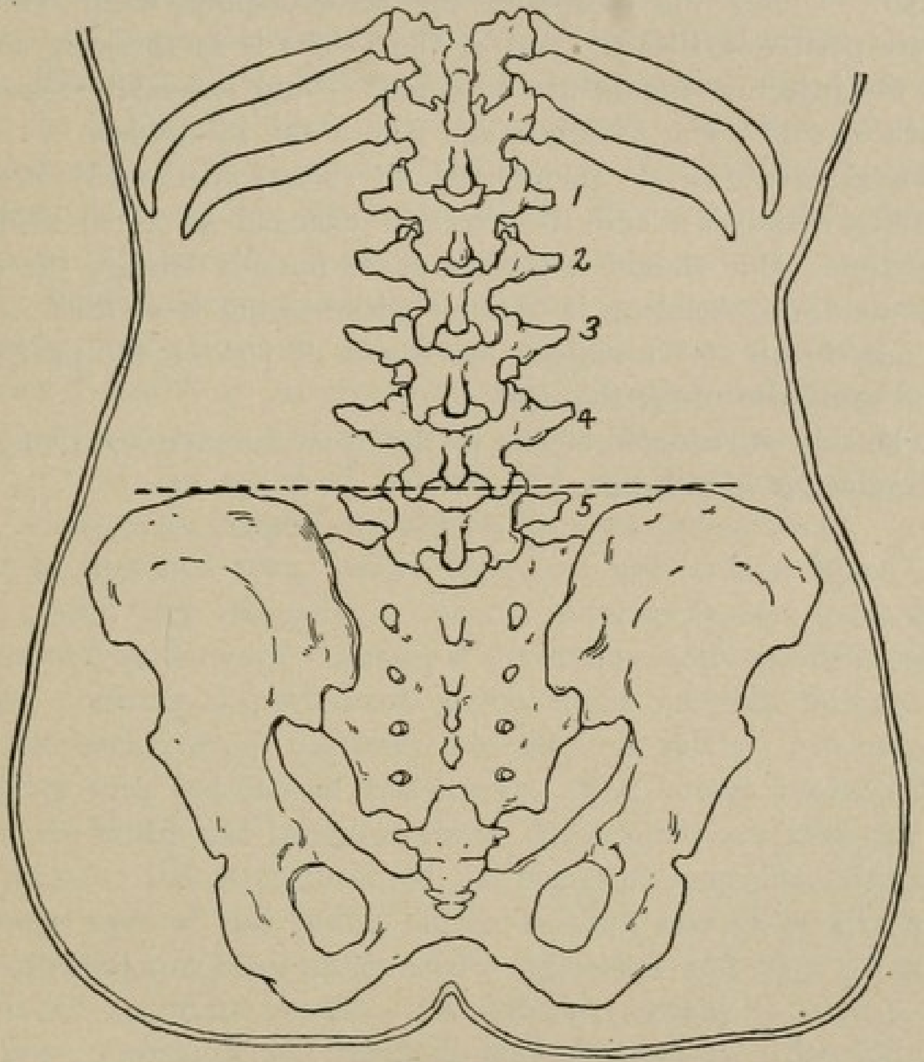

Fig. 242.—Lumbar Puncture. Tip of spinous process of fourth lumbar vertebra corresponds to a line drawn across the back touching the highest point of each iliac crest. The needle is inserted just below and to right of the tip of the spinous process of the fourth lumbar vertebra.

of diminished resistance which is readily appreciated, especially by the experienced. The positive proof that the extremity of the needle is in the subarachnoid space is the escape of the clear cerebro-spinal fluid, which flows from the end of the needle drop by drop when the stylet is withdrawn. Not more than about 5 c.c. of the cerebro-spinal fluid in the child or 10 c.c. in the adult should be withdrawn. If the puncture has been made for diagnostic purposes the fluid is caught, drop by drop, in a sterile glass vessel. Occasionally the pressure of the cerebro-spinal fluid may be so increased that the fluid escapes with considerable force from the needle. If some analgesic solution or antitoxin, etc., is to be introduced, the syringe containing the flud is adjusted to the needle and the contents slowly injected. Unless the escape of the cerebro-spinal fluid occurs to indicate positively that the end of the needle is in the subarachnoid space the injection should not be made. Fluid is usually reached at a depth of 4 to 7 cm. in adults and 2 to 3 cm. in children.

If the needle strikes an impediment (bone) on the way, it should be partly withdrawn and its direction changed so as to avoid the obstruction. One should not attempt to forcibly change the course of the needle by bending it without withdrawing it at least in part, as it may break off; a sudden movement or jerk on the part of the patient may also break the needle.

The skin is rendered sterile in the usual manner, scrubbing, etc., or by painting with iodine.

PART VI.

THE RECTUM.

Surgical Anatomy of the Rectum.—The rectum is the termination of the alimentary canal and is contained within the true pelvis. The true pelvis is bounded in front by the symphysis pubis and by the bodies and rami of the pubic bones. On either side by the body and ramus of the ischium and toward the back by the greater and lesser sacro-sciatic ligaments, which fill in, to a large extent, the space between the ischium and the side of the sacrum and coccyx. Behind the pelvic cavity is bounded by the sacrum and coccyx. The pelvic cavity is much less roomy in males than in females.

THE SACRUM is an irregular, triangular--shaped bone formed by the coalescence of five vertebræ. With the coccyx it forms the lower part of the vertebral column and the posterior wall of the pelvis, where it is wedged in between the ossa innominata.

It is flattened from before backward and curved upon itself, and is placed very obliquely, so that its anterior surface looks downward as well as forward. Above, it articulates with the fifth lumbar vertebra, forming a prominent angle which projects forward and forms the back part of the inlet into the true pelvis. Its lower end articulates with the base of the coccyx. The lateral borders of the sacrum are broad and irregular above, for articulation with the iliac bones and for the attachment of the posterior sacro-iliac ligaments. The lower part of the lateral border is thin, and gives attachment to the greater and lesser sacro-sciatic ligaments and to a portion of the gluteus maximus muscle. Its anterior surface is smooth, concave, looks downward and forward, and presents on either side, one below the other, the four anterior sacral foramina, through which openings the anterior sacral nerves escape from the sacral canal. The branches which emerge from the first, second, and third anterior sacral foramina are large and go to form the sacral plexus. Through the fourth anterior sacral foramina emerge nerves which are distributed to the rectum and the bladder.

The posterior surface of the sacrum is convex, rough, and irregular. In the middle line from above downward are three or four tubercles, which represent the corresponding spinous processes;

usually the fourth and always the fifth are absent. External to the spinous processes, on either side of the middle line, are the four posterior sacral foramina, one below the other. These provide exit to the posterior sacral nerves, which are of no importance surgically. Between the posterior sacral foramina and the spinous processes the bone is smooth, and corresponds to the laminæ of the other vertebræ, forming the posterior wall of the sacral canal; the laminæ of the fourth usually and of the fifth always are absent, thus leaving the sacral canal open at its lower part. The margins of the laminæ below, where the canal is open, are prominent, and are called the cornua. They articulate with the corresponding cornua of the coccyx. The posterior surface of the sacrum is covered by and gives attachment to the erector spinæ muscle.

THE COCCYX is formed of four rudimentary vertebræ, and contains no spinal canal. Below, at the tip, the coccyx is pointed and gives attachment to the sphincter ani. Above, it presents a base with a prominent process on each side, the cornu. Its base articulates with the lower end of the sacrum; its cornua articulate with those of the sacrum. Its lateral border gives attachment to the greater and lesser sacro-sciatic ligaments, to the coccygeus muscle, and low down near its tip to a few fibers of the levator ani muscle.

THE RECTUM is the terminal part of the alimentary canal. It is continuous with the sigmoid flexure (pelvic colon) above and ends below at the anus. The rectum is about eight inches long and consists of two parts: the first, the upper dilated part, *ampulla recti;* the second or lower part, the anal canal, *pars analis recti.*

In the older descriptions the rectum is considered in three parts, an upper, a middle and a lower portion. The upper or first part of the rectum, according to the older descriptions, reaches from the left sacro-iliac synchondrosis to the level of the third sacral vertebra. This part of the bowel is attached by a long mesentery to the back part of the pelvic cavity from the left sacro-iliac synchondrosis to the third sacral vertebra. It consists of a large, redundant loop of gut, and is found loose and freely movable within the pelvic cavity, and presents all the characteristic features of the colon, appendices epiploicæ, longitudinal striæ, sacculations, etc. It is therefore better to consider this portion of the bowel, not as the first part of the rectum, but rather as a part of the sigmoid flexure, or as a separate segment, the pelvic colon. According to this plan the rectum consists of that portion of the bowel only which reaches from the level of the upper border of the third sacral vertebra to the anus, and may be described as consisting of two parts, an upper dilated part, *ampulla recti,* and a lower part, the anal canal, or *pars analis recti.*

THE UPPER PART OF THE RECTUM, the *ampulla recti,* is five or six inches long. It is roomy and dilatable and begins about on a level with the upper border of the third sacral vertebra, and terminates by passing through the pelvic floor (between the levatores ani

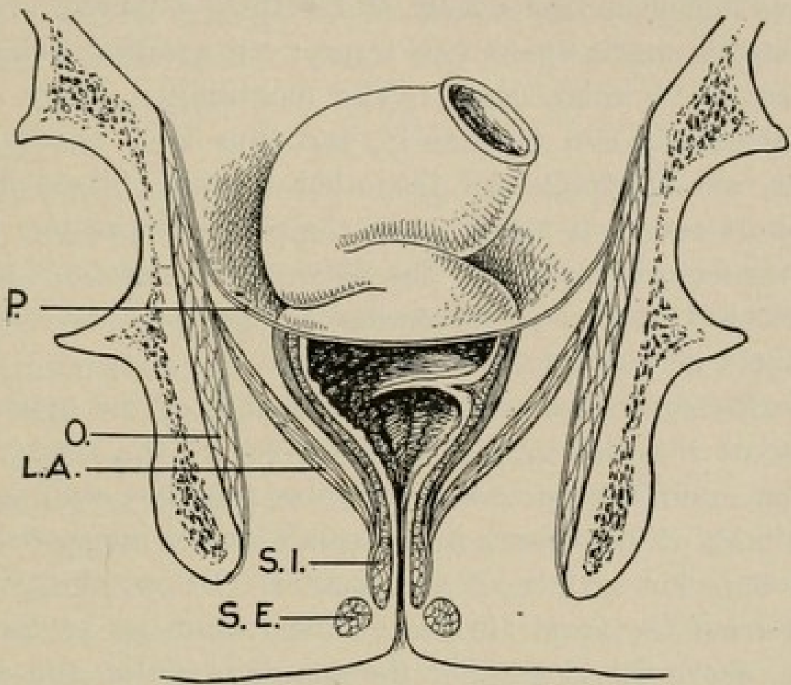

Fig. 243.—The Rectum. The portion below the peritoneal fold is represented as cut in transverse section. The three lateral curves are shown; below, in the cross-section, the lowest of the three valves of Houston. *L.A.*, levator ani, covered upon its upper surface by the pelvic fascia; upon its under surface, by the anal fascia. *O.*, obturator internus covered over by the obturator fascia. *P.*, cut edge of peritoneal fold that is reflected from the anterior wall of the rectum forward on to the posterior wall of the bladder in the male; on to the upper part of the posterior wall of the vagina and the uterus, in the female. *S.E.*, external sphincter ani. *S.I.*, internal sphincter ani. The three layers of the wall of the rectum, the mucous and the circular and longitudinal muscular layers are shown on section.

muscles) opposite the lower border of the prostate (in the male), to become continuous with the anal canal (*pars analis recti*). This part of the rectum presents an antero-posterior curve with its convexity backward corresponding to the hollow of the sacrum and coccyx. It also presents three lateral curves with well-marked indentations. The uppermost curve with its convexity toward the right; the middle curve, the most prominent, with its convexity toward the left, and the lowest, with its convexity to the right and just above the point where this part of the rectum becomes continuous with the anal canal. Corresponding to the concavity of each of these lateral curves the wall of the rectum is sharply indented so that three corresponding crescentic, valve-like shelves are made to present into the lumen of the rectum. These folds are called the *plicæ transversales recti,* or the valves of Houston. They serve to support the weight of the rectal contents.

The wall of the upper part of the rectum is thick and consists of a mucous and submucous layer and a thick muscular coat. The muscular coat is made up of two layers: an external, longitudinal, and an internal, circular, layer. The longitudinal fibers are more numerous anteriorly and posteriorly, and thus form two prominent, thick bands, one in front and the other behind. These bands are relatively short and, as a result, cause the rectum to assume the three lateral curves described above. The fibers of the levatores ani where they are attached to the rectum are interwoven with the longitudinal muscular fibers of the rectal wall.

The peritoneum covers the front and sides of the upper part of this portion of the rectum, but below it covers the anterior aspect only. The rectum has no mesentery. Its posterior wall is in relation with a mass of loose connective tissue which is interposed between it and the anterior surface of the sacrum. Below, the peritoneum is reflected from the front surface of the rectum on to the bladder in the male, above the location of the seminal vesicles, and about one inch above the base of the prostate. In the female the peritoneum is reflected on to the upper one-fourth of the posterior wall of the vagina and thence upward upon the posterior surface of the uterus. It forms the pouch of Douglas, between the front of the rectum and the posterior wall of the vagina. The rectum is in relation posteriorly with the sacrum and coccyx, a considerable mass of loose connective tissue and the lymph-nodes that receive the lymphatics from the rectum intervening. In the space behind the rectum the superior hemorrhoidal artery, the continuation of the inferior mesenteric, decends to supply this part of the rectum, Below, in the male, this part of the rectum is in relation, anteriorly, with the base of the bladder, vasa deferentia, vesiculæ seminales, and the prostate gland. In the female, this part of the rectum is in relation anteriorly with the posterior wall of the vagina.

The Lower Part of the Rectum, the *pars analis recti,* is about one and one-half inches long and reaches from the level where the rectum pierces the muscular pelvic floor (*levatores ani*) to the cutaneous margin of the anal orifice. Corresponding to this part of the rectum the circular muscular fibers are greatly increased in number and form a strong muscular bundle, the internal sphincter. This muscle surrounds the entire length of the anal portion of the rectum.

The Levatores Ani Muscles form the chief part of the floor of the true pelvis. They arise from the inner aspect of the front and side walls of the pelvic cavity. They take their origin anteriorly from the posterior surface of the pubic bone; upon the sides they arise from the fascia that covers the inner surface of the obturator internus muscles, along the "white line," back as far as the spine of the ischium. The fibers of the muscles of both sides pass downward, backward and inward, joining in the middle line to form the muscular floor of the pelvis. Those fibers of the levatores ani that arise from the posterior surface of the pubic bone, and which correspond to the inner edge of each muscle, pass backward and inward, some joining together in front of the rectum, the others being inserted into the sides of the rectum. Those fibers of the levatores ani that arise from the anterior part of the "white line" join together behind the rectum, thus filling in this posterior part of the pelvic floor—from the rectum to the coccyx—and are inserted into the tip and sides of the coccyx. The fibers that arise from the posterior part of the "white line" as far back as the spine of the ischium—are attached to the sides of the coccyx. Those fibers of the levatores ani which are inserted into the sides of the rectum are interwoven with the longitudinal muscular fibers of the rectal wall and below with the fibers of the external sphincter.

The upper surface of the levatores ani is covered over by a layer of fascia which is derived from the pelvic fascia. Where the rectum penetrates between the levatores ani this fascia is reflected upward upon the rectum and thus serves to materially strengthen its wall.

Anteriorly, there is a space between the levatores ani which is filled in by a dense fascia, the posterior or deep layer of the deep perineal fascia or, as it is sometimes called, the triangular ligament. This fascia forms the uro-genital diaphragm—the *trigonum urogenitale*—and is perforated in the male by the urethra, in the female by the urethra and vagina. Farther back the levatores ani are attached to the sides of the rectum, which is gripped tightly between the two muscles at the point where the upper portion of the rectum, *ampulla recti*, penetrates between the muscles to become the anal canal. Posterior to the rectum—between the rectum and coccyx—the muscles join together in the middle line to close in this posterior part of the pelvic floor.

Corresponding to the level where the fibers of the levatores ani are attached to the rectum, at the junction of the upper part and the anal portion, the rectum presents a constricted appearance caused by its being gripped by the levatores ani at this point. The levatores serve to support the rectum by suspending it from the anterior and lateral walls of the true pelvis. The levatores, by their contraction, close the anal canal and lift the rectum and pelvic floor.

In the quiet state the lumen of the anal portion, as a result of the tonic contraction of the levatores ani and the external sphincter, is obliterated, being reduced to a mere slit-like passage. The anal portion of the rectum has a direction from above downward and backward, and forms almost a right angle with the upper portion of the rectum. When the finger is introduced into the anal canal it should, therefore, be in a direction upward and forward.

The lower part of the anal canal is surrounded by a strong bundle of striped muscle fibers, the external sphincter. This muscle arises from the tip of the coccyx and passes forward upon either side of the anal opening to be attached in front to the mid-point of the perineum. This muscle and the levatores ani are both under control of the will. Under ordinary quiet conditions, by their constant contraction, they serve to maintain the anal canal closed.

The anal portion is in relation behind with a wad of connective and muscular tissue that lies between it and the coccyx—the anococcygeal body. Anteriorly, in the male, the anal portion is in relation with the bulb of the urethra. In the female it is in relation, anteriorly, with the perineal body, which intervenes between it and the vagina.

The upper portion of the rectum is voluminous and capable of considerable distention, and is called the ampulla and presents three crescentic folds: *plicæ transversales recti,* valves of Houston. These folds are caused by the indentation of the wall of the rectum, and include both the mucous and circular muscular layers. The most marked and constant of these folds is located about half-way up, upon the right wall—6 to 8 cm. above the anal orifice and about on a level with Douglas's fold. The two others are upon the left wall, not so constant nor so prominent, and are placed one nearer and the other farther away from the anus than the one first mentioned.

These folds may offer considerable obstruction to the passage onward of bougies, etc. They serve to support the weight of the contents of the rectum.

The walls of the anal portion, in the quiet state, are in contact. The lumen is obliterated and upon section appears as a mere antero-posterior slit. The mucous membrane of the anal canal presents a number of longitudinal folds, six to ten, called the columns of Morgagni.

The skin about the anus is thrown into folds, which radiate toward the anus, and often in the form of tags, etc., may become hypertrophied, inflamed, and itch—external, or itching, piles; or a small varicosed vein may rupture into one of them—hemorrhagic pile; or they may present cracks or fissures between them, at the edge of the anus—*fissure in ano.*

THE BLOOD-SUPPLY OF THE RECTUM is derived chiefly from the superior hemorrhoidal artery, which is the continuation of the inferior mesenteric. The inferior mesenteric passes into the pelvis between the two layers of the mesentery of the sigmoid flexure (pelvic colon). As the superior hemorrhoidal it descends behind the rectum. About the middle of the rectum it divides into two lateral hemorrhoidal arteries, which descend upon either side of the rectum, breaking up into a number of branches which anastomose with branches from the middle hemorrhoidal and pierce the wall of the rectum to supply it. The middle hemorrhoidal arteries are given off from the anterior division of the internal iliac and are distributed upon the lateral wall of the rectum. The inferior hemorrhoidal arteries, several on each side, are derived from the internal pubic. They pass inward across the ischio-rectal space, toward the lower end of the rectum and anus to supply these parts. The branches of all three hemorrhoidal arteries anastomose freely with each other, up and down the wall of the rectum.

The veins that drain the rectum originate in a plexus in the submucous layer which presents numerous sac-like dilatations just above the anal orifice. The veins pierce the wall of the rectum to form a plexus upon the external surface of the wall of the rectum—the external hemorrhoidal plexus. This plexus is drained by the superior hemorrhoidal vein which passes upward in the connective-tissue space behind the rectum, in company with the superior hemorrhoidal artery, to become continuous with the inferior mesenteric. The blood carried by the superior hemorrhoidal is therefore discharged into the portal system and must first pass through the liver before it reaches the right side of the heart. The superior hemorrhoidal vein has no valves. The middle and inferior hemorrhoidal veins are formed by branches of the external hemorrhoidal plexus. They empty, the middle hemorrhoidal, into the internal iliac vein, and, the inferior hemorrhoidal, into the internal pudic. The middle and inferior hemorrhoidal veins have valves. The blood carried by these veins finds its way to the heart through the vena cava. The venous plexus situated in the submucous layer, in the lower part of the rectum, just above the external sphincter, is tortuous, and in certain conditions—obstruction of the portal circulation (the superior hemorrhoidal vein has no valves), habitual constipation, pressure of the gravid uterus, etc.—may become enlarged, pouched and varicose, and give rise to the condition known as "bleeding piles," or internal hemorrhoids. Through the veins which drain the rectum infection may be carried to the portal vein, liver—abscess of the liver, etc.

THE LYMPHATICS that drain the rectum—the upper part—originate in the submucous layer and terminate in the lymph-nodes that are situated in the loose connective tissue in the space behind the rectum, between the rectum in front and the sacrum behind, and are continued in a chain upward along the course of the iliac vessels. In the space behind the rectum and along the course of the iliac vessels, especially upon the left side, are the affected lymph-nodes to be sought in cancer of the rectum. The smallest lymphatics originate and ramify in the submucous layer. The disease spreads by permeation of the submucous layer with cancer cells. The wall of the rectum may thus be affected for some distance above the apparent upper limit of the disease; hence the necessity for resecting the rectum several inches, at least two inches, above the apparent limit of the disease.

The lymph-vessels that drain the anal portion of the rectum terminate in the inguinal glands, which therefore become affected early in malignant disease of this part of the rectum.

The left ureter, as it descends into the pelvis, over the bifurcation of the common iliac artery, is in close relation to the inferior mesenteric artery and vein and to the iliac group of glands that are frequently found involved in cancer of the rectum.

The nerves that emerge from the first, second, and third anterior sacral foramina join with each other to form the sacral plexus. The rectum is supplied by nerves that emerge through the fourth anterior sacral foramen. Branches from these nerves are also distributed to the bladder.

OPERATIONS UPON THE ANUS AND RECTUM.

Dilatation of the Sphincter.—This operation is practiced as a curative measure for fissure in ano and as a preliminary step in other operations upon the anus and rectum.

The patient is placed in the lithotomy position. Under anæsthesia two fingers or the thumb of each hand are introduced through the anus and well up into the rectum beyond the level of the internal sphincter, and a gradually increasing steady force is exerted in a lateral direction toward either tuber ischii until the sphincter is

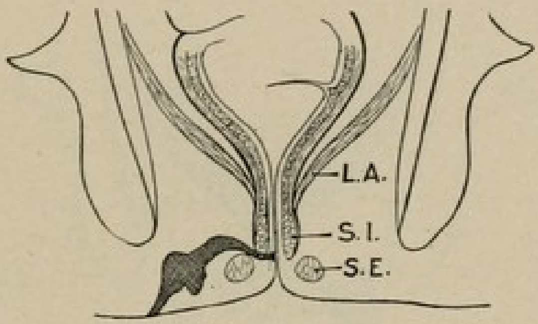

Fig. 244.—Complete Fistula in Ano. *L.A.*, levator ani; *S.E.*, external sphincter; *S.I.*, internal sphincter. Dark portion represents the fistula.

thoroughly relaxed. Considerable force may be employed, but it should be applied gradually, and not abruptly. In cases where the stretching of the sphincter is done for fissure the sphincter is paralyzed and the parts thus placed at rest so that they can heal. Mere stretching of the sphincter will cure many cases of hemorrhoids.

Fistula in Ano.—This may be either complete or incomplete. The incomplete may be either blind external or blind internal.

A complete fistula is a tract, or sinus, which opens internally into the rectum and externally upon the skin near the margin of the anus, and may allow the escape of gas and fæcal material from the bowel.

The opening into the rectum is usually single, but there may be several openings upon the skin about the anus.

If the finger is introduced into the rectum and a probe passed into the fistula through the opening in the skin, its point may be felt beneath the rectal mucous membrane and may be guided through the inner orifice of the fistula into the rectum. This opening will be found a variable distance above the anal orifice and at times may be somewhat difficult to discover; it may be located above the internal sphincter or it may be just above the external sphincter close to the margin of the anus.

An incomplete, or blind, fistula is one which presents an orifice at only one end. If it opens into the rectum, but not externally upon the skin, it is called a blind internal fistula; if it opens externally upon the skin, but not internally into the rectum, it is called a blind external fistula.

Operation for Complete Fistula.—The anus is first thoroughly stretched. The finger is then introduced into the rectum and a blunt-pointed grooved director passed into the fistula through the opening in the skin. The point of the director, which may be

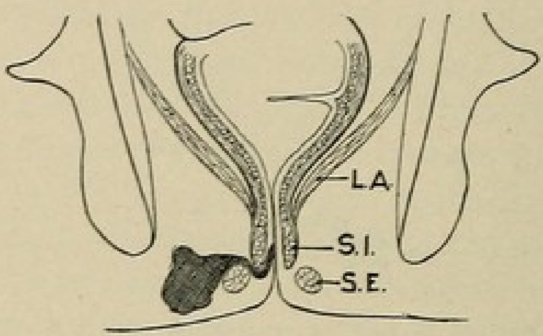

Fig. 245.—Blind Internal Fistula.

recognized by the finger in the rectum beneath the rectal mucous membrane, is guided into the bowel through the internal orifice of the fistula. It is important to find this opening. The end of the director is then brought out through the anus,—the director may be bent somewhat in order to do this,—and the bridge of tissue upon the director is divided with the knife, carried along the groove of the director; the fistula is thus laid open through its whole length into the rectum. If there is more than one external orifice upon the skin, the intervening tissue between the separate openings should be divided. Any secondary sinuses branching off from the main fistulous tract should also be laid open. Methylene blue injected into the fistula may help identify the fistulous tract and its various ramifications.

In searching with the probe for additional fistulous tracts leading off from the main tract, care must be exercised not to make false passages by forcing the probe into the healthy loose tissue adjacent to the fistula. As the internal orifice of the fistula is above the external sphincter or may be above the internal sphincter, these muscles are naturally divided when the fistula is laid open. The tract of the sinus may be curetted after it has been laid open, but too much force should not be used. The whole wound is finally packed with iodoform gauze. This packing should not be too tight, but should reach well to the bottom of the wound in every direction. The bleeding is usually readily controlled by the packing. Any spurting vessels should be clamped and tied.

A dose of castor oil is given in the evening of the third day and the packing removed on the fourth day.

Operation for Incomplete Fistula is practically the same as the foregoing. If there is no opening into the rectum,—a blind external fistula,—the point of the director, which is passed into the

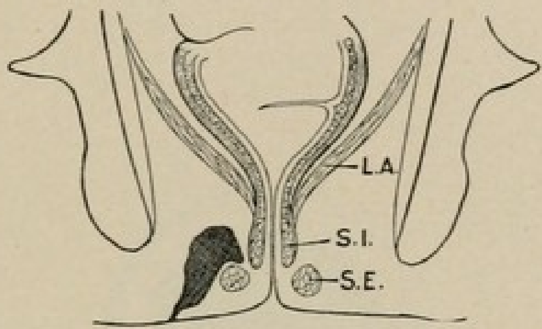

Fig. 246.—Blind External Fistula.

fistula through the external orifice and which is felt beneath the rectal mucous membrane by the finger within the rectum, may be forced into the rectum, the sinus being thus converted into a complete fistula, and the parts then divided as already described.

If there is no external opening,—a blind internal fistula,—we make one. The skin near the margin of the anus, at the point corresponding to the blind external extremity of the fistulous tract, is usually marked by redness, induration, etc. An incision is made through the skin at this point, thus converting the sinus into a complete fistula, which is then treated as described above—the director is introduced through the fistula into the rectum and the entire fistulous tract laid open.

Hemorrhoids.—External, or Itching, Piles present themselves about the margin of the anal orifice outside, external to the sphincter; they consist of cutaneous tags, which may be snipped off with the scissors, the edges of the skin being then, if necessary, brought together with a single suture. Occasionally they contain a varicosed vein which may be thrombosed or ruptured. These piles are often very painful. They may be laid open, the clot turned out, and the edges of the skin brought together with a single catgut suture. Frequently a fissure is located at the base of one of these ex-

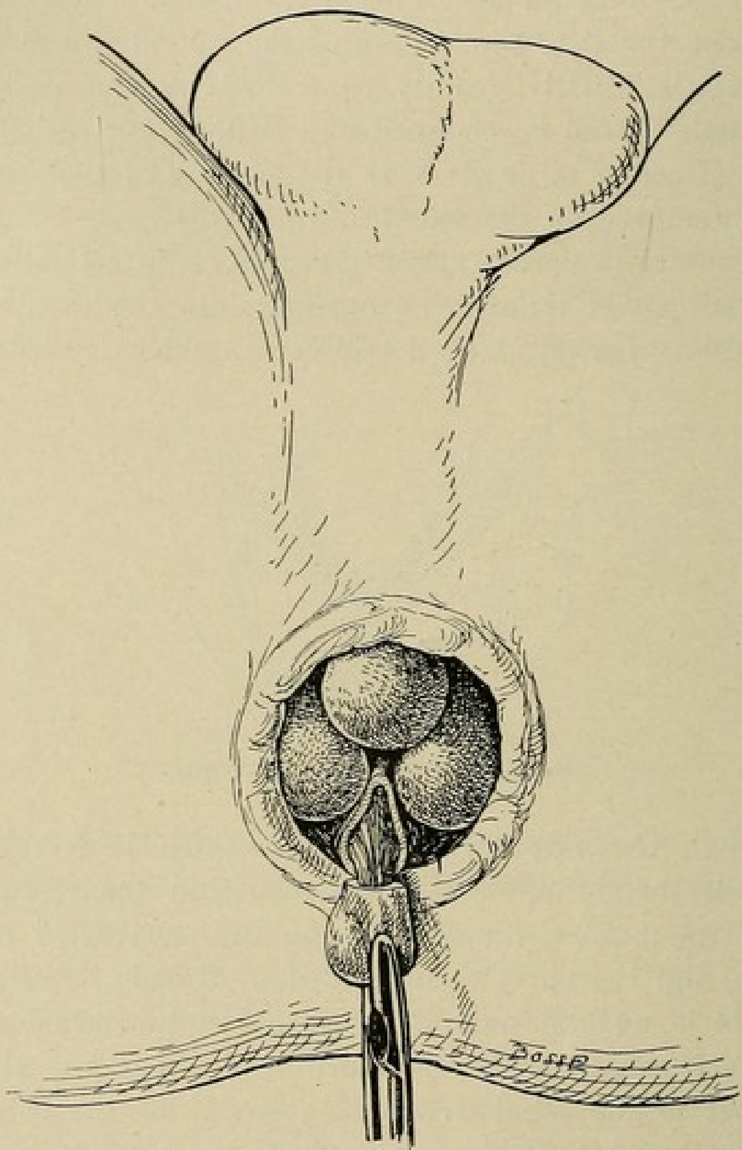

Fig. 247.—Operation for Hemorrhoids. An hemorrhoidal mass is seized with the clamp and a collar cut in its base, all around, through the mucous membrane. The edges of the incision are pushed up and the pile drawn down, so as to obtain a pedicle of some length.

ternal tags, or piles, and it is therefore wise, in all these cases, to stretch the sphincter before removing the pile.

Internal, or Bleeding, Piles.—These are located entirely within the anus, only appearing externally when the patient strains, or bears down. They may be extruded and caught in the grasp of the external sphincter and become strangulated. When the patient strains they may appear as one or more fairly well defined bunches. Each mass consists of one or more arterial twigs and a bunch of dilated, pouched, varicosed veins covered over by mucous membrane which may be normal in appearance or may be more or less ulcerated.

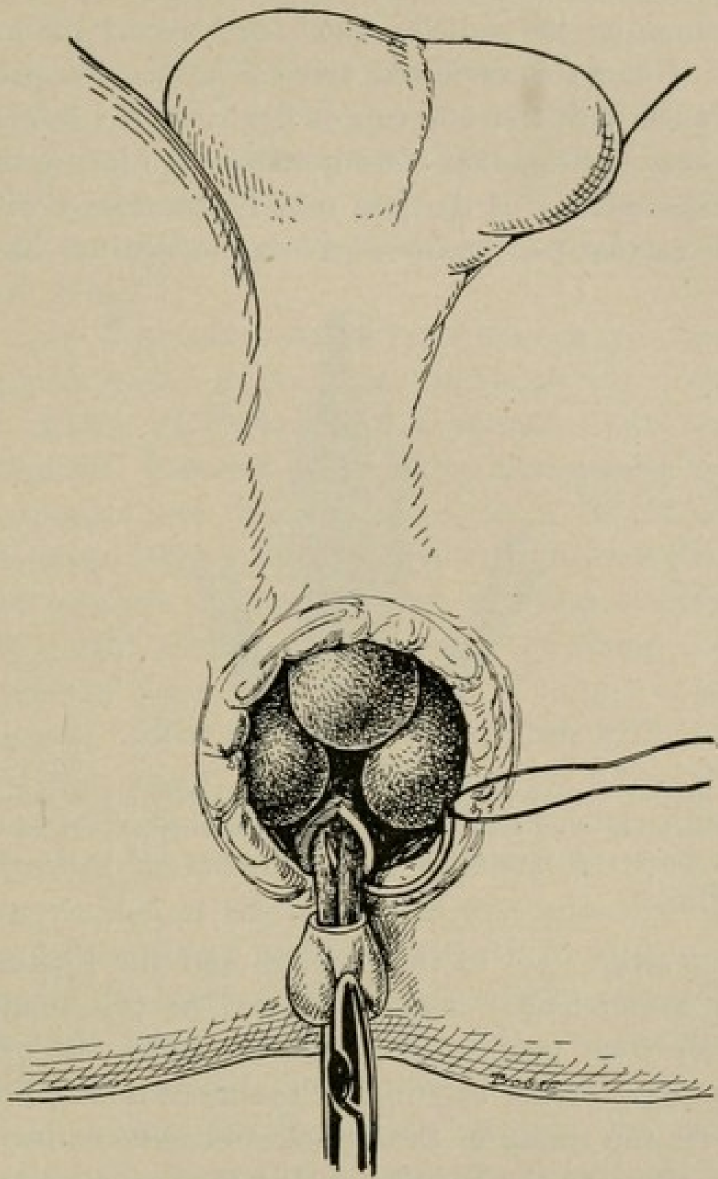

Fig. 248.—Operation for Hemorrhoids. The pedicle is transfixed, high up, with the needle carrying the catgut ligature.

Ligation and Excision.—The sphincter is first stretched and the rectum thoroughly irrigated. Each individual hemorrhoidal mass is then seized with a clamp, an ordinary artery forceps, and while it is pulled down the mucous membrane around its base is cut through by snipping with the blunt-pointed scissors. This incision should extend through the mucous membrane all around the base of the pile into the submucous connective-tissue layer, but should not cut into the vessels that go to form the hemorrhoidal mass. After this the mucous membrane at the base of the pile is peeled back for a considerable distance with the finger-nail or with the end of the blunt-pointed scissors, with the result that the pile, in the grasp of the clamp, hangs by its pedicle, which consists of the arterial twig that supplies it and the varicosed veins. The base or pedicle of the pile is surrounded with a strong catgut ligature (No. 2, plain catgut), which is tied very tight so that it cannot slip. To insure the ligature's not slipping the pedicle of the pile may be transfixed with a curved needle, which carries the ligature. After the ligature has been tied,

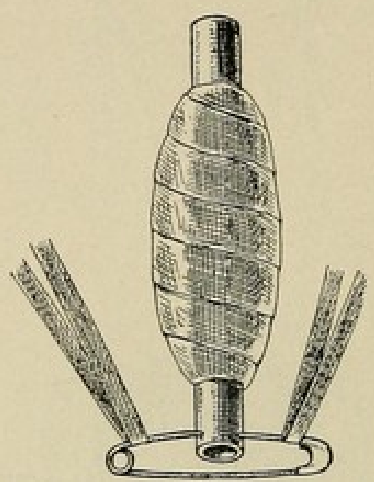

Fig. 249.—Rectal Tube Wrapped with Gauze. A safety-pin is passed through the end of the tube. The tube is prevented from slipping out of the rectum by the tapes which pass through the safety-pin, being tied to the waistband of the T-bandage.

the pile is cut away close to the ligature and the ligature then cut short. Each hemorrhoidal mass is treated in this manner. They usually number from three to five masses. After the pile has been cut away the edges of the opening in the mucous membrane will be seen to fall over the stump of the pedicle and more or less completely bury it. The edges of the opening in the mucous membrane may be brought together over the stump of the pile with one or two sutures of plain catgut. As a rule, however, this is not necessary.

After the operation has been completed a rubber tube, wrapped around with iodoform gauze, is inserted into the rectum. The tube and gauze should reach a point above the level of the site of the operation. The gauze wrapping stops the oozing. A considerable hemorrhage may take place from the slipping of a ligature and a large quantity of blood may escape into the bowel without any appearing externally. If the tube has been inserted and should this accident occur, the blood will escape through the tube and appear externally and give warning. The tube also permits the escape of gas. The gauze may be smeared with sterile vaseline to facilitate its introduction. The tube is prevented from slipping out of the rectum by two bands of tape which are fastened to a safety-pin in the end of the tube and tied to the belt of the T-bandage. The tube is left in place for four days. On the evening of the third or fourth day a dose of castor oil is administered. From the time of operation until the bowels move the diet is restricted to broths, albumin water, etc.; no milk or solids that would leave a considerable residue in the bowel are given.

CLAMP AND CAUTERY.—After the sphincter has been stretched, etc., each pile is seized at its most prominent part with an artery forceps and drawn well down and a special clamp—pile clamp—applied to its base. The end of the clamp as it grasps the pile should be directed upward into the rectum; *i. e.*, it should not grasp the hemorrhoidal mass along a line parallel with the margin of the anus, as this would result in an annular scar, which is not desirable. The pile is firmly caught between the blades of the clamp and completely crushed by turning the screw down tight. The pile is then cut away with the scissors, rather close to, but not flush with, the surface of the blades of the clamp; a small part of the tissue should be left protruding beyond the surface of the clamp after the pile is cut away. The cautery at a red heat is now applied to the cut edge of the remaining portion of the pile which protrudes beyond the surface of the blades of the clamp and this is slowly burned to a crisp down to the surface of the blades. The clamp is then removed. Each pile is treated in this manner. It will be seen, when the operation is completed, that the seared lines corresponding to the several piles that have been burnt off all radiate up into the rectum. They should not join each other to form an annular scar around the anus. The rectum is not tamponed. The introduction of the gauze pack would tend to open the seams made by the cautery and might thus cause bleeding.

Prolapsus Recti.—Lesser degrees of this condition may be corrected by minor procedures; by cauterizing the prolapsed portion—lines made with the actual cautery radiating from the anal margin up into the rectum. Another plan is to resect the prolapsed portion and then suture the end of the rectum to the margin of the anus. If the prolapse is due to the presence of a polyp, hemorrhoids, etc., these conditions should be corrected.

SIGMOIDOPEXY.—This operation which consists in anchoring the sigmoid flexure to the anterior abdominal wall offers a very effectual method of treatment for those cases that resist less radical measures.

An incision about three inches long and corresponding to the middle of the left rectus muscle is made. The incision crosses the line drawn from the anterior superior iliac spine to the umbilicus. The incision penetrates through the skin and fat and through the aponeurosis of the external oblique (anterior layer of the sheath of the rectus), exposing the fibers of the muscle. The fibers of the rectus are split bluntly with the fingers. The transversalis fascia (posterior layer of the sheath of the rectus) is incised. The deep epigastric artery and vein are encountered, passing obliquely across the bottom of the incision. These vessels are drawn to one side or are ligated double and cut between the ligatures. The peritoneal layer is incised. The sigmoid flexure is secured and drawn up into the incision, quite taut, so as to draw up the slack. Care must be exercised not to twist the sigmoid as it is drawn up into the abdominal incision. Four or five sutures of chromic catgut are introduced in the wall of the bowel. These sutures each take several good, broad bites in the wall of the bowel, but they should not penetrate into the lumen of the bowel. The sutures are placed so as to include the strong longitudinal stria, and are placed about one-half inch apart. The ends of the sutures are left quite long. The bowel is then replaced in the abdominal cavity and the ends of the sutures, each threaded in a large, curved needle and carried through the corresponding edges of the peritoneum and transversalis fascia (posterior layer of the sheath of the rectus). The sutures are left untied until they have all been introduced. When the sutures are tied they have the effect of securing the wall of the sigmoid against the peritoneum and at the same time they close the incision by drawing the edges of the peritoneum and transversalis fascia together. The edges of the split rectus are approximated with several sutures of plain catgut. The edges of the aponeurosis of the external oblique are sutured with a continuous suture of chromic catgut and the skin finally closed with an intracuticular suture of plain catgut.

In cases of prolapse of the rectum the mesosigmoid is unusually long. This operation pulls the sigmoid and the rectum up taut and anchors the bowel to the anterior abdominal wall.

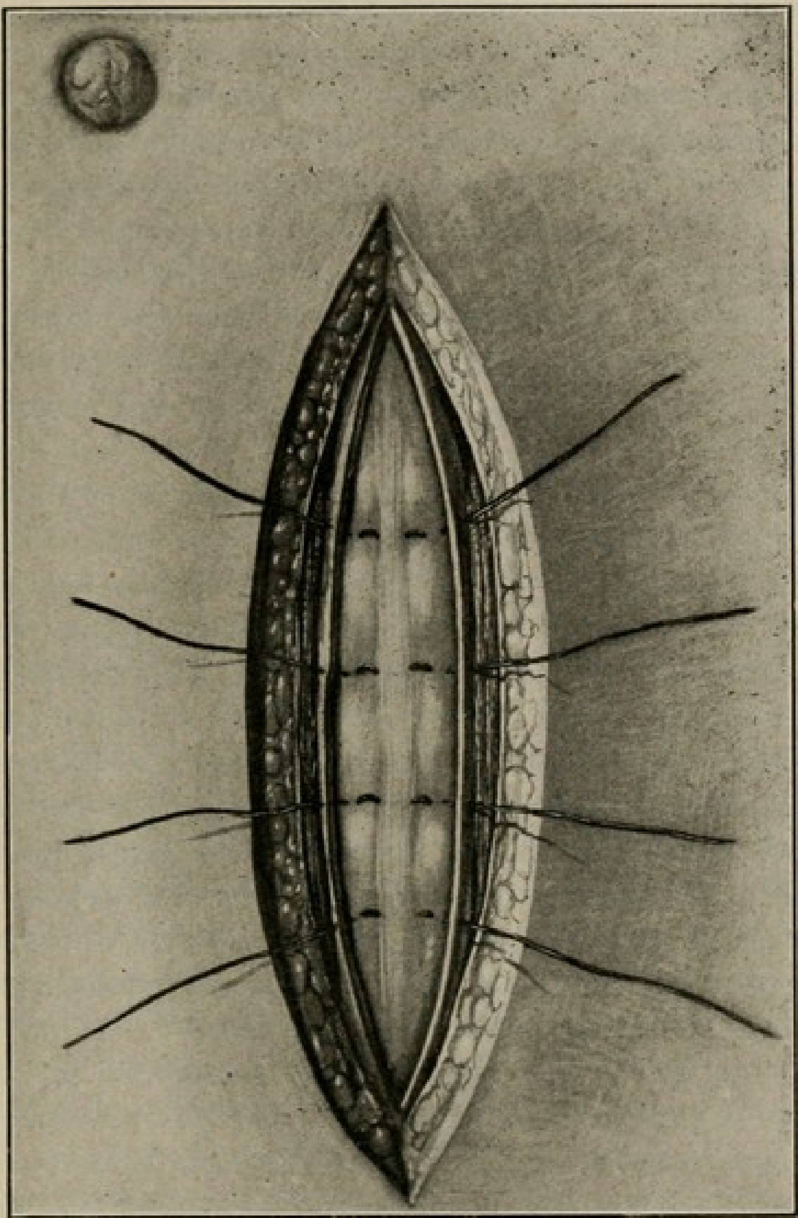

Fig. 250.—Sigmoidopexy. The anchor sutures which secure the wall of the sigmoid have been carried through the edges of the peritoneum and transversalis fascia.

The writer has used this plan in a considerable number of cases of long standing, intractable prolapse, in both children and adults, with uniform satisfactory results, and with no recurrences.

Resection and Amputation of the Rectum.—Resection of the rectum consists in cutting away a portion of the rectal tube in continuity. The operation is usually done for malignant disease; sometimes for syphilitic and tubercular disease, chronic ulceration, stricture, etc., where the disease is limited to the upper part of the rectum (the ampulla part), the anal portion not being involved in the disease. After the diseased part has been resected the upper end of the rectum is brought down and sutured to the lower, anal portion. In this operation the sphincter apparatus is not interfered with. Cases where this procedure (restriction of an annular segment and reunion of the two ends of the rectum) is applicable are of rather rare occurrence.

Amputation of the rectum consists in removal of the lower part of the rectum, including the anal portion, or of the entire rectum. If the entire rectum is excised the operation may be described as extirpation of the rectum or excision of the rectum. Amputation of the rectum is done for carcinoma, extensive ulcerations, stricture.

The upper end of the bowel may be drawn down and sutured to the margin of the skin at the original site of the anus or an artificial anus may be established in the left iliac region. In all cases where it has been possible to preserve the sphincter apparatus, external sphincter muscle, the bowel may be brought down and sutured to the edges of the skin about the anus, with the expectation of obtaining a fairly continent anus. If it has been necessary to sacrifice the sphincter apparatus, however, it will be better to establish an artificial anus in the left iliac region. A controllable artificial anus in this region is infinitely preferable to a fæcal orifice in the original anal region over which there is little or no control.

The various methods of resecting or amputating the rectum, entire or in part, may be considered under three heads: the perineal the sacral, and the combined methods.

A single plan of operating will not apply to all cases. The method must be adapted, and if necessary modified, to meet the requirements of each individual case. The indications call for a plan of operation by which the disease can be completely eradicated and which will provide a controllable anal orifice either in the original site of the anus or in the left iliac region.

In those cases where the tumor is within reach of the examining finger, in the anal region or in the lower part of the first portion (ampulla) of the rectum, the perineal route will be found most convenient for amputation, and the sacral route most convenient for resection and subsequent end-to-end anastomosis. Where the tumor is situated high up, in the upper part of the first portion of the rectum, or where it involves the sigmoid flexure (pelvic colon), the combined method will be found to be the most satisfactory and, furthermore, has the advantage of permitting more accurate examination of the rectum and the adjacent structures; of the lymph-glands behind the rectum, of the liver, etc. In those cases where the anal portion is involved in the disease and the sphincter apparatus must be sacrificed, the combined method of operation with the establishment of an artificial anus in the left iliac region will give the most satisfactory results.

Preparation of the Patient.—It is necessary that the bowels be thoroughly emptied before proceeding with any operation upon the rectum, and this is especially desirable if the operation involves resection or excision of a part or all of the rectum. A period of several days to a week should be devoted to the proper preparation of the patient for the operation. During several days or the week preceding the operation the bowels are thoroughly emptied by repeated doses of cathartics, but during the twenty-four hours immediately prior to the operation no laxatives should be administered. The rectum is irrigated daily with salt solution. The diet during the last day or two before operation should be limited to substances which leave little or no residue in the bowel—eggs, broths, albumin water, etc., but no milk. During the last twenty-four hours preceding the operation repeated doses of bismuth and tincture of opium should be given to set the bowel at rest. One-half hour before operation a hypodermic dose of one-quarter grain of morphine is administered.

If the constriction caused by the growth is so tight that difficulty is experienced in emptying the bowel by laxatives, then it will be necessary to establish an artificial anus, usually in the left iliac region. This should be done one or two weeks before the operation upon the rectum is undertaken. At the same time that the colostomy is made the operator is able to investigate the condition of the rectum through the abdominal incision; whether the rectum is movable or adherent, the presence of affected lymph-glands, secondary deposits in the liver, etc. If it is intended to resect the diseased portion of the rectum and to draw the end of the bowel down and suture it to the anal portion or to the margin of the anus, then the transverse colon should be used for the colostomy because, if the sigmoid is used, it may be difficult or impossible to draw the end of the bowel down at the time of the operation upon the rectum.

After resection or amputation of the rectum the bowels are not permitted to move for five of six days, and during this period the diet is restricted to eggs, broths, albumin water, etc., but no milk, so that there will be little or no solid residue in the bowel. Castor oil given in the evening is a satisfactory laxative when the time comes to move the bowels.

Perineal Method.—Working from the perineum we may resect a part of the rectum and afterward reunite the ends of the bowel,—*resectio recti;* or a part of the rectum or the entire rectum may be amputated,—*amputatio recti,*—and the upper end of the bowel brought down and sutured to the margin of the anus. If it has been possible to preserve the external sphincter we will have more or less complete control of the bowel. If it has been necessary to sacrifice the external sphincter, there will be no control over the bowel, and under these circumstances the fæcal opening will be located in a very inconvenient situation. It would seem to be better, in all cases where it is necessary to sacrifice the sphincter apparatus, to establish an artificial anus in the left iliac region, which will usually be quite continent.

Resection of the Rectum in Continuity (Dieffenbach).—This operation may be performed for excision of cicatricial stricture or for a malignant growth involving a limited part of the wall of the rectum above the anal portion, the lower, anal portion being free from the disease. The diseased part of the rectum is resected in its continuity, an annular segment of the rectum corresponding to the diseased area excised, and the lower end of the upper portion then brought down and sutured to the healthy lower anal part. A great disadvantage in this method of operation is that the work is done from within the rectum, and the wound and often the peritoneal cavity must almost necessarily become infected. It would appear that the sacral method (Kraske) would be the preferable one for resecting a part of the rectum in continuity.

The patient is placed in the lithotomy position with the buttocks raised high upon a sandbag placed underneath them.

The sphincter is thoroughly dilated and the rectum irrigated with salt solution. The anal portion of the rectum is divided by two incisions, one of which, commencing within the anus, passes backward, dividing the anus and the lower part of the rectum as far back as the coccyx. The second incision commences within the anus and passes forward, dividing the anus and the lower part of the rectum as far forward as the bulb of the urethra in the male and the posterior wall of the vagina in the female. Two broad, blunt-pronged retractors are introduced, one on either side, and the wound thus held wide open.

A transverse incision is made in either side of the rectal wall just below the lower limits of the disease. These incisions pass through the entire thickness of the wall of the rectum and divide the lower, healthy anal portion of the rectum from the upper diseased part. A strip of gauze is inserted into the upper diseased part of the rectum to prevent its contents from escaping and soiling the wound. The edge of the upper diseased part of the rectum is loosened all around and secured with a volsella forceps or with several heavy silk sutures which close the end of the bowel and at the same time serve as tractors. The diseased portion of the rectum is detached from the loose connective tissue which surrounds it. Making steady traction, the diseased part of the bowel is drawn down more and more and its separation from the surrounding connective tissue continued until it is entirely free on all sides. We are then able to pull down the end of the bowel and reach well beyond the upper limits of the disease, at least two inches above the upper limits of the disease. The separation of the diseased part of the rectum is accomplished chiefly by blunt dissection with the finger or the end of the blunt-pointed scissors, removing most of the loose tissue behind the rectum at the same time. Vessels are clamped as they are cut during the course of the operation. All vessels that have been clamped are ligated.

In liberating the rectum anteriorly we meet the fold of peritoneum which is reflected downward upon its front aspect. If this is not involved in the disease it can usually be peeled away from the front wall of the rectum with the finger without opening into it. If diseased, or if it cannot be separated from the front wall of the rectum, we may cut through it close to the wall of the rectum, and, introducing the finger into the opening thus made, draw the rectum down. A gauze pad is temporarily introduced to prevent the prolapse of intestine through the opening and to protect the peritoneal cavity.

After the rectum has been drawn down for a sufficient distance the opening in the peritoneum may be closed by suturing its edge with catgut to the peritoneal layer that covers the anterior wall of the rectum or the opening may be left unsutured and a strip of gauze introduced into the pertioneal cavity for the purpose of drainage. The end of the gauze drain is left protruding through the wound in the perineum, in front of the anus. The upper part of the rectum, the part above the disease, should not be separated from its surrounding parts any more than is necessary to permit of its being drawn down to the edge of the lower segment of the bowel without tension, and furthermore one should not work too close to the wall of the rectum, in order not to damage the blood-supply to such a degree that the nutrition of the rectum might be seriously impaired.

After the rectum has been liberated to a point beyond the upper limits of the disease we may proceed to excise the diseased portion. Before doing this two tractors of silk are passed through the whole thickness of the wall of the rectum above the diseased area in order to steady it after the diseased segment has been excised. When this has been accomplished the end of the healthy bowel is sutured to the edge of the lower segment (anal portion). This is done with fine silk sutures which alternately pass through the whole thickness of the bowel and through the mucous membrane only. The edges of the anterior and posterior incisions in the lower segment of the rectum, including the ends of the sphincter, are then brought together in a similiar manner, and thus the continuity of the bowel is restored. The incision in the skin in front of the anus and that behind the anus are only partly closed, and a strip of gauze is packed to the bottom of each incision, as thorough drainage is imperative.

A soft-rubber tube, wrapped around with gauze, is introduced well up into the upper part of the rectum beyond the line of suture. This is to prevent soiling of the suture line and also to allow the passage of gas during the few days immediately following the operation.

If the peritoneal pouch has been opened and packed the end of the gauze strip emerges through the incision in the perineum in front of the anus.

Amputation of the Rectum.—In this operation the anal portion and part or all of the upper part of the rectum are excised. Amputation of the rectum may be accomplished with sacrifice of the entire sphincter apparatus,—Lisfranc's operation; or the external sphincter may be preserved, in which case we have a fairly continent anus.

Lisfranc's Operation.—This operation is adapted to those cases in which the disease has already involved the lower part of the rectum, the anal portion, and where the lower end of the bowel (sphincter) cannot be saved. The operation consists in cutting well beyond the anal margin, removing the anal portion and all the connective tissue in both ischio-rectal fossæ and the rectal tube well up beyond the site of the disease—at least two inches above the apparent upper limit of the disease. The end of the bowel is then brought down and sutured to the margin of the skin about the anus. In this operation the entire sphincter apparatus is sacrificed; hence the result is very unsatisfactory in that there is little or no control over the artificial anus which is established at the site of the original anus.

The patient is placed in the lithotomy position with the buttocks raised high upon a sandbag placed underneath them. The rectum is loosely packed with strip gauze to prevent leakage and to help identify it during the course of the operation. The anus is closed with several silk sutures, which are left long to serve as tractors.

An incision which encircles the anus is made through the skin. This incision is carried down into the loose connective tissue about the lower end of the rectum, and, when this part of the bowel has been liberated all around, it is seized and drawn down. The levatores ani, which are inserted into the sides of the lower part of the rectum, are encountered. The finger is hooked under the levatores and they are divided with the scissors close to the wall of the rectum, and then, gradually working deeper and deeper, the rectum is thoroughly separated all around from the loose connective tissue which surrounds it and is pulled down more and more as this step of the operation progresses. The isolation of the rectum is accomplished chiefly by dissecting with the fingers or with blunt-pointed scissors.

If more space is required, accessory incisions may be added. A posterior incision which reaches from the circular incision that surrounds the anus backward to the tip of the coccyx may be made. This incision may still farther be extended upward upon the back of the coccyx, and, if necessary, this bone may be enucleated, after the soft parts which cover it have been separated with a periosteum elevator. An anterior incision may also be added. This incision passes forward from the circular incision which surrounds the anus, as far as the bulb of the urethra in the male and the posterior wall of the vagina in the female. This anterior incision not only provides more room, but allows the operator to keep himself informed of the location of the urethra and vagina and may thus diminish the liability of injuring these parts.

In isolating the rectum in the female it will be necessary to separate it upon its anterior aspect from the posterior wall of the vagina. The vagina may also be involved in the disease, and it will then be necessary to excise a part of its wall together with the rectum. In the male the rectum has to be separated anteriorly from the deep urethra and the prostate gland and from the base of the bladder.

As we continue with the isolation of the rectum upon its anterior aspect we meet the fold of peritoneum which dips down in front of the rectum: in the female between the rectum and the vagina, in the male between the rectum and the bladder. If this fold of peritoneum is not involved in the disease, it may be peeled away from the front wall of the rectum without opening into it. At times, however, it is opened, either intentionally when it is diseased or accidentally. This is of no special significance, especially if the rectum itself has not been opened. The opening in the peritoneum may be closed by suturing its edge to the peritoneal layer that covers the front wall of the rectum with several catgut stiches; or it may be left unsutured and the peritoneal cavity packed with gauze. In separating the rectum posteriorly there may be considerable hemorrhage. Blood-vessels that pass to and from the rectum and ramify upon the lateral walls of the rectum, branches of the superior and middle hemorrhoidals, must be secured with artery clamps and ligated. Diseased lymph-nodes which are found situated behind the rectum must also be enucleated.

After the rectum has been separated beyond the upper limits of the disease the whole tube is pulled down and the lower diseased portion is amputated, making a straight cut across the bowel. After this has been done the edge of the bowel is sewed to the edges of the skin around the anus with alternating superficial and deep stitches of silk.

If there have been made accessory posterior and anterior incisions, these may be closed with several interrupted sutures. These sutures must not be placed too close together, as there should be sufficient space between the sutures to allow free drainage from the parts about the rectum.

Drainage is made with strips of gauze, which are packed loosely into the incision, both in front and behind the rectum. The strip of gauze behind the rectum should reach well up into the connective-tissue space between the sacrum and rectum.

Amputation of the Rectum With Preservation of the External Sphincter.—This operation is adapted to those cases where the growth is situated in the upper part of the rectum and the anal portion is not involved. If the external sphincter muscle can be preserved we are able to make a new anus which is fairly well under control.

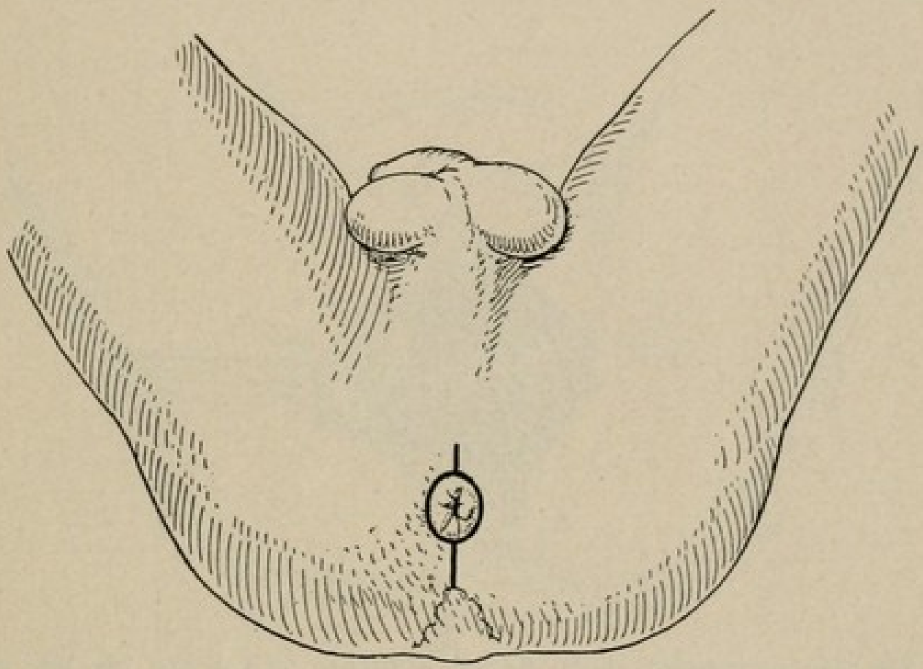

Fig. 251.—Resection of the Rectum (*Quénu*). Shows incision encircling the anus and extending forward into the perineum and backward to the tip of the coccyx. The incision around the anus is made very close to the anal margin in order to preserve the external sphincter.

The patient is placed in the lithotomy position with the buttocks raised high upon a sandbag which is placed under them. The anus is stretched and the rectum irrigated and then packed with strip gauze.

A circular incision is made in the skin entirely around and close to the anus. The lower end of the rectum is dissected loose from within the external sphincter, all around, so that it can be pulled down and out of the anal orifice for a short distance,—about an inch. In this way the external sphincter is left uninjured. The lower end of the rectal tube which has thus been dissected loose from within the anal margin is closed with several silk sutures which are left long to serve as tractors. Gloves which have been used for this part of the operation are discarded. The parts about the anus are again thoroughly cleansed and the operator proceeds to resect the rectum as a closed tube.

An incision is made from the anterior part of the incision that encircles the anus, forward, through the anterior part of the external sphincter as far as the bulb of the urethra and another incision backward through the posterior end of the external sphincter, in the middle line, as far as the tip of the coccyx, and then continued farther backward upon the coccyx to the base of this bone. The coccyx is

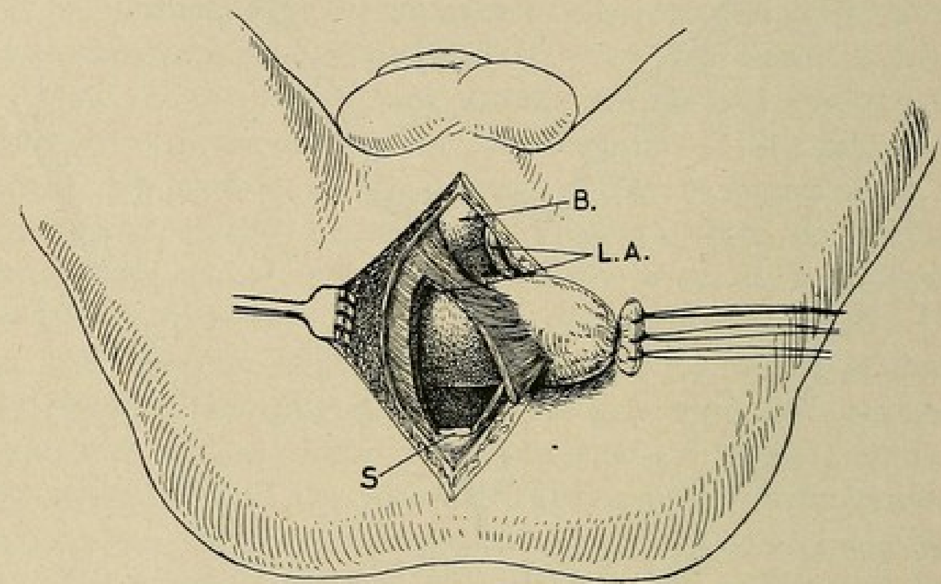

Fig. 252.—Amputation of the Rectum (*Quénu*). The coccyx has been enucleated and the rectum detached and pulled over toward the left. The right levator ani has been partly cut through. The bulb of the urethra is exposed in the anterior part of the incision. *B.*, bulb of the urethra; *L.A.*, the levatores ani muscles; *S.*, lower edge of sacrum; the coccyx has been enucleated.

enucleated after detaching the soft parts with the periosteum elevator. The external sphincter is thus divided into its two halves and left, one-half in each edge of the skin incision. The space behind the rectum is entered and the rectum and the loose connective tissue, lymph-nodes, etc., that lie behind it all detached in one mass from the front of the sacrum; the levatore ani of either side is hooked down with the finger and divided with the scissors. The rectum is separated, anteriorly, from the deep urethra, prostate gland, seminal vesicles, base of bladder in the male, and from the posterior wall of the vagina in the female. In the male a catheter in the urethra will indicate the position of the urethra and protect it from injury.

After the levatores ani have been cut and the rectum separated anteriorly it may be drawn down sufficiently to show the peritoneal fold which is reflected upon its front surface. This fold is incised close to the wall of the rectum, first around one side and then around the other. The peritoneal cavity which has been thus opened is packed temporarily with gauze. The rectum may be drawn down out of the incision for a distance of four or five inches. The effort to pull the rectum down still farther out of the incision is resisted by the folds of peritoneum that pass from the upper part of the rectum back to the sacrum, and which correspond to the folds of

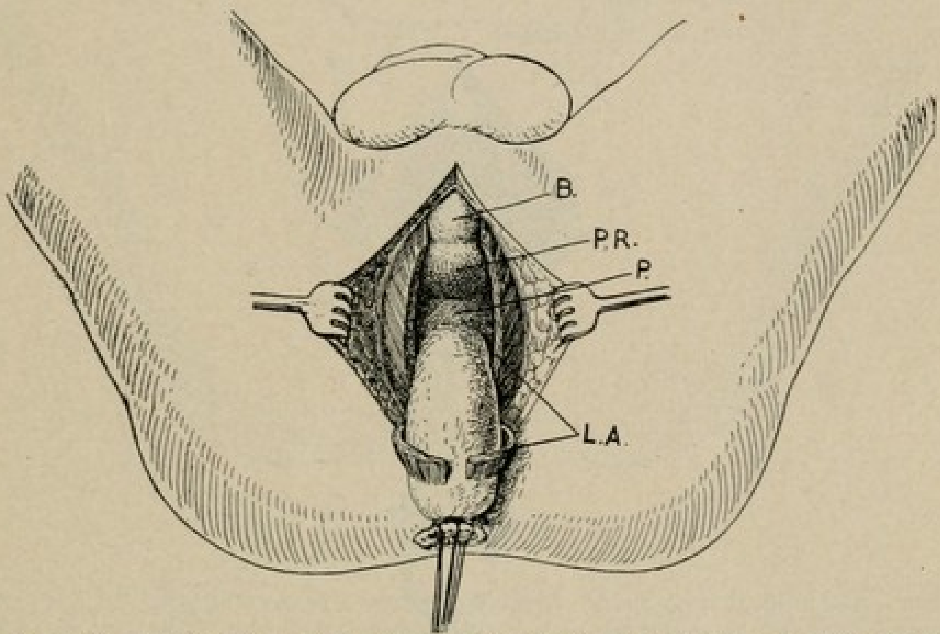

Fig. 253.—Amputation of the Rectum (*Quénu*). The levatores ani have been divided and the rectum drawn down still farther out of the incision. The bulb of the urethra, the posterior surface of the prostate and the recto-vesical fold of peritoneum are exposed. *B.*, bulb of the urethra; *L.A.*, levator ani muscle; *P.*, recto-vesical fold of peritoneum; *PR.*, prostate gland.

peritoneum that form the mesosigmoid (pelvic colon). The superior hemorrhoidal artery descends between these folds to reach the rectum. A clamp is applied to the peritoneal fold, close up to the sacrum, and the fold divided in front of the clamp, between the clamp and the rectum. The clamp has the superior hemorrhoidal vessels in its grasp. The rectum may now be pulled down freely out of the incision. The rectum is drawn out until a portion of the sigmoid flexure, well above the disease, can be brought down into the anal margin without tension. Occasionally the mesosigmoid is quite short and resists the effort to pull down the end of the bowel, and it may then be necessary to still further clamp and divide the mesosigmoid before the desired part of the rectum can be brought down without tension. In making the additional incision into the mesosigmoid the cut should be made as close as possible to its root (line of attachment to the sacrum) in order to avoid injuring the terminal branches of the sigmoid arteries which are necessary for the supply of the bowel.

All vessels that have been clamped are ligated and the edge of the peritoneal fold which was cut away from the front of the rectum

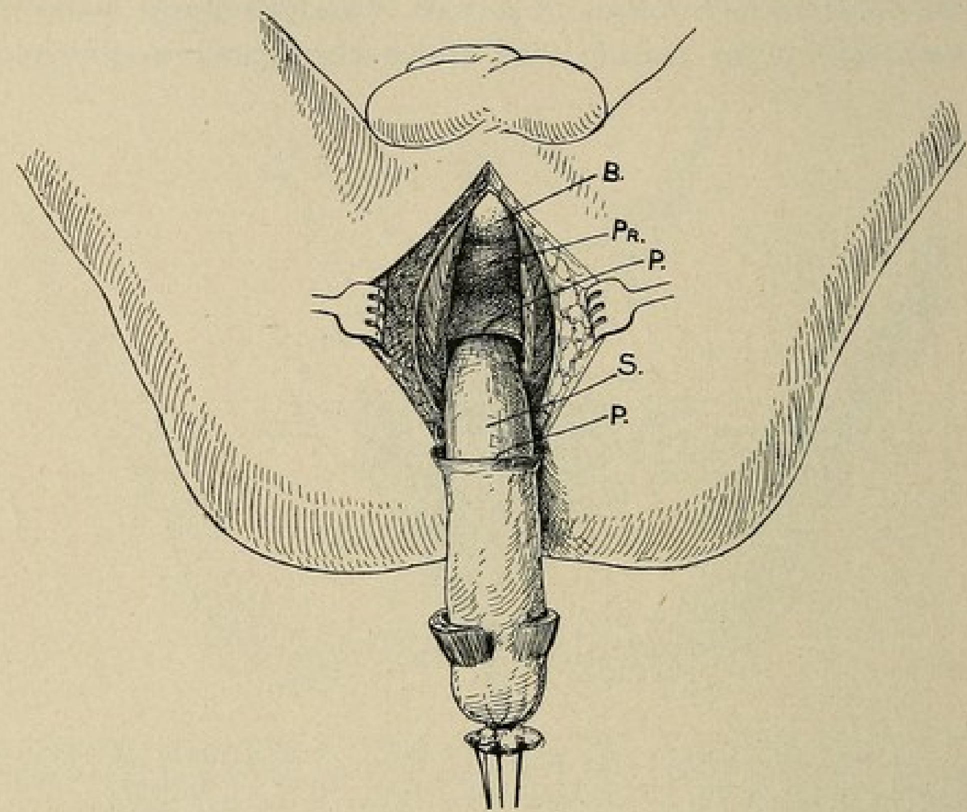

Fig. 254.—Amputation of the Rectum (*Quénu*). The recto-vesical fold of peritoneum has been incised and the bowel drawn down, far out of the incision, so that the sigmoid flexure presents in the incision. *B.*, bulb of the urethra; *P.P.*, edges of the recto-vesical fold of peritoneum; *PR.*, prostate gland; *S.*, sigmoid flexure.

is sutured with plain catgut stitches to the front and sides of the bowel—sigmoid flexure, thus closing the peritoneal cavity. The incisions in the perineum are closed with interrupted silk stitches and the anterior and posterior ends of the external sphincter carefully and accurately sutured together. The lower, diseased part of the bowel is amputated, and the end of the sigmoid sutured to the edges of the anal margin, all around, with silk sutures placed quite close together, spaces of one-half inch between them.

A rubber tube wrapped around with gauze is introduced into the rectum to permit the escape of gas, etc. A gauze strip is packed into the posterior part of the perineal incision, behind the anal opening, and reaching well up into the space between the rectum in front and the sacrum behind, in order to insure good drainage of this space. A second drainage strip is inserted into the anterior part of the incision, in front of the anus.

Vaginal Method.—Access to the rectum may be obtained through an incision in the posterior wall of the vagina. After the rectum has been exposed it is detached in the manner described in the preceding operations,—"perineal method." After the rectum has

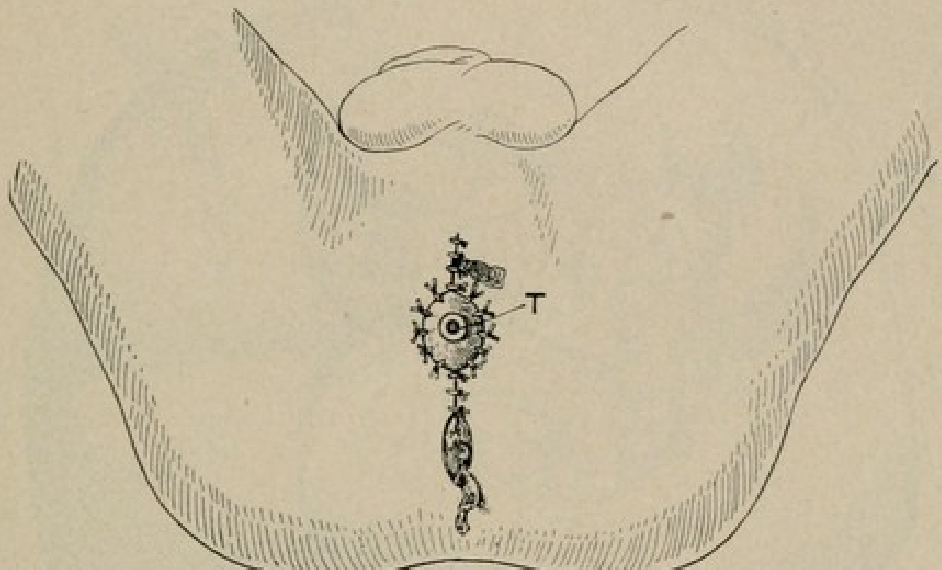

Fig. 255.—Amputation of the Rectum (*Quénu*). The rectum has been amputated and the lower edge of the sigmoid sutured to the edges of the anal incision. Gauze drains emerge from the incisions in front of and behind the anus. *T*, a rubber tube wrapped around with gauze, which is introduced into the rectum to permit the escape of gas, etc.

been resected or amputated the incision in the vaginal wall is closed by suture.

Sacral Route (Kraske).—The rectum is approached through an incision in the sacro-coccygeal region after the coccyx and usually a portion of the sacrum have been removed. This plan of operation is well adapted to resection of a portion of the rectum, where the disease is limited to the upper part of the rectum and the anal portion is healthy. It affords good access to the upper diseased part of the bowel. Through this route the diseased portion may be resected and the upper end of the bowel brought down and sutured to the lower, anal, end; or the rectum, including the anal portion, may be amputated and an artificial anus established in the upper corner of the incision. The perineal or the combined method will be found more satisfactory, however, in those cases where amputation, rather than resection, of the rectum is to be performed.

Resection of the Rectum in Continuity.—The operation is adapted to these cases where the disease is limited to a circumscribed part of the bowel and the anal portion is not involved.

The operation is described in three steps:—

1. Sacral "Vor operation": resection of the coccyx and part of the sacrum.

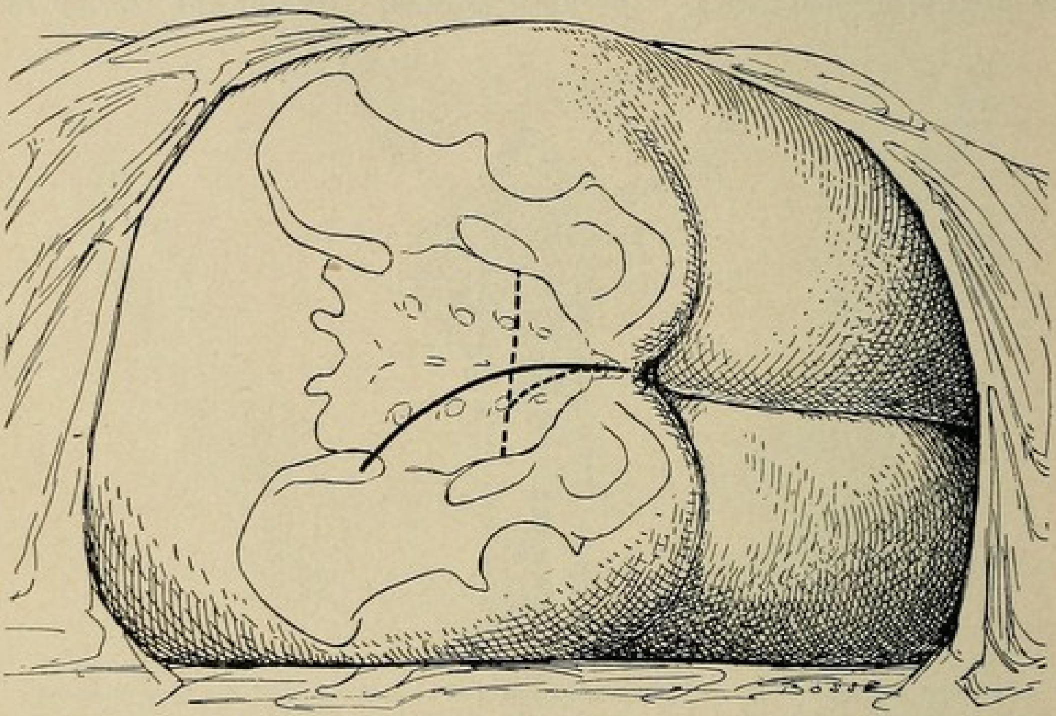

Fig. 256.—Resection of the Rectum (*Kraske*). The patient lies upon the left side. The incision is indicated by the solid line. It reaches from the posterior inferior iliac spine to the tip of the coccyx. The coccyx is enucleated and the lower portion of the sacrum resected as indicated by the dotted lines according to the amount of space required.

2. Resection of the diseased portion of the bowel.

3. Apposition of the ends of the bowel and treatment of the incision, etc.

Sacral "Vor Operation."—The patient lies upon the left side (Hochenegg), with the belly inclined somewhat toward the table, the lower limbs strongly flexed at the knees and hips and supported thus by an assistant; or he may lie upon the abdomen with the pelvis raised high upon a sandbag placed underneath.

A slightly curved incision with the concavity toward the left is made. The incision begins upon a level with the posterior inferior iliac spine, about level with the middle of the sacrum and about two inches to the left of the middle line. It is carried down to the middle of the upper border of the coccyx, and from this point it is continued down in the middle line upon the coccyx, ending at its tip. This incision divides the skin, subcutaneous fat, and superficial fascia, and exposes in the upper part of the wound the lower portion of the gluteus maximus muscle, the fibers of which run at right angles to the line of the incision. That part of the gluteus maximus which presents itself in the wound is incised and retracted when the line of attachment of the greater and lesser sacro-sciatic ligaments to the

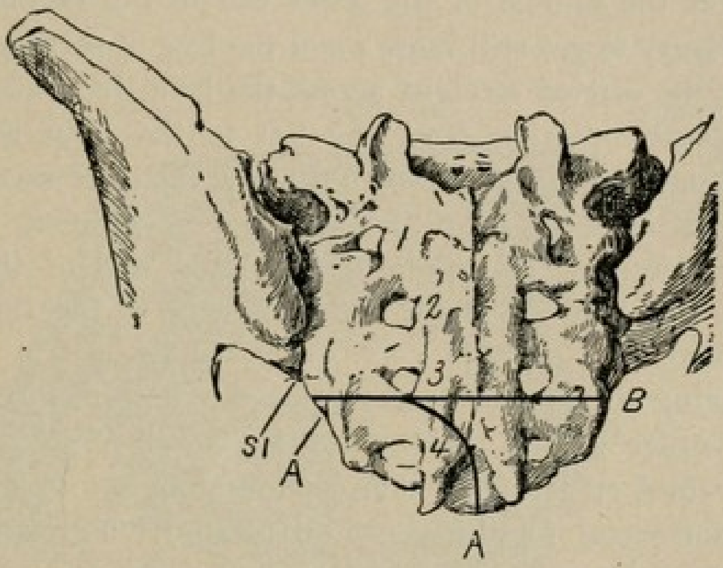

Fig. 257.—Back Part of Ilium and Sacrum. Coccyx removed. *A*, *A*, usual line of section through sacrum; *A*, *B*, line of section to remove all of lower part of sacrum; *SI*, lower end of sacro-iliac articulation; 1, 2, 3, 4, posterior sacral foramina.

sacrum is exposed. These structures are also divided close to the edge of the sacrum.

Penetrating through the fat in the ischio-rectal fossa the coccygeus which is attached to the border of the coccyx and sacrum, and the levator ani which is attached to the coccyx near its tip, are exposed. These muscles are covered over by a thin fascia—the anal; they are divided with the knife close to the edge of the sacrum and coccyx. The soft parts are separated with a periosteum elevator from the posterior surface of the coccyx and the bone then seized with the bone forceps and extirpated. The sphincter ani is cut away from the tip of the coccyx close to the bone. If the arteria sacra media, which decends in front of the sacrum, is injured, it may be clamped and tied.

The levator ani and coccygeus muscles having been already divided, the operator penetrates through the loose, fatty tissue which lies behind the rectum with the fingers so as to expose the posterior surface of the rectum. If this space is not sufficiently wide after extirpation of the coccyx it will be necessary to resect a portion of the sacrum. This is done with the chisel and mallet. The soft parts are separated from the lower part of the sacrum with the periosteum elevator, and that portion of the sacrum is resected which lies below a curved line that commences at the left border of the bone, just below the level of the third posterior sacral foramen, and which terminates at the middle of the lower end of the sacrum.

If necessary to get still more room the line of section through the sacrum may be carried straight across the bone just below the third posterior sacral foramina from the left to the right border of the bone, thus removing all of the sacrum below the third sacral foramina. The guide to the location of the third sacral foramen is the lower end of the sacro-iliac articulation. The lower end of the sacro-iliac articulation lies just above the lower margin of the third posterior sacral foramen.

In making the resection of the sacrum it is unwise to go above the lower border of the third posterior sacral foramen on account of the important structures which emerge from the first, second, and third anterior sacral foramina (sacral plexus). Through the fourth anterior sacral foramen branches emerge which are distributed to the bladder and the rectum. If these branches are damaged some disturbance of the function of these organs will follow, but this is only temporary, control being rapidly regained. If the left half only of the lower portion of the sacrum is removed, this disturbance will be much less marked.

Resection of the Diseased Portion of the Rectum.—The diseased part of the rectum is freed upon its posterior aspect and upon the sides from the loose fat and connective tissue that surround it. It is then separated upon its anterior aspect. All blood-vessels are clamped and ligated as they are cut. The separation of the rectum is accomplished with the finger, and care must be taken not to open into the bowel. When the diseased part of the rectum has been freed all around, a heavy silk ligature is tied tightly around it just below the lower limits of the disease, and the lower part of the bowel is again irrigated and packed with strip gauze through the anus. The bowel is then divided below the ligature, thus cutting the diseased part away from the lower, healthy anal portion. The wound is not soiled, because the diseased segment is shut off by the ligature which has been applied about it, and the lower anal segment, besides having been thoroughly irrigated, is packed with gauze.

The diseased portion of the gut is now seized, and, while traction is made, it is gradually dissected out of its bed of fat and connective tissue, being thoroughly isolated upon all sides, so that it

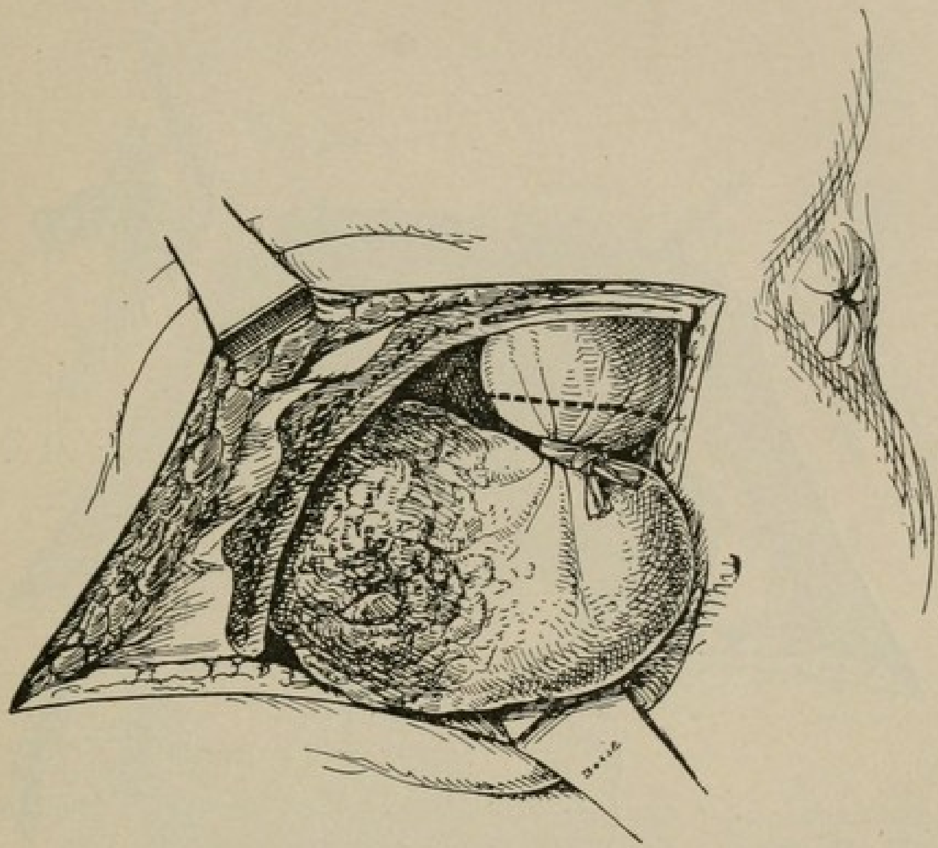

Fig. 258.—Resection of the Rectum (*Kraske*). The lower part of the rectum is loosened all around and drawn out of the incision. A ligature is thrown around the rectum below the location of the disease and the bowel divided below the ligature as indicated by the dotted line.

can be pulled down as far as may be necessary. The detachment of the bowel is accomplished largely by blunt dissection with the fingers.

In freeing the rectum upon its anterior aspect, the pouch of peritoneum which dips down upon its front wall, between it and the uterus and vagina in the female and the bladder in the male is encountered. It may be necessary to open the pouch, and, indeed, this is probably desirable in all cases, since the bowel can then be brought down with much more ease. After the opening has been made in the peritoneal pouch it may be enlarged by cutting with the scissors, upon either side, close to the wall of the rectum.

Through the opening which is thus made two fingers are introduced and the bowel pulled down. After the bowel has been pulled down as far as necessary the edge of the opening in the peritoneum may be sewed to the peritoneal layer of the sigmoid flexure with plain catgut suture, thus closing off the peritoneal cavity; or else the peritoneal pouch may be left open and packed with gauze. If the peritoneal

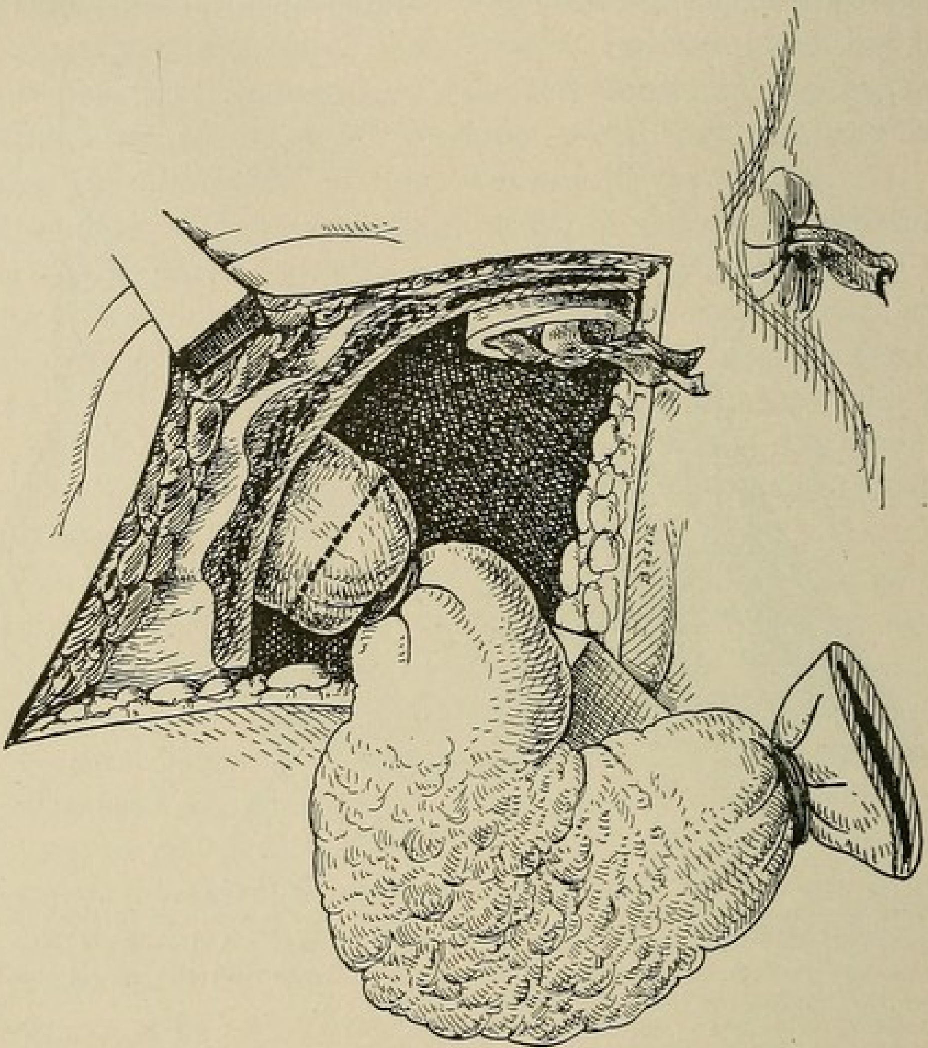

Fig. 259.—Resection of the Rectum (*Kraske*). The rectum has been extensively detached and drawn out of the incision and ligated well above the upper limits of the disease. It is divided above the ligature as indicated by the dotted line. The lower, anal portion is packed with iodoform gauze.

fold is involved in the disease it may be already obliterated by its opposing surfaces having become agglutinated, or the growth may have extended still farther so as to involve the uterus or bladder. This will add to the difficulty of the operation; but some surgeons do not consider it a counter-indication to the continuance of the operation, because, if necessary, the parts of these organs that are involved may be resected. If the peritoneal fold is not involved in the disease it can usually be peeled away from the front wall of the rectum with the finger, and in this case the operation may be completed without opening into the peritoneal cavity.

Diseased lymph-nodes located behind the rectum, between it and the sacrum, should also be enucleated. There may be considerable bleeding caused by separating the rectum upon its posterior aspect

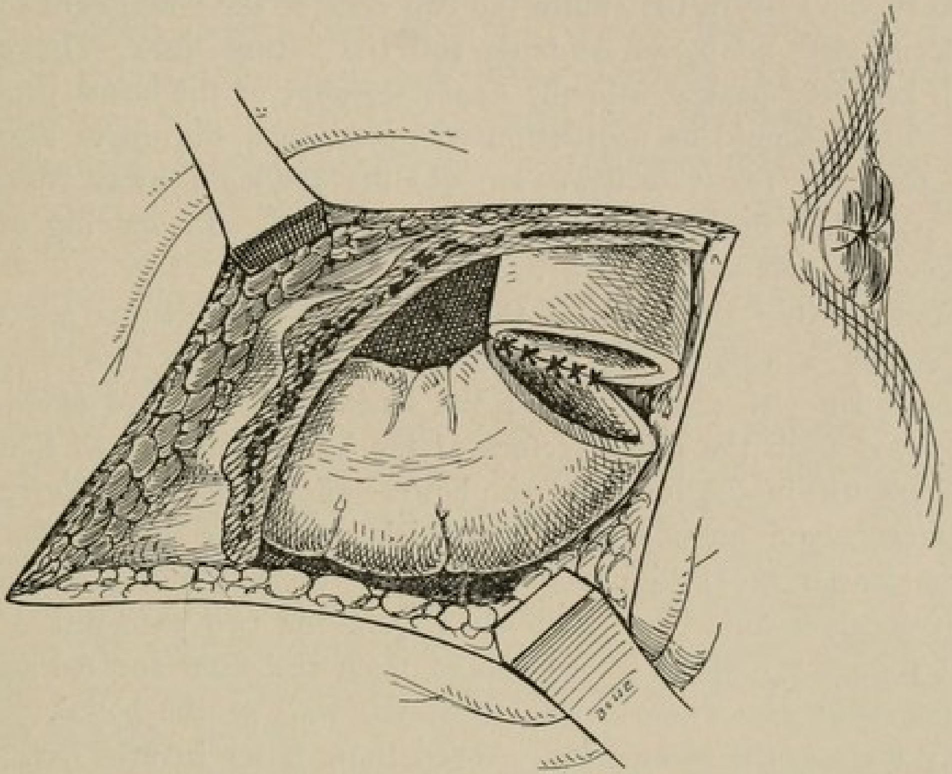

Fig. 260.—Resection of the Rectum (*Kraske*). The upper end of the bowel is brought down and united by interrupted sutures to the lower, anal end.

and sides from branches of the superior hemorrhoidal; they should be clamped and ligated.

After the bowel has been detached all around it is drawn out of the incision as far as possible. Just beyond the upper limits of the disease a heavy silk ligature is thrown around the rectum and tied, and the contents of the diseased portion of the bowel are thus confined within that part of the bowel which is to be resected. Gauze pads are placed about and underneath the rectum to protect the wound from possible leakage and the diseased part is then cut away from the upper healthy portion of the bowel. Before the bowel is divided an assistant grasps it, beyond the intended line of section, with a broad, rubber-sheathed clamp or with the fingers so that, when the diseased part is cut away, there will be no leakage of the bowel contents. The diseased portion having been thus excised, the upper end of the bowel is released from the grasp of the assistant and immediately packed with gauze, and we are ready for the final step of the operation,—the anastomosis of the upper end of the bowel to the lower anal portion.

Anastomosis of the Ends of the Bowel.—During the application of the sutures that unite the two ends of the bowel care should be taken that no bowel contents soil the suture line. The gauze which has been packed into the upper segment of the bowel prevents this. There should be no tension whatever upon the upper segment —no tendency for it to draw up into the abdomen, away from the anal portion. Proper detachment of the bowel and opening of the peritoneal pouch will obviate this.

For uniting the ends of the bowel fine-silk sutures are used. The suture is commenced anteriorly, in the middle line, working around upon either side toward the back. The sutures should be introduced from the inner surface of the bowel and tied so that the knots are within the lumen of the bowel—they should be interrupted and each should include the whole thickness of the wall of the gut, and be placed about $1/6$ inch distant from each other. The sutures which are introduced last and which join the two segments of the bowel posteriorly, must be introduced from the outer surface and do not penetrate the whole thickness of the wall of the bowel. They simply include the outer coats. When these latter sutures have been tied, it will be found that the knots are upon the outer aspect of the bowel. Before completing the anastomosis of the two ends of the bowel behind, a rubber tube, wrapped around with gauze, is introduced through the anus into the bowel, well up beyond the line of suture. This protects the suture line and also permits the escape of gas during the few days immediately following the operation. A strip of gauze is introduced into the wound down to the line of suture upon either side of the bowel for the purpose of providing drainage in the event of leakage.

Union most often fails in the posterior part of the suture line in the bowel; this is due probably to the damage done to the vessels which supply the bowel, in isolating it. Such a break of the suture line, however, usually does no harm if proper drainage of the wound has been provided and usually the resulting fæcal fistula closes spontaneously, or may be closed by a subsequent operation.

Amputation of the Rectum Including the Anal Portion.—If it is desired to remove the lower (anal) portion of the bowel, together with the rest of the rectum, the skin incision should be prolonged from the tip of the coccyx, so as to encircle the anus. After the coccyx and part of the sacrum have been resected as described above, the whole length of the bowel, including the anal portion, is isolated, beginning below at the anus and working upward. Upon either side, near the anus, the attachment of the levator ani is separated from the rectum with the scissors, working close to the wall of the rectum. At times, some difficulty in separating the rectum from the prostate or the vagina is experienced. A catheter is introduced into the bladder as a precautionary measure to indicate the location of the urethra. When the bowel has been isolated to a point beyond the upper limits of the disease, a ligature is thrown around the rectum and the diseased portion cut away. The end of the proximal (upper) part of the bowel into which a strip of gauze has been packed is then sewed to the margins of the skin in the upper part of the incision close to the edge of the sacrum with interrupted silk sutures. The wound is then packed carefully about the bowel, above and below, and the skin incision partly closed with several silk sutures. The bowel may be twisted through a quarter of a circle before uniting it to the margin of the skin, with the idea of making the artificial anus more continent. A fæcal fistula in this position is very inconvenient. Better to establish an artificial anus in the left iliac region.

In some cases it may be possible to preserve the external sphincter muscle. Under these circumstances the end of the bowel may be drawn down and sutured to the edges of the anal margin after the mucous-membrane layer has been dissected away from within the anal ring.

Combined Method (also Called the Abdomino-Perineal, Abdomino-Anal, etc.).—This operation is suitable for cancer involving the upper part of the rectum and sigmoid flexure (pelvic colon). With many surgeons this is the operation of choice for practically all cases of cancer of the rectum. Up to the present the immediate mortality has been high, especially in fat men. In men the mortality varies between 50 and 80 per cent.; in women, between 10 and 20 per cent. It is to be hoped that these figures will be greatly improved as surgeons become more familiar with the operation.

By the combined method the diseased portion of the bowel (pelvic colon and rectum) is detached through the abdominal incision and then removed later through an incision in the perineum. The proximal end of the bowel is either fixed in an incision in the abdominal wall and a permanent artificial anus thus established; or else it is pulled down and sutured to the lower end of the rectum (if the lower portion has been left remaining) or to the edge of the original anal margin.

Combined Operation with the Establishment of an Artificial Iliac Anus.—This operation is less complicated than some of the others that may be practiced by the combined method. It permits of very radical excision of the diseased parts and gives an artificial anus which is quite continent. The operation may be described in two steps, the abdominal and the perineal.

The Abdominal Step.—The patient is placed in the Trendelenberg position and an incision made in the middle line from the symphysis pubis upward for a distance of four or five inches. The liver is examined to ascertain whether it is free from metastatic growth. In men, in order to gain enough room, it may be necessary to incise the recti muscles close to their attachment to the pubic bones. This is to be avoided if possible.

The small intestines are pushed up toward the diaphragm and held thus, out of the way, by several gauze pads. The sigmoid flexure is secured well above the location of the disease and followed downward to the point where it becomes continuous with the rectum, opposite the third sacral vertebra. This part of the sigmoid flexure which lies loose in the pelvic cavity is called the pelvic colon and was formerly described as the first part of the rectum. The growth is examined, whether movable or adherent to adjacent organs. Investigation is also made as to the degree of involvement of the lymph-nodes behind the rectum, and along the course of the internal iliac vessels. It must also be determined whether, after the diseased part has been excised, there will be enough of the sigmoid (pelvic colon) remaining to permit the end of the bowel to be brought down and sutured to the anal portion of the rectum or to the margin of the anus; or whether it would be more satisfactory to make an artificial anus in the left iliac region. It will be noticed that there is ample room to make the necessary investigation in the female pelvis, whereas, in the male, and especially in fat men, the pelvic cavity is narrow and, at times, considerable difficulty will be experienced in exploring the pelvis and carrying out the steps of the operation.

If it is decided to proceed with the operation the sigmoid is drawn up out of the pelvis into the incision, emptied of its contents by stripping between the fingers and surrounded by two heavy silk ligatures which are passed through the mesosigmoid and placed fairly close together. The bowel is divided between the ligatures. The end of each segment of the bowel is cleansed and then inverted and secured thus with a purse-string suture of silk, which is placed

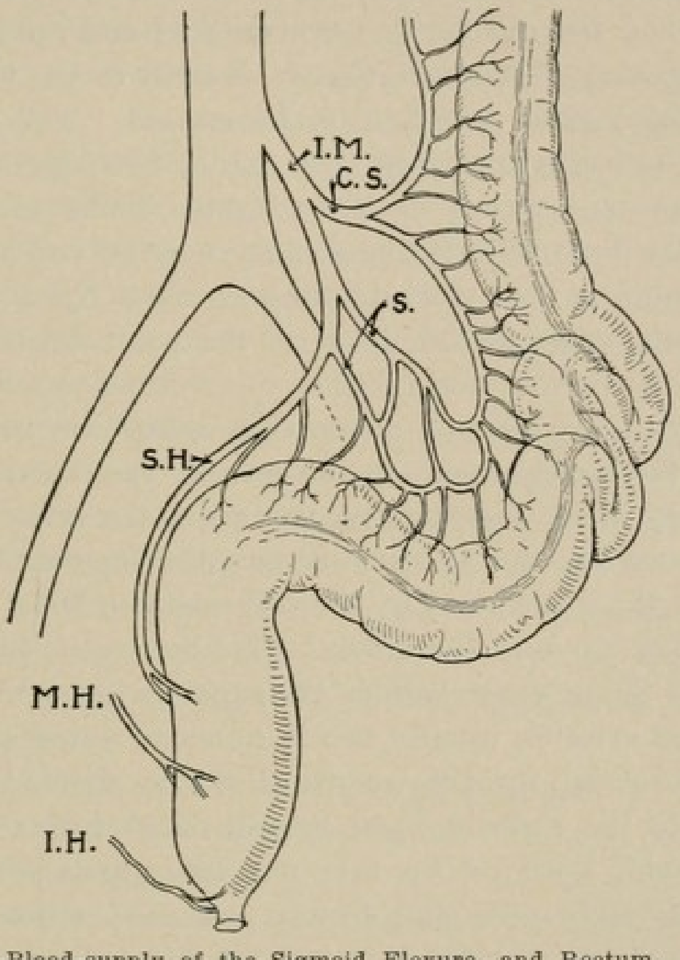

Fig. 261.—Blood-supply of the Sigmoid Flexure, and Rectum. *C.S.*, arteria colica sinistra; *I.H.*, inferior hemorrhoidal; *I.M.*, inferior mesenteric; *M.H.*, middle hemorrhoidal; *S.*, sigmoid arteries; *S.H.*, superior hemorrhoidal.

in the wall of the bowel about one inch beyond the ligatured end. The end of the bowel is inverted, the purse-string pulled tight and tied. Both ends of the bowel are treated in this manner. The ends of the purse-strings are left long to serve as tractors.

For the purpose of the artificial iliac anus an incision is made in the left iliac region, penetrating, "grid-iron" fashion, between the fibers of the several abdominal muscles and the end of the upper segment of the bowel drawn out through the incision for a distance of three-quarters of an inch with the tails of the purse-string suture which were left long for this purpose. The end of the bowel is fixed in the incision by several sutures of chromic catgut, No. 1, which secure the end of the bowel to the edges of the peritoneum and transversalis fascia in a manner quite analogous to that described for colostomy, page 465. The bowel is not opened for twenty-four to forty-eight hours after the operation, depending upon the conditions in each case—degree of distention, etc. To open the bowel the purse-string is cut and the end of the bowel everted and opened.

The next step of the operation is devoted to the lower piece of the bowel—the portion which is to be excised. The mesentery of this part of the bowel is tied off with one or two ligatures of catgut. These ligatures are passed double with the blunt carrier, so that after they have been tied, the mesentery may be cut between them. The mesosigmoid is thus treated, using as many ligatures as may be necessary to tie it off as far down as the point where it ceases to exist—where the pelvic colon becomes the rectum—opposite the third sacral vertebra. The inferior mesenteric vessels are sought between the folds of the mesosigmoid, to the left of, and upon a level with, the promontory of the sacrum. At this point the inferior mesenteric artery dips down into the pelvis to become the superior hemorrhoidal. It rests upon the bifurcation of the left common iliac artery and is in close relationship with the ureter. Just before the inferior mesenteric dips into the pelvis to become the superior hemorrhoidal it gives off the sigmoid arteries, usually two in number, which are distributed to and are essential for the nutrition of the sigmoid flexure. In their course to the sigmoid these vessels run between the layers of the mesosigmoid, breaking up into numerous branches which communicate with each other and form a series of arches before they reach the bowel. Care must be taken, in tying the superior hemorrhoidal, to apply the ligature below the point where the sigmoid arteries are given off from the inferior mesenteric.

The peritoneum which covers the rectum is incised downward, along each side of the rectum and below, across the front of the rectum—where it is reflected forward on to the bladder in the male and on to the posterior wall of the vagina in the female. The rectum, including all the loose connective tissue and lymph-nodes that are situated behind it, between it and the front surface of the sacrum, is peeled out in one mass. This is done, bluntly, with the fingers, cleaning the parts away clear back to the anterior surface of the sacrum. The sacro-media artery is secured and ligated just below its origin from the point where the aorta bifurcates, before beginning this part of the operation. Working downward along the sides of the rectum some bands of connective tissue, including the middle hemorrhoidal arteries, are met with and may be clamped before being torn or cut close to the wall of the rectum. Below and anteriorly, in the male, the rectum is separated from the base of the bladder and from the posterior surface of the prostate; in the female from the upper part of the vagina, uterus. The isolation of the rectum is continued downward as far as the attachment of the levator ani muscle upon either side. In enucleating affected lymph-nodes, etc., care must be exercised not to injure the ureters as they dip down into the pelvis at the sacro-iliac synchondroses. It is also necessary to again avoid the ureters in separating the rectum below, from the base of the bladder, as the ureters pass forward in this situation close to the sides of the rectum to reach the base of the bladder and would be in danger of being injured.

After the pelvic colon and rectum have been completely detached they are pushed down into the bottom of the pelvis and the torn edges of the pertioneum are brought together with sutures so as to restore the peritoneal lining of the floor of the pelvis. The detached rectum and pelvic colon thus lie below the restored peritoneal lining of the pelvic floor. The abdominal part of the operation is thus complete and the extirpation of the rectum from below remains to be accomplished.

Perineal Step.—The technique of this part of the operation does not differ from that described under "Perineal Method," "Lisfranc's operation," page 567.

The patient is placed in the lithotomy position, the legs flexed upon the abdomen and the buttocks raised high upon a sandbag placed underneath them.

The rectum is loosely packed with strip gauze through the anus, and the anus closed with several silk sutures. An incision is made which encircles the anus and reaches back to the coccyx (see page 567). The rectum is then detached, working from below upward, separating it from the bulb of the urethra and prostate in the male and from the vagina in the female, until the point is reached where the levatores ani are attached to the sides of the rectum. This represents the boundary between the upper and lower parts of the operation. The levatores ani are cut close to the wall of the rectum and the rectum then removed. The perineal incision is closed in part and a plug of gauze left in for drainage.

The entire operation can be done by a single operator or a second operator may do the work from below. The abdominal incision may be left open (or partly closed with a few temporary sutures) until the perineal part of the operation has been completed, when the first operator or the single operator, if only one, may, with a change of gloves, complete the operation by suturing the edges of the torn peritoneal lining of the pelvic floor and closing the abdominal incision.

Combined Operation with Suture of the End of the Sigmoid to the Anal Margin or to the Anal Portion.—In those cases where there is a sufficient length of sigmoid flexure (pelvic colon) left after the diseased part of the bowel has been resected, it may be decided to pull down the end of the sigmoid and suture it to the anal margin if it has been possible to preserve the external sphincter; or to anastomose it to the anal portion of the rectum if this part remains. Special care will be necessary to preserve enough of the blood-supply of the sigmoid to insure the nutrition of the end of the bowel which is drawn down for suture, to the anal margin or to the anal portion of the rectum. Care must be exercised, in ligating the superior hemorrhoidal, to secure the vessel below the level of the promontory of the sacrum, that is, below the point where the sigmoid branches are given off from the inferior mesenteric. The sigmoid flexure (pelvic colon) depends upon these vessels for its vascular supply (see Fig. 261).

With Suture of the End of the Bowel to the Anal Margin.—The abdomen is opened and the sigmoid flexure drawn up into the incision and cut across, low down, as close to the growth as may be, between two heavy silk ligatures which have been tied around the bowel.

The ends of the ligatures are left long to serve as tractors. The two ends of the gut are carefully cleansed. The end of the upper segment is wrapped in gauze and placed to one side temporarily. The mesosigmoid, corresponding to the lower segment, is tied off with one or two ligatures as far as the point where the mesentery ceases to exist, where the pelvic colon becomes continuous with the rectum. The ligatures are each applied double so that the mesentery can be divided between them. The superior hemorrhoidal artery is secured below the level of the promontory of the sacrum, below the point where the sigmoid branches are given off from the inferior mesenteric. The detachment of the rectum is continued as far down as possible.

A second operator working from below, through the perineal incision, detaches the rectum and removes it (see "Perineal Method," page 569), and then passes a forceps up through the perineal incision into the pelvic cavity and grasps the ends of the silk ligature which closes the end of the upper segment of the bowel (the end of the sigmoid), and draws this part of the bowel down and out through the anal incision. The bowel should come down without any tension whatever. There may be some difficulty in drawing the end of the bowel down to the anal margin on account of the shortness of the

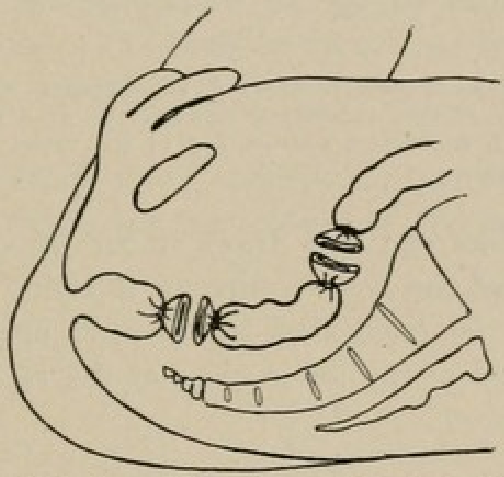

Fig. 262.—Resection of Rectum, Abdomino-anal Method. The diseased portion has been tied off and cut away from the healthy bowel above and below.

mesentery that attaches it near the left sacro-iliac synchondrosis. This difficulty may be overcome by incising the mesosigmoid near its attachment to the pelvic brim and without jeopardizing its blood-supply, provided the sigmoid arteries which are given off from the inferior mesenteric just before it dips into the pelvic cavity to become the superior hemorrhoidal, are not injured.

The end of the sigmoid which has been drawn down and out through the anal incision is sutured to the edges of the skin around the anus. If the external sphincter has been preserved we may expect a fairly continent anus.

With Anastomosis of the End of the Sigmoid to the Lower, Anal Portion.—The diseased portion of the bowel may be resected by the operator working through the abdominal incision, leaving the lower part of the rectum so that the end of the sigmoid flexure may be anastomosed to this lower portion of the rectum.

Two heavy silk ligatures are tied around the lower part of the rectum after it has been detached, and the diseased part of the bowel is removed by dividing the bowel between the two ligatures. A second operator working from below inserts a forceps through the anus, up into the blind pocket which corresponds to the lower, anal part of the rectum

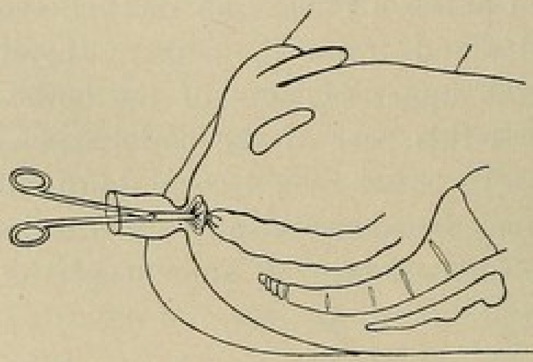

Fig. 263.—Resection of the Rectum, Abdomino-anal Method. The lower, anal segment of the rectum is everted through the anal orifice. The forceps is passed up through the lower, everted end of the bowel and grasps the end of the upper segment.

and seizes the tied-off end and draws it out through the anus, thus everting this part of the bowel—turning it inside out. This step of the operation may be facilitated by the first operator, from above, pushing the tied end of the lower piece of the rectum into the grasp

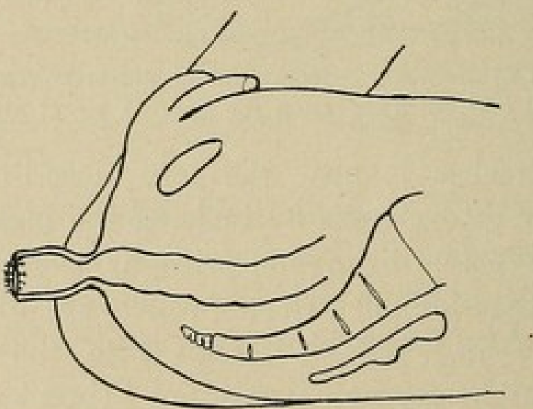

Fig. 264.—Resection of the Rectum, Abdomino-anal Method. The upper segment has been drawn down through the lower, everted segment. The edges of the two segments have been sutured together and the parts are ready to be returned into the pelvis.

of the forceps or the tails of the ligature which secures the end of this segment of the bowel may be threaded in the eye of a probe and the probe pushed through the middle of the tied-off stump and out through the anus. The tails of the ligature may then be used as tractors to evert the lower segment of the bowel. The ligature is removed from the end of the everted lower end of the bowel and the forceps is again passed up into the pelvis through the everted anal portion. The tails of the suture which secures the end of the sigmoid portion are seized and this end of the bowel is pulled down and out through the everted anal portion, "telescope" fashion. The edges of the two segments are sewed together, all around, with interrupted silk sutures placed close together. The edges of the two segments are thus united very accurately.

After the end of the sigmoid has been sutured to the anal portion the bowel is returned through the anus into the pelvic cavity. A plug of gauze is introduced through an incision which is made behind the anus, reaching well up into the pelvis, into the connective-tissue space behind the rectum, for the purpose of drainage. A rubber tube wrapped around with gauze is introduced into the rectum, up beyond the line of suture, to protect the suture line and to permit the escape of gas.

The operator from above restores the peritoneal lining of the pelvic floor by suturing the torn edges of the same and closes the abdominal incision.

PART VII.

HERNIA, SPERMATIC CORD, TESTES, ETC.

The Surgical Anatomy of the Groin.—The groin may be divided into the inguinal and femoral regions. These parts may be considered more or less together, on account of the close relationship that exists between them.

The inguinal region corresponds to that part of the anterior abdominal wall which lies just above Poupart's ligament, and is traversed by a canal for the passage of the spermatic cord, in the male, and the round ligament, in the female. By invaginating the integument of the scrotum, the finger may be introduced into this canal.

The femoral region corresponds to the upper anterior part of the thigh—the area immediately below Poupart's ligament. Underneath Poupart's ligament, between it and the pubic bone, there is a space through which the ilio-psoas muscle and anterior crural nerve, and the femoral vessels, etc., pass from the abdomen into the thigh.

The Superficial Layer of the Superficial Fascia.—Beneath the skin of the groin there is a loose connective-tissue layer which contains a varying amount of fat, and in which the blood-vessels, nerves, lymphatic glands, etc., are located. This layer is called the superficial layer of the superficial fascia. In some subjects it is very thick. It is continuous with the general fatty layer of the body. In the male it is continued on to the penis, where it is thin and loose, forming one of the coats of that organ, and in the scrotum is continued into the dartos. From the scrotum it may be traced back into the perineum, where it is known as the superficial layer of the superficial perineal fascia. In the female it is continuous with the fatty layer of the labia majora, each one of which corresponds to one-half of the scrotum. The vessels which are found in this layer, and which may be cut in making the skin incisions in operating upon these parts, are the superficial epigastric, superficial circumflex iliac, and superficial external pubic arteries, together with their corresponding veins.

THE LYMPHATIC GLANDS.—The lymphatic glands of this region are arranged in two groups: one group, the inguinal, is spread along Poupart's ligament, and drains the external genitals, scrotum, penis, etc.; the other group lies along the saphenous vein, and in and about the saphenous opening. These drain the lower limb. In extirpating the inguinal group of glands there is but little hemorrhage, but it is necessary to avoid the spermatic cord. In extirpating the lower, femoral, group there may be considerable hemorrhage, and one must avoid injury to the internal saphenous vein and to the femoral vein, especially when excising those glands that are lodged in the saphenous opening.

THE DEEP LAYER OF THE SUPERFICIAL FASCIA.—After the fatty layer has been removed from this region the deep layer of the superficial fascia is exposed. This fascia is thin, and covers the aponeurosis of the external oblique muscle in the inguinal region, and the fascia lata in the femoral region. It is adherent, in the middle line, to the linea alba, and, just below Poupart's ligament, to the fascia lata. In the male it forms one of the coverings of the penis, and is continued into the scrotum, where it forms the dartos, and backward beyond the scrotum, into the perineum, where it forms the deep layer of the superficial perineal fascia. In the perineum it is attached laterally to the rami of the pubes, and behind to the transverse perineal raphé. In the female this layer is continued into the labia majora. This fascia is firmly attached to the margins, or pillars, of the external ring, and is known as the external spermatic fascia. Entrance into the inguinal canal cannot be effected until this layer of fascia has been incised. From the margins of the ring this layer of fascia is continued downward, surrounding the cord and forming one of its investments, and below, as already mentioned, it is found in the scrotum as the dartos. Below Poupart's ligament, in the femoral region, this layer of fascia is firmly adherent to the margins of the saphenous opening in the fascia lata, where it is perforated by numerous vessels and lymphatics, and is called the cribriform fascia. From this point on, the inguinal and femoral regions may be studied separately.

THE INGUINAL REGION.—The inguinal region is the site of inguinal hernia. After removing the deep layer of the superficial fascia from the inguinal region (including the margins of the external ring), we expose the aponeurosis of the external oblique and the external inguinal ring, into which the finger may be introduced, and from which the spermatic cord (the round ligament in the female) is seen to emerge.

The aponeurosis of the external oblique is the strong, smooth, glistening, bluish-white, fibrous expansion of the external oblique muscle. Its fibers have an oblique direction downward and inward toward the middle line, and join with each other in the linea alba. The lower fibers of the aponeurosis of the external oblique are collected into a thick bundle to form Poupart's ligament

Poupart's ligament is a strong, fibrous band which extends from the anterior superior spinous process of the ilium downward and inward to the spine of the pubes. Both these bony processes are easily made out; the latter, the spine of the pubes, is readily felt beneath the soft parts upon the upper border of the pubic bone, about three-fourths inch from the symphysis. The fibers of the aponeurosis of the external oblique immediately above Poupart's ligament pass inward toward the middle line, interlacing with those from the opposite side, and are attached to the symphysis, and there is thus left a triangular opening in the aponeurosis, which is called the external inguinal ring. This so-called ring is simply a split in the aponeurosis of the external oblique. Its outer or lower border, or pillar, is formed by Poupart's ligament; its inner or upper border, or pillar, is formed by those fibers of the aponeurosis of the external oblique which are attached in the middle line to the symphysis, interlacing with those of the opposite side. The apex of this opening is directed upward and outward; its base corresponds to the crest, or upper surface, of the body of the pubic bone, that portion of the bone which is included between the pubic spine, to which Poupart's ligament is attached, and the symphysis. Various stay fibers are seen in the aponeurosis, passing from below upward and inward, near the apex of the external ring. These serve to bind the pillars of the ring firmly together, and are called the intercolumnar fibers.

The spermatic cord (round ligament in the female) is seen emerging from the external ring, and a director may be introduced through the ring upward and outward into the inguinal canal. From the inner end of Poupart's ligament—*i.e.*, from the external pillar of the ring—a triangular sheet of fibers is given off, which is reflected upward and inward toward the middle line, and is continued into the anterior layer of the sheath of the rectus muscle. This is called the triangular ligament, or Colles's ligament, and is situated behind the inner end of the external ring, and in front of the conjoined tendon,

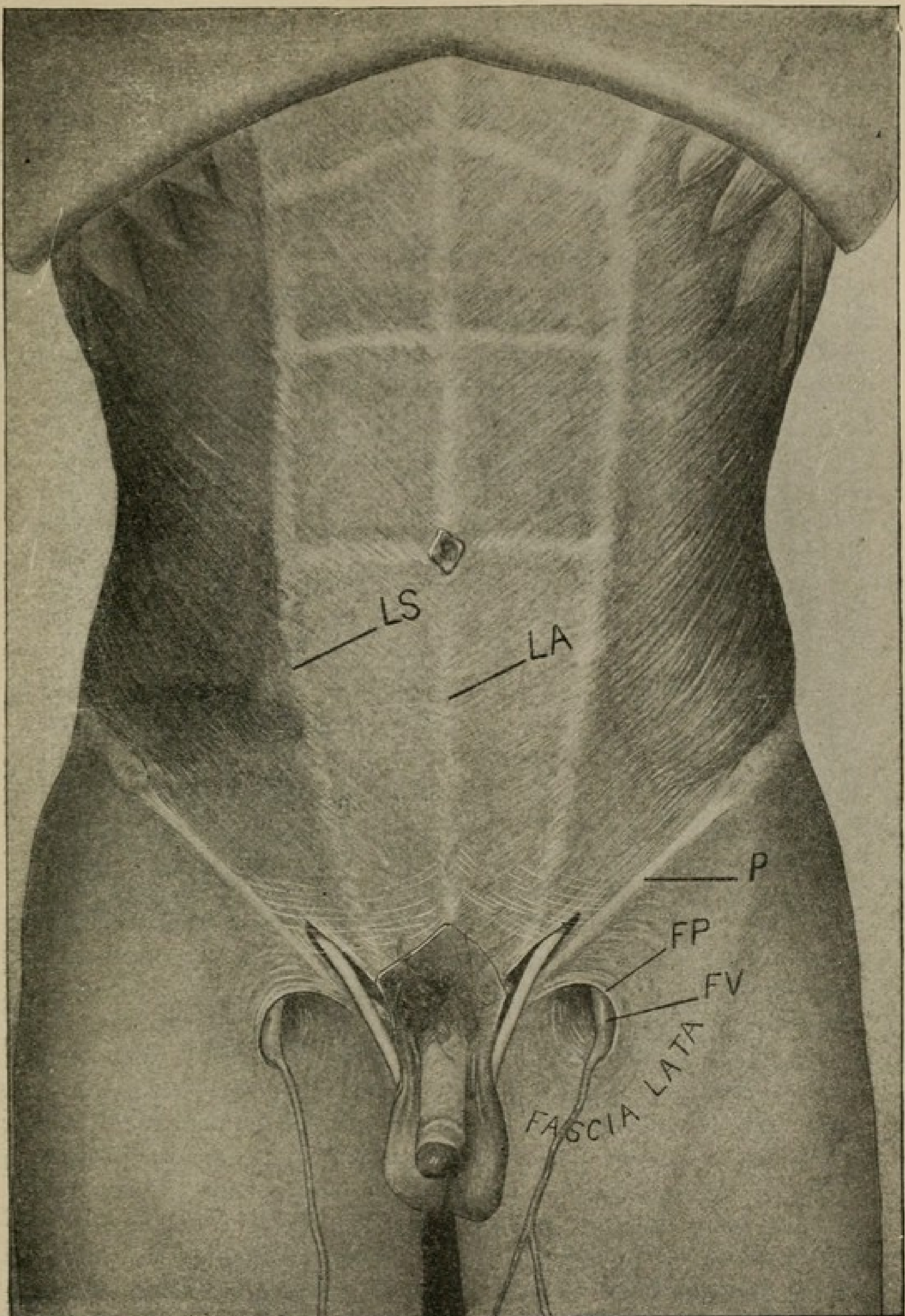

Fig. 265.—Inguinal and Femoral Regions. *FP*, edge of falciform process; *FV*, femoral vein; *LA*, linea alba; *LS*, linea semilunaris; *P*, Poupart's ligament. The external inguinal ring is shown with the spermatic cord emerging. The fibers crossing the upper outer angle of the ring are known as the intercolumnar fibers.

and serves to strengthen this part. If we examine still further this inner end of Poupart's ligament,—*i.e.,* the external pillar of the ring,—we find given off from its lower border, just before its attachment to the pubic spine, a strong triangular band, which is attached to the ilio-pectineal line, a prominent ridge upon the upper surface of the pubic bone, which is continued outward and backward from the pubic spine to the edge, or brim, of the true pelvis. This band is known as Gimbernat's ligament. It presents an outer, sharp, curved edge, and is of much anatomical interest in the study of femoral hernia.

The Inguinal Canal.—The inguinal canal is an oblique slit in the abdominal wall, and, under ordinary circumstances, the greater the intra-abdominal pressure, the tighter its closure. It is from 4 to 5 cm. (one and one-half inches) long, and lies above and parallel with Poupart's ligament. It terminates beneath the integument at the external inguinal ring, a triangular opening in the aponeurosis of the external oblique, which is located just above the crest of the pubes.

If we introduce a director through the external ring into the inguinal canal, and pass it in a direction upward and outward underneath the aponeurosis of the external oblique, to a point about half an inch above the middle of Poupart's ligament,—*i.e.,* the location of the internal ring,—and then split the aponeurosis upon this, we open up the inguinal canal and expose its contents: the spermatic cord, in the male; the round ligament, in the female. The cut edges of the aponeurosis should be seized with artery forceps and separated freely from the underlying parts with the finger. The spermatic cord is a structure as big around as the little finer. It is made up of the vas deferens, which is the efferent duct of the testicle; the artery of the vas deferens and the cremasteric artery, and their corresponding veins; the spermatic artery, and the pampiniform venous plexus. As these structures traverse the inguinal canal they are all bound together into a single rounded cord by a strong sheath of fascia, the infundibular process of the transversalis fascia. Descending upon the cord are also seen the fibers of the cremaster muscle, which are derived from the lower edge of the internal oblique in the descent of the testes. The cord is also accompanid, in its course through the inguinal canal, by the genital branch of the genito-crural nerve and the inguinal branch of the ilio-inguinal nerve.

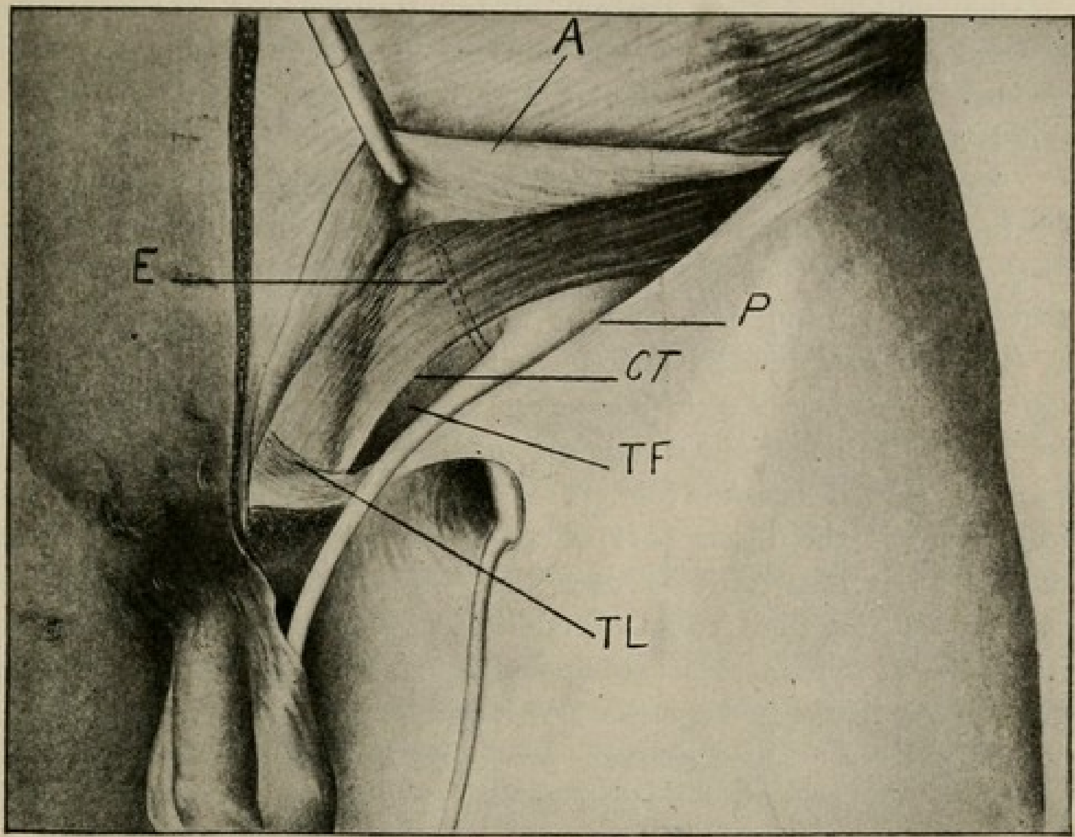

Fig. 266.—The Inguinal Canal. The canal has been laid open by splitting the aponeurosis of the external oblique (*A*), which is grasped with the artery forceps and drawn upward; *CT*, edge of the internal oblique muscle (conjoined tendon); *E*, dotted line represents the course of the deep epigastric artery, which is located beneath the transversalis fascia; *P*, Poupart's ligament; *TF*, transversalis fascia, which forms the posterior wall of the inguinal canal; *TL*, triangular ligament, which is given off from the inner end of Poupart's.

After the inguinal canal has been opened by splitting the aponeurosis of the external oblique, the free, curved, fleshy edge of the internal oblique is exposed to view. This muscle, the part seen here, arises from the outer half of Poupart's ligement. If the edge of this muscle is raised and drawn upward and outward for a short distance, or incised, we expose the transversalis muscle, which lies beneath the internal oblique. That portion of the transversalis which is thus exposed arises from the outer third of Poupart's ligament, and is covered by the internal oblique, and is not seen until the edge of this latter muscle has been drawn aside.

Toward the outer part of the inguinal canal these two muscles, where they arise from Poupart's ligament, are situated for a short distance in front of the spermatic cord. They then arch inward above the cord, and, joining with each other, become tendinous, and, as the conjoined tendon, descend behind the cord, to be attached to the upper surface of the pubic bone; *i.e.*, the crest and the pectineal line. The conjoined tendon, at its attachment to the pubic bone, is placed behind the external ring, and participates in the formation of the inner part of the posterior wall of the inguinal canal. It is important to note that that portion of the posterior wall of the inguinal canal which is included between the arching free edge of the internal oblique muscle above and Poupart's ligament below is formed by the transversalis fascia only. This fascia is a fibrous layer which lines the whole inner surface of the abdomen, including the posterior surface of the anterior abdominal wall, and it is here exposed to view where the muscle is deficient; *i.e.*, between the edge of the internal oblique muscle above and Poupart's ligament below. Through the outer part of the posterior wall of the inguinal canal the several structures which go to make up the spermatic cord (round ligament in the female) pass forward into the inguinal canal, being provided with a strong, fibrous sheath, which is known as the infundibular process, by the fascia transversalis. This sheath incloses the several elements of which the cord is composed, and serves to bind them together into a single bundle, which traverses the inguinal canal and emerges at the external inguinal ring. The point at which the structures which constitute the spermatic cord pass forward into the inguinal canal is the site of the internal inguinal ring. The internal ring is an opening in the transversalis fascia, which is located half an inch above the middle of Poupart's ligament. The inguinal canal proper has no internal opening; *i.e.*, it does not communicate with the abdominal cavity. The internal inguinal ring is really the mouth of the infundibular process, which is, in reality, the sheath that is provided to the spermatic cord from the transversalis fascia.

The infundibular process is a glove-finger-like diverticulum, or pocket, which is derived from the fascia transversalis, being prolonged downward into the bottom of the scrotal sac, and, through this, the testicle, drawing the vas deferens, etc., after it, descends in its journey from the abdomen into the scrotum. After the testis has reached the bottom of the scrotal sac, the upper part of this infundibular process—*i.e.*, the part which corresponds to the cord —contracts and shrinks so closely around the structures which make up the cord, and which are contained within it, that its cavity is, in this way, entirely obliterated, and the shrunken infundibular process remains permanently as the proper fibrous sheath of the spermatic cord.

The lower part, however, of the infundibular process remains permanently unchanged as one of the layers of the scrotum.

The contraction of the infundibular process about the upper part of the cord may be incomplete, and there may be thus left a space within the sheath of the cord (infundibular process), into which the point of the finger may be insinuated from within the abdomen. The finger under these circumstances does not enter the inguinal canal, but passes through the internal ring into the proper sheath of the spermatic cord. The mouth of the infundibular process, the "internal ring," may be best studied from within the abdomen, after the peritoneum, which lines this portion of the abdominal wall, has been stripped away.

Beneath the transversalis fascia—*i.e.*, the posterior wall of the inguinal canal—is found the parietal layer of the peritoneum, with an intervening stratum of loose connective tissue, containing fat, between it and the transversalis fascia; this is the so-called subperitoneal connective-tissue layer. The layer of peritoneum which lies behind, or rather beneath, the posterior wall of the inguinal canal presents no opening whatever. Within the abdomen, about the mouth of the infundibular process, "internal ring," the parietal peritoneum is adherent to the transversalis fascia, and may show a slight bulging into the neck of the infundibular process (sheath of the cord).

In the study of these parts the deep epigastric artery plays an important rôle. This artery may be seen, or its pulsation felt, as it lies beneath the transversalis fascia in the subperitoneal connective tissue between the transversalis fascia and the peritoneum. The artery is accompanied by one or two veins. It arises from the external iliac (femoral) just before this vessel passes out of the abdomen under Poupart's ligament, and ascends obliquely upward and inward toward the umbilicus to reach the outer border of the rectus muscle. It passes across the posterior wall of the inguinal canal about the middle, and so divides it into two parts, an outer and an inner. The outer part of the posterior wall of the inguinal canal, that part which lies external to the deep epigastric artery, is formed by the transversalis fascia and the underlying peritoneum, and presents the opening through which the structures that form the spermatic cord (round ligament) leave the abdomen, the internal ring. The presence of this orifice tends to weaken this outer part of the posterior wall of the inguinal canal. The inner portion of the posterior wall of the inguinal canal, that part which lies internal to the deep epigastric artery, is strengthened, in part, by several additional layers. From before backward this part of the posterior wall of the inguinal canal is formed of the triangular ligament, conjoined tendon, transversalis fascia, and parietal peritoneum. This inner portion of the posterior wall of the inguinal canal is, therefore, much more secure than the outer part.

A hernia that protrudes through the posterior wall of the inguinal canal external to the deep epigastric—*i.e.,* one which passes through the "internal ring" and works its way downward along the cord—is an oblique, or external, inguinal hernia, the common variety. In those cases in which the upper part, or neck, of the infundibular process has failed to become tightly contracted around the elements of the cord right up to the point at which they emerge from the abdomen, the predisposition to hernia is, without doubt, more pronounced, and this is especially the case if, in addition, the peritoneum, which is normally adherent about the site of the "internal ring," shows a certain degree of bulging into the mouth of the patent infundibular process.

A hernia that bulges forward through the posterior wall of the inguinal canal to the inner side of the deep epigastric artery is a direct, or internal, inguinal hernia. Such a hernia does not pass through the "internal ring" and descend along the course of the cord, within its sheath (infundibular process), but bulges directly forward into the inguinal canal, to the inner side of the cord, and, besides the transversalis fascia, it may have to push the conjoined tendon, etc., before it, or else force its way between the fibers of this structure. These accessory structures form a strong barrier against the formation of a direct hernia, which variety is much less common than the oblique.

In the female the inguinal canal and rings are all less well developed than in the male. The round ligament is a thin structure, often difficult to find. After passing through the inguinal canal it emerges from the external ring, and is then lost in the connective tissue about the external ring and in the labia majora.

Inguinal hernia is comparatively infrequent in the female. When it occurs, it is analogous to that in the male, and may descend into the labia majora.

THE DESCENT OF THE TESTES.—The testes (ovaries in the female) are developed within the abdomen from the Wolffian body, and in early fœtal life they are situated in the back part of the abdominal cavity near the kidneys. They lie not within the peritoneal cavity, but, like the kidney, behind the peritoneum, which is adherent to their front surface. From this position, the testes, during the later months of fœtal life, gradually descend. They descend behind the peritoneum and enter the infundibular process through its mouth, the "internal ring." Finally, during the last month of intra-uterine life they arrive at their normal destination, the bottom of the scrotal pouch.

The ovaries descend in an analogous manner, but do not pass out of the abdominal cavity.

Preparatory to the descent of the testes there is a pouch-like bulging of the lower part of the anterior abdominal wall in either inguinal region. A shallow pouch is thus formed on either side, which gradually becomes deeper, and finally the two join together in the middle line to form the scrotum. Each of these pouches is lined on its internal aspect by a sac-like prolongation from the transversalis fascia (infundibular process). These pouches are empty and ready to receive the testes.

Reaching from the testis as it lies within the abdomen, downward into the bottom of the infundibular process (scrotum), there is a musculo-fibrous structure, the gubernaculum of Hunter. It serves to lead the testis down into the scrotal sac.

About the sixth month of fœtal life the descent of the testis begins. The gubernaculum contracts and draws the testis downward toward the inguinal region. About the seventh month the testis arrives at the "internal ring," the wide-open mouth of the infundibular process. The testis then passes into the infundibular process, and, as it does so, it brings a bag-like process of the peritoneum, which is adherent to it, with it. This is called the vaginal process of the peritoneum. At the eighth month the testis is found in the infundibular pouch, together with the vaginal process of the peritoneum, which accompanies it, and during the last month of intrauterine life it is found at the bottom of the infundibular pouch, the scrotum, together with its vaginal peritoneal process.

The testis may be interrupted in its journey into the scrotum at any point, and may remain stationary either in the abdomen or in the inguinal canal. This condition occasionally complicates congenital hernia. After the testis has reached the bottom of the scrotal sac, the peritoneal pouch, which accompanied it, becomes, for that part of its extent which corresponds to the vas deferens, gradually obliterated. This process of obliteration commences in the middle of the tube and extends upward toward its abdominal orifice, and downward toward the testis, and, in the adult, this obliterated portion of the vaginal process is represented only by a fibrous strand that is found, together with the vas deferens, etc., inclosed within the proper sheath of the cord.

The lower part of the vaginal process, that portion which corresponds to the testis, remains permanently as the tunica vaginalis testis. At birth the canal of the vaginal process is still pervious, but very much shrunken, and becomes rapidly obliterated during the first few weeks of extra-uterine life.

If the peritoneal pouch, the vaginal process, which accompanies the testis in its descent, remains pervious after birth throughout its whole extent, and, if its orifice is large enough to permit, a coil of intestine may enter; and we shall then have a congenital hernia.

In the female the round ligament is the remains of the gubernaculum. The ovary descends like the testis, but does not leave the abdominal cavity; it remains in the pelvis. It does, however, exceptionally leave the abdominal cavity, and may then be found in the labia majora. Congenital hernia is uncommon in the female.

To recapitulate: There are two varieties of inguinal hernia, the direct, or internal, and the oblique, or external. The direct is always acquired, and is less common than the indirect. In this

1. At Sixth Month.

Testis located in the back part of the abdominal cavity, covered by the peritoneum upon its anterior aspect.

G, gubernaculum of Hunter.

IP, infundibular process of the transversalis fascia.

P, peritoneum lining the interior of abdominal cavity.

S, scrotum.

T, testis.

TF, transversalis fascia.

VD, vas deferens.

2. At the Seventh Month.

The testis has descended into the inguinal region toward the mouth of the infundibular process—future internal inguinal ring.

3. At the Eighth Month.

The testis has entered the infundibular process, carrying a process of the peritoneum with it.

VP, vaginal process of peritoneum.

4. At Ninth Month.

Testis has reached the bottom of the infundibular process,—scrotum,—carrying process of peritoneum with it.

5. Third to Fourth Week after Birth.

Testis is located in the bottom of the infundibular process—scrotum. Obliteration has begun in the vaginal process.

6. Several Months after Birth.

Normal adult condition.

Testis rests in bottom of infundibular process—scrotum. The vaginal process which accompanied the testis in its descent has become obliterated except for that portion of its extent which corresponds to the testis. This remains as the tunica vaginalis testis.

CT, cavity of tunica vaginalis testis.

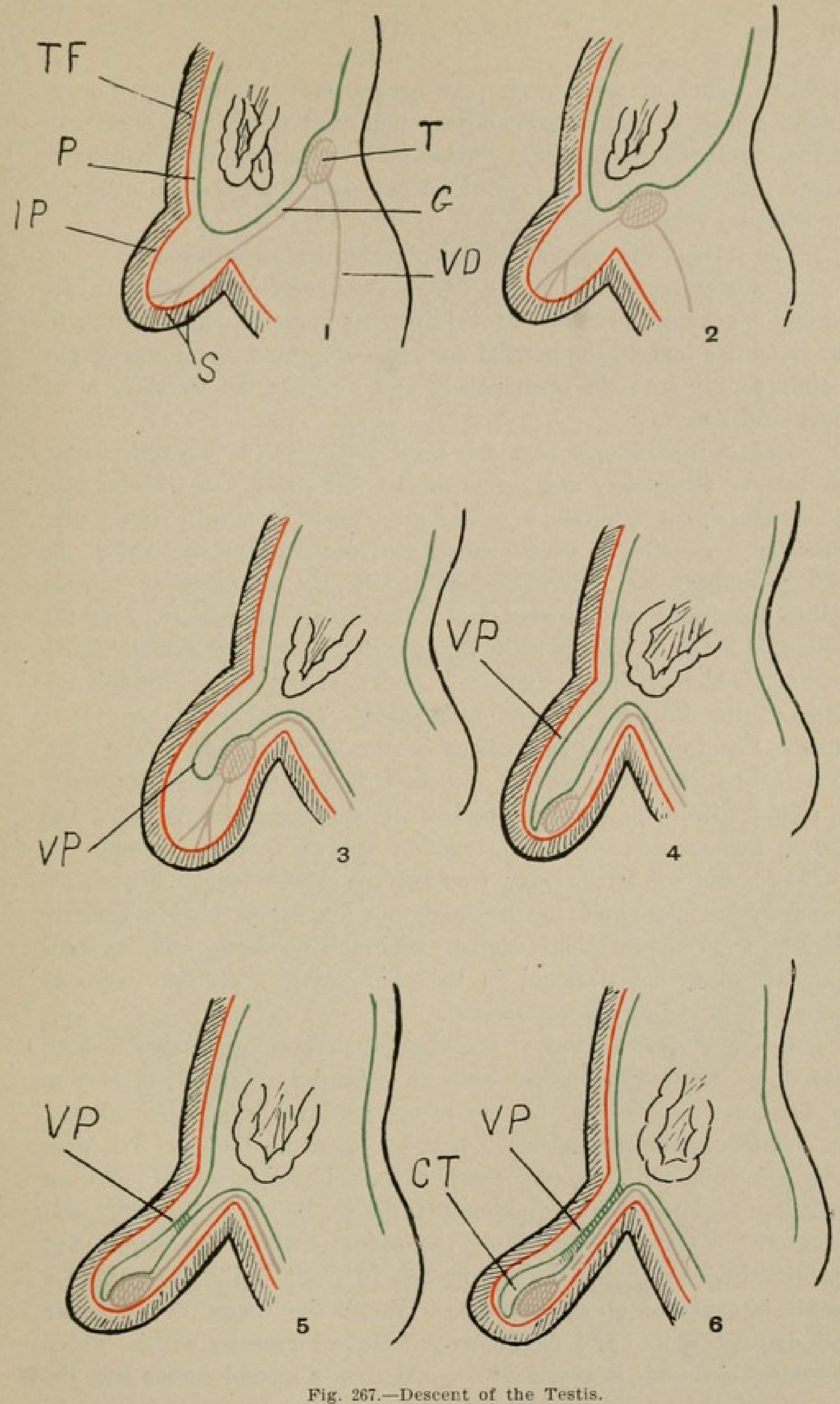

Fig. 267.—Descent of the Testis.

variety a pouch of peritoneum (the hernial sac)—containing, for example, a loop of gut—simply forces that part of the posterior wall of the inguinal canal that lies to the inner side of the deep epigastric artery before it into the inguinal canal, and finally down through the external ring.

The oblique variety may be either congenital or acquired.

A congenital hernia is due to the absence of obliteration in the vaginal peritoneal process. If this process remains patent throughout its entire length, the hernial contents—for example, a coil of gut—simply drop into the open pouch, and we have the usual form of congenital hernia.

An acquired oblique hernia is produced after the vaginal process has become completely and permanently obliterated. In this variety the contents—for example, a coil of gut—must force an entirely new pouch of peritoneum, which constitutes the hernial sac, before it. This peritoneal sac enters the mouth of the infundibular process ("internal ring") like a wedge, and works its way downward along the spermatic cord, inclosed within the sheath of the cord (infundibular process), which it simply distends; or else, after passing through the internal ring into the infundibular process (sheath of the cord), it causes a bulging of a circumscribed portion of the sheath of the cord, with the result that a pocket, or pouch, is formed, which is usually an offshoot from the proper sheath of the cord, and in this pouch the hernial peritoneal sac is found, together with the hernial contents.

An acquired hernia may traverse the whole length of the inguinal canal and enter the scrotum, but its sac is always entirely distinct from the original vaginal peritoneal process, and its contents are never to be found in the same cavity with the testis, as is the case in the congenital variety.

A partial obliteration of the vaginal process of the peritoneum may occur, and we may then have an infantile, or encysted, hernia. In this case the vaginal process is occluded at or near its mouth, but remains open throughout a part of its extent below. We then have a hernia, with its own newly acquired peritoneal sac, like an ordinary acquired hernia, passing through the internal ring and downward within the sheath of the cord, pushing the closed, but unobliterated, vaginal peritoneal process in front of it. When such a hernia is operated upon, it looks as though there were two separate and distinct sacs. The unobliterated vaginal process, within which the testis is found, is entered first, and then a second serous sac, the

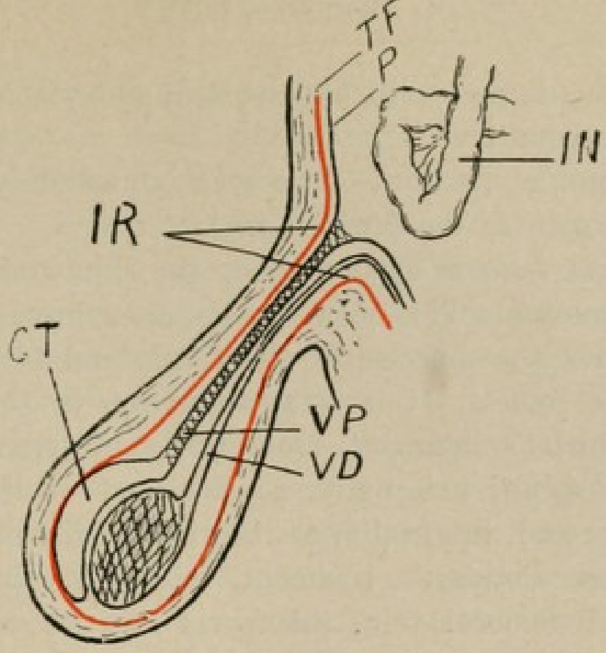

Fig. 268.—Normal Condition of Inguinal Region, Scrotum, etc. Testis in bottom of scrotum and vaginal process obliterated. *CT*, cavity of tunica vaginalis testis; *IN*, intestine within abdominal cavity; *IR*, internal inguinal ring—the mouth of the original infundibular process of the transversalis fascia; *P*, peritoneum lining abdominal cavity; *TF*, transversalis fascia; *VD*, vas deferens; *VP*, vaginal process of peritoneum—obliterated.

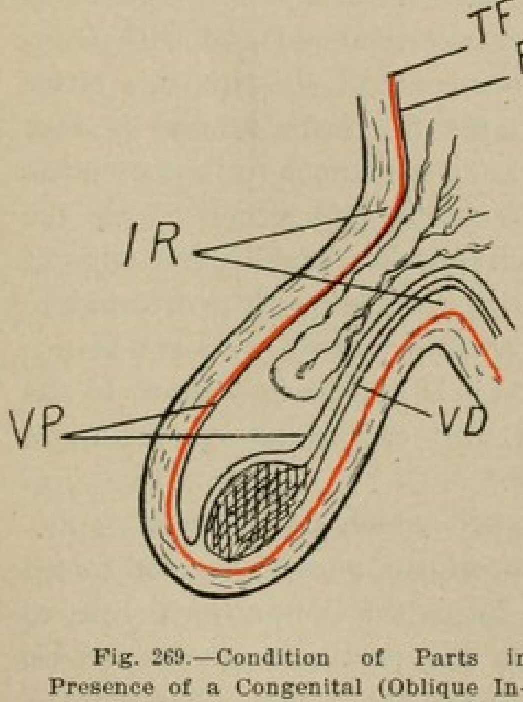

Fig. 269.—Condition of Parts in Presence of a Congenital (Oblique Inguinal) Hernia. Note that the vaginal process is patent, unobliterated, and that a coil of intestine has entered.

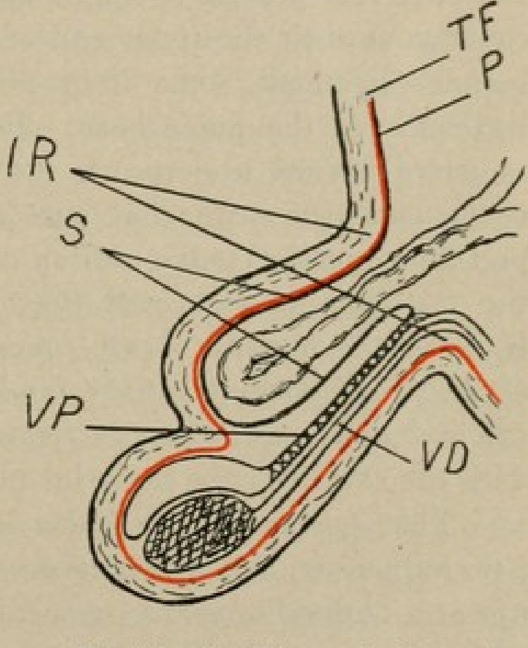

Fig. 270.—Condition of Parts in Presence of an Acquired Oblique Inguinal Hernia. Note that the vaginal process (*VP*) is obliterated and that a coil of intestine has pushed its way down into the original infundibular process (sheath of the spermatic cord), driving a new process of peritoneum (*S*) before it. This peritoneal process forms the sac of the hernia.

true hernial sac, is met with and incised, and within this the hernial contents are encountered.

THE FEMORAL REGION.—The area immediately below Poupart's ligament is known as the femoral region.

The Fascia Lata is exposed after the skin and superficial fascia have been removed. This is a strong, apenourotic layer which entirely surrounds the muscles of the thigh, and serves to bind them into a compact mass. It is attached above, in front, to the whole length of Poupart's ligament, from the pubic spine to the anterior superior iliac spine; externally, to the crest of the ilium; behind, to the sacrum; and, internally, to the rami of the pubes and ischium.

Just below Poupart's ligament, where the internal saphenous vein enters the femoral vein, the fascia lata presents an oval opening, the saphenous opening. It is only exposed after the cribriform fascia (that part of the deep layer of the superficial fascia which is attached to the margins of the saphenous opening) has been removed. The outer margin of the saphenous opening is sharp and curved, and was called by Allan Burns the falciform process. If the falciform process is traced upward and inward, it is found to be continuous with the inner end of Poupart's ligament and with Gimbernat's ligament, some of its fibers being attached, with this latter ligament, to the pubic bone. Below, the falciform process is seen to curve inward underneath the internal saphenous vein, becoming continuous here with that part of the fascia lata which covers the pectineus muscle (pubic portion of the fascia lata). The free edge of the falciform process, and that part of the fascia lata external to it, cover the femoral sheath upon its anterior aspect, and are known as the "iliac portion" of the fascia lata. It is attached above to the whole length of Poupart's ligament, and externally is continuous with the sheath of the sartorius muscle.

That portion of the fascia lata upon which the internal saphenous vein rests, and which covers the pectineus muscle, may be traced upward, under Poupart's ligament, as far as the ilio-pectineal line, to which it is attached, and from which the pectineus muscle arises. This is known as the "pubic portion" of the fascia lata. Beneath the femoral vessels this pubic portion of the fascia lata is continuous, externally, with the fascia which covers the ilio-psoas muscle (fascia iliaca). Above, under Poupart's ligament, this fascia, which covers the pectineus muscle, is thickened, and is known as the pubic ligament of Cooper. These two portions of the fascia lata, the iliac and pubic portions, are so arranged that a slit-like opening, the saphenous opening, exists between them, and through this the internal saphenous vein joins the femoral vein.

The femoral vessels, inclosed within their sheath, are sandwiched in between these two portions of the fascia lata, resting behind upon the fascia which covers the pectineus and ilio-psoas muscles, and covered in front by the iliac portion of the fascia lata. The two portions of the fascia lata, which have just been described, the iliac and pubic portions, are simply parts of one and the same fascia, and are seen to be directly continuous with each other, below the saphenous opening upon the front of the thigh. The pubic portion of the fascia lata, which corresponds to the pectineus muscle, is, as already said, continuous externally, behind the sheath of the femoral vessels, with the iliac fascia, which invests the ilio-psoas muscle. One should not confuse the names "iliac portion of the fascia lata" with "iliac fascia."

The Space Beneath Poupart's Ligament.—Through this space the ilio-psoas muscle and the anterior crural nerve and the femoral vessels pass out of the abdomen into the thigh.

The ilio-psoas muscle, with the anterior crural nerve, occupies the outer part of the space. The ilio-psoas muscle is a thick mass of muscle which has its origin within the abdomen from the iliac fossa, bodies of the lumbar vertebræ, etc. It consists of the psoas and iliacus muscles, and passes downward under Poupart's ligament into the thigh, where it is attached to the lesser trochanter of the femur and to the surface of the bone immediately below this.

Within the abdomen the ilio-psoas muscle is covered by a thick fascia, the fascia iliaca, which is attached to the bodies of the lumbar vertebræ and to the sacrum, to the crest of the ilium, and to the brim of the pelvis.

At Poupart's ligament, that part of the iliac fascia which covers the outer portion of the ilio-psoas muscle—*i.e.*, corresponding to the outer third of Poupart's ligament—does not pass down into the thigh with the muscle, but is attached to Poupart's ligament, whence it is reflected upward, becoming continuous with the transversalis fascia, which lines the whole posterior surface of the anterior abdominal wall. Internal to this, however, corresponding to the inner portion of the ilio-psoas muscle, the fascia which covers the muscle passes with the muscle, underneath Poupart's ligament, down into the thigh, and in the upper part of the thigh is continuous, behind the sheath of the femoral vessels, with the fascia which covers the pectineus muscle (pubic portion of the fascia lata). Immediately beneath Poupart's ligament the iliac fascia is thickened, and this thickened portion is called the ilio-pectineal ligament. This is not an isolated ligamentous band of fibers, but simply a thickened portion of the fascia iliaca as it passes with the ilio-psoas muscle under Poupart's ligament into the thigh. It extends from the junction of the outer and middle thirds of Poupart's ligament downward and inward to the ilio-pectineal eminence, and serves thus to divide the space underneath Poupart's ligament into two portions: an outer, the ilio-psoas space, which contains the ilio-psoas muscle and the anterior crural nerve, and an inner and upper, the femoral space, through which the femoral vessels pass from the abdomen into the thigh.

The femoral space is bounded above by Poupart's ligament; below, it is bounded externally by the ilio-pectineal ligament, and, internally, by the pubic ligament of Cooper. The so-called pubic ligament of Cooper is simply the thickened upper portion of the fascia which covers the pectineus muscle. Internally, the space is bounded by the sharp, curved edge of Gimbernat's ligament. The space is limited externally by the junction of Poupart's ligament and the ilio-pectineal ligament.

The Femoral Sheath.—As the femoral vessels pass into the thigh, through the femoral space, they are inclosed in a special connective-tissue sheath, and rest upon the ilio-psoas and pectineus muscles. The femoral sheath is a funnel-shaped connective-tissue envelope which is prolonged downward from the margins of the femoral space, inclosing the vessels as they pass into the thigh. Corresponding to its commencement at Poupart's ligament, the femoral sheath is wide-mouthed, and attached all around to the margins of the femoral space. Above, it is attached to Poupart's ligament; below, to the ilio-pectineal ligament (thickened portion of the fascia covering the ilio-psoas muscle) and to the ligament of Cooper (thickened upper portion of the fascia that covers the pectineus muscle). Internally, it is attached to the edge of Gimbernat's ligament. The femoral sheath is continued but a short distance downward upon the femoral vessels, becoming narrow and contracted below, and closely applied to the walls of the vessels.

The femoral sheath is divided into three compartments, which are entirely separate and distinct from each other, by connective-tissue septa. In the outer compartment the femoral artery is

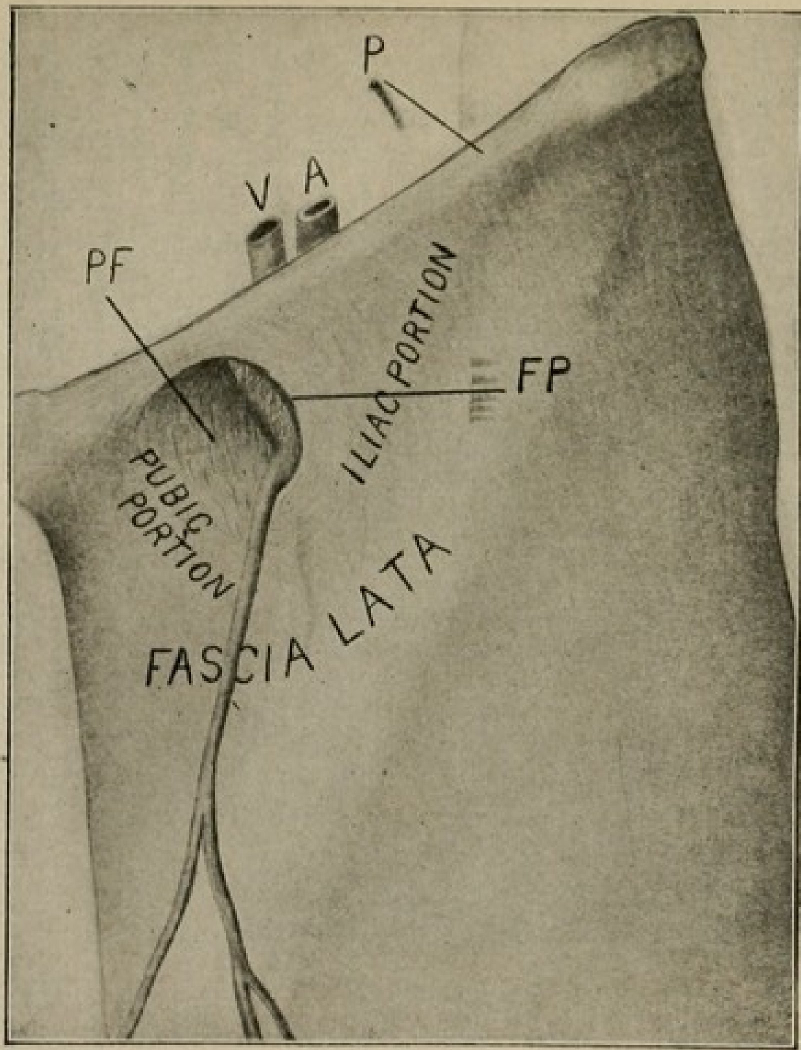

Fig. 271.—Superficial Femoral Region. *A*, femoral artery; *FP*, edge of falciform process; *P*, Poupart's ligament; *PF*, pectineal fascia (*i.e.*, that part of the pubic portion of the fascia lata that covers the pectineus muscle); *V*, femoral vein.

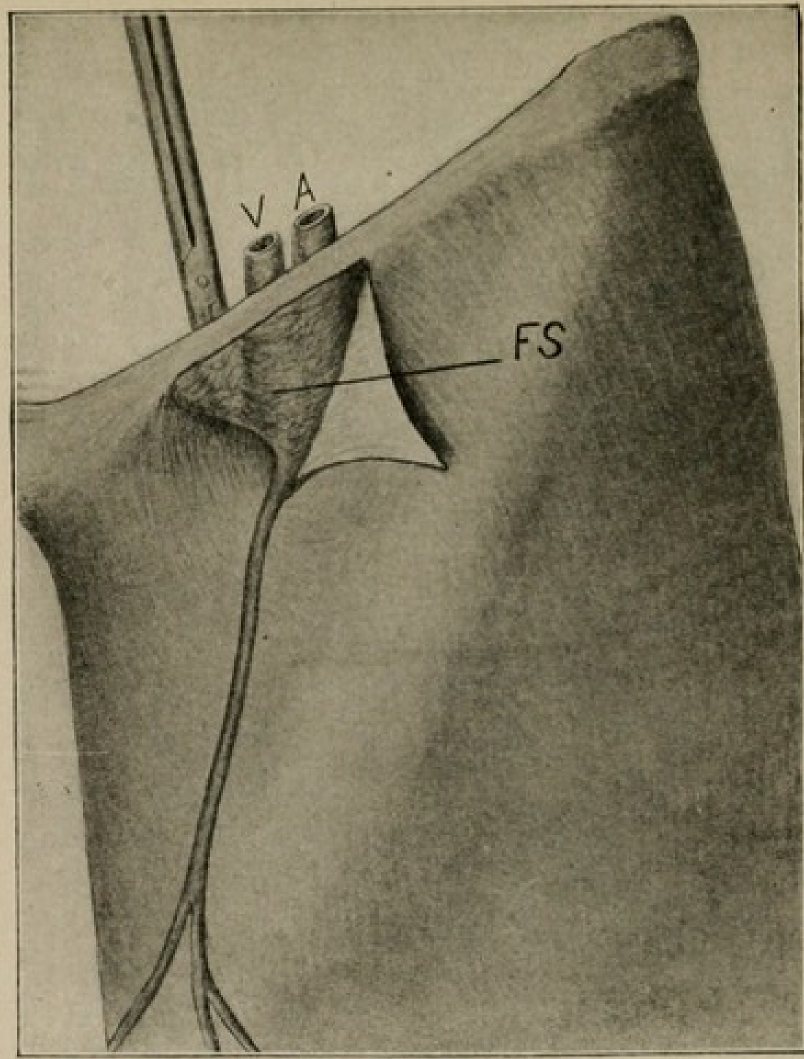

Fig. 272.—Superficial Femoral Region—Femoral Sheath. Falciform process adjoining part of the iliac portion of fascia lata has been reflected, showing the femoral artery (*A*) and the femoral vein (*V*) inclosed within their connective-tissue sheath (*FS*). The end of the artery forceps has been passed under Poupart's ligament into the inner compartment of the femoral sheath (*i.e.*, into the crural canal).

lodged; in the middle, the femoral vein; the inner compartment contains a lymphatic gland and some loose connective tissue, and gives passage to the lymphatic vessels that enter the abdomen from the lower extremity. This space, the inner, is called the crural canal. It is inclosed within the femoral sheath, and reaches from Gimbernat's ligament downward upon the inner side of the femoral vein as far as the junction of the internal saphenous vein with the femoral, at which point the crural canal ceases to exist, because here the femoral sheath is applied directly to the wall of the femoral vein.

The orifice of this crural space, or canal, is called the crural ring. The crural ring is bounded above by Poupart's ligament; below, by the pectineus muscle and the fascia which covers it, and which is here thickened and called the pubic ligament of Cooper; internally, by Gimbernat's ligament; and, externally, by the femoral vein. A femoral hernia, as it descends into the thigh, usually occupies this crural canal, lying to the inner side of the femoral vein, and, just above the junction of the internal saphenous vein with the femoral vein, where the crural canal terminates, it presents in the saphenous opening.

Study of the Inguinal and Femoral Regions from Within the Abdomen.—To examine these regions from within the abdomen, an incision is made through the anterior abdominal wall, on either side, passing from the umbilicus outward and then downward to a point just external to the anterior superior spine of the ilium.

THE INGUINAL REGION.—The bladder is seen to occupy the anterior median portion of the true pelvis, and when moderately full reaches as high as the symphysis. It will be observed that the peritoneum which covers the bladder is continued forward from the fundus of that organ over on to the posterior surface of the anterior wall of the abdomen, where it presents several folds, or ridges, which are caused by the projection of prominent underlying structures. These several ridges, or plicæ, converge in a direction upward, toward the umbilicus, and include between them areas which are more or less depressed, and which are called foveæ. In the middle line, reaching from the summit of the bladder upward to the umbilicus, the peritoneum is raised in the shape of a fold by the superior ligament of the bladder, the remains of the fœtal urachus. External to this, passing from either side of the body of the bladder upward to the umbilicus, there is a fold, beneath which the obliterated hypogastric artery runs. Still more externally there is another fold, which corre-

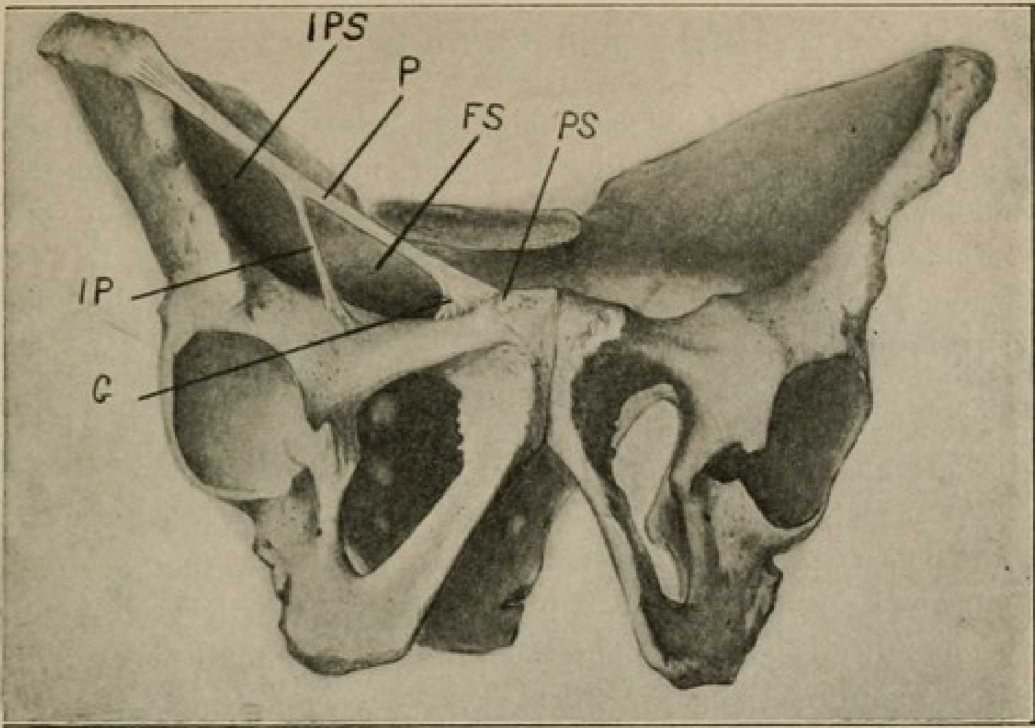

Fig. 273.—The Pelvis and Ligaments of the Ilio-pubic Region. *FS*, femoral space; *G*, Gimbernat's ligament; *IP*, ilio-pectineal ligament; *IPS;* ilio-psoas space; *P*, Poupart's ligament; *PS*, pubic spine.

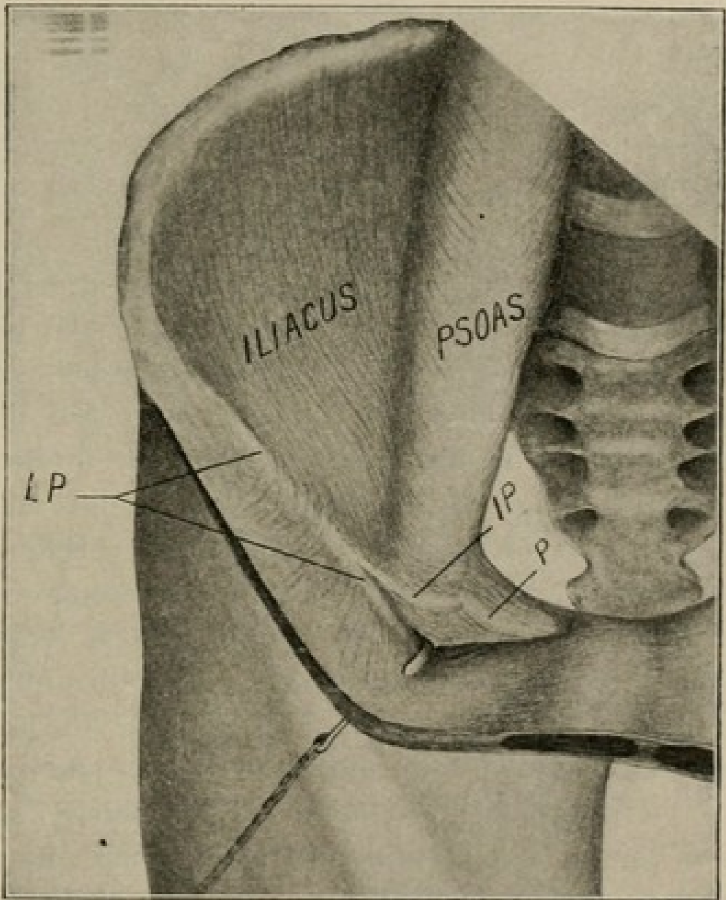

Fig. 274.—Femoral Space. Femoral vessels and sheath as they pass under Poupart's ligament have been cleared away. Poupart's ligament lifted upon hook. The iliacus and psoas muscles are covered by their fascia, the fascia iliaca; *IP*, ilio-pectineal ligament—thickened portion of the fascia that invests the ilio-psoas muscle; *LP*, Poupart's ligament; *P*, pubic ligament of Cooper—upper thickened part of the fascia that covers the pectineus muscle.

sponds to the course of the deep epigastric artery; this is a large vessel given off from the external iliac (femoral) just before it passes out of the abdomen under Poupart's ligament, and is accompanied by one or two veins. The peritoneal folds are named, respectively, the plica vesico-umbilicalis media, corresponding to the urachus, in the middle line; the plica vesico-umbilicalis lateralis, corresponding to the obliterated hypogastric artery; and the plica epigastrica, corresponding to the epigastric artery and vein. Between these peritoneal folds, or plicæ, are the foveæ, already mentioned, which are deeper in some subjects than in others. External to the plica epigastrica is the fovea inguinalis externa. Between the plica epigastrica and the plica vesico-umbilicalis lateralis is the fovea inguinalis interna. Between the plica vesico-umbilicalis lateralis and the plica vesico-umbilicalis media is the fovea supravesicalis.

The Fovea Inguinalis Externa.—After the peritoneum has been stripped off from this area, and some loose connective tissue (subperitoneal connective tissue) which lies beneath it has been removed, we expose the transversalis fascia. This fascia presents the opening into the infundibular process, the so-called "internal ring," which is located about half an inch above the middle of Poupart's ligament. The vas deferens, spermatic artery, veins, etc., structures of which the spermatic cord is formed (in the female, the round ligament), pass into this opening. The lower, inner, margin of the internal ring presents a distinct, sharp, crescentic edge. A probe or the finger can be introduced into the internal ring, and may be insinuated for a greater or less distance into the sheath of the spermatic cord, infundibular process. About the internal ring the peritoneum is more or less plaited upon itself, and is adherent to the margins of the ring, and may bulge for a certain distance into it. A fibrous cord passes from the peritoneum into the internal ring, and may be traced downward into the infundibular process along with the other constituents of the spermatic cord. This fibrous band, or string, represents the shrunken, obliterated vaginal process of peritoneum which accompanies the testis in its descent into the scrotum. Directed upward and inward toward the umbilicus, and passing to the inner side of the internal ring, is the deep epigastric artery, with its accompanying vein. If a hernial protrusion occurs in this location, the process of peritoneum which forms the sac of the hernia forces its way through the internal ring (to the outer side of the deep epigastric), and gradually works its way downward within the fibrous

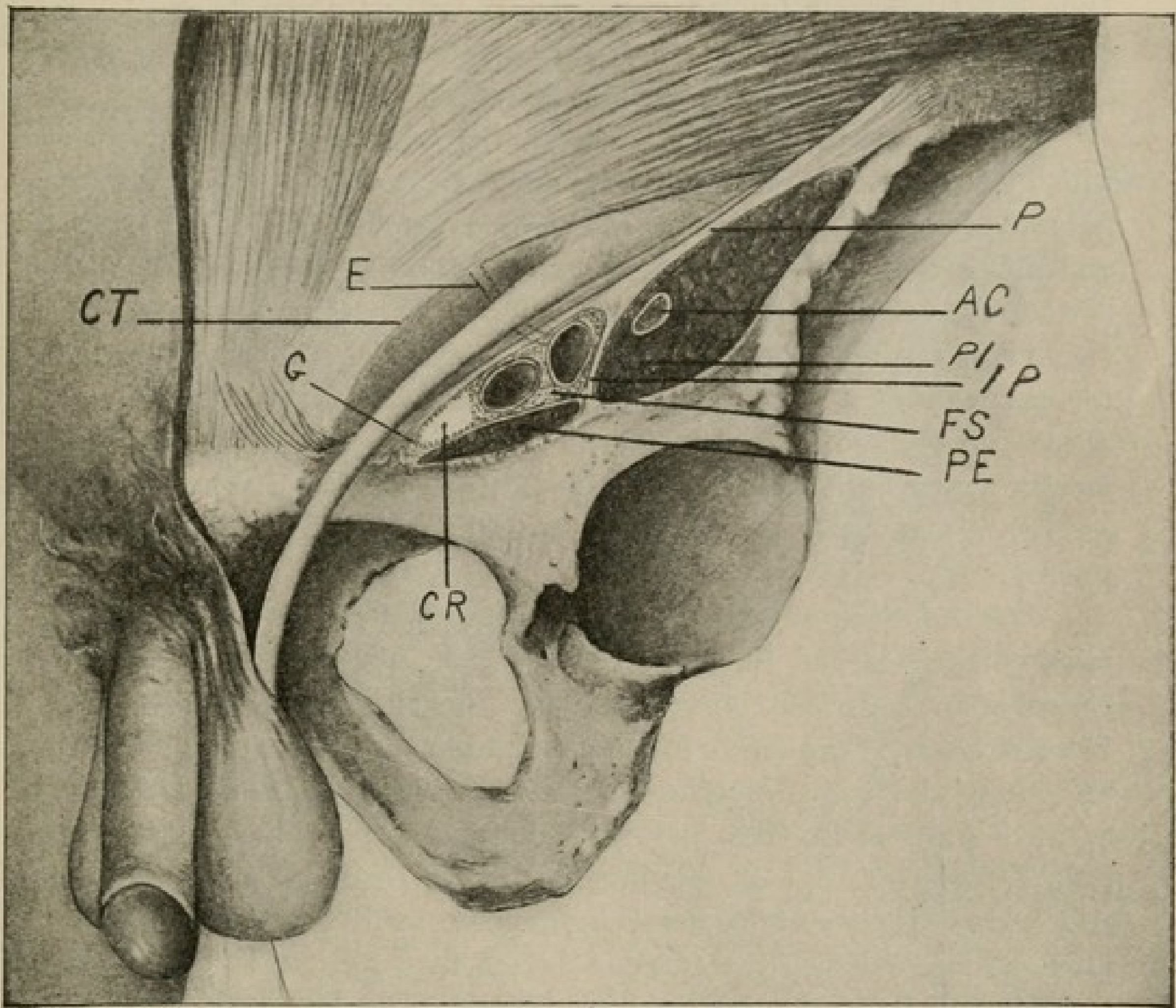

Fig. 275.—Deep Femoral Region—the Femoral Vessels, etc., Cut Across as they Emerge Under Poupart's Ligament. *AC*, anterior crural nerve; *CT*, edge of the conjoined tendon; *CR*, crural ring; *E*, dotted line indicates the course of the deep epigastric artery; *FS*, femoral sheath; *G*, Gimbernat's ligament; *IP*, ilio-pectineal ligament; *P*, Poupart's ligament; *PE*, pectineus muscle. This muscle rests upon the pubic bone and is covered by its fascia,—the pectineal fascia,—which is somewhat thickened immediately beneath Poupart's ligament, where it is known as the pubic ligament of Cooper. It will be noticed that the femoral sheath is divided into three compartments: the outer for the femoral artery; the middle for the femoral vein; the inner (*CR*) is the crural ring, the mouth of the crural canal.

sheath of the cord, which is the remains of the original infundibular process, and we then have a typical external, or oblique, inguinal hernia. The coverings of this variety of hernia, from within outward, are, besides its peritoneal sac, the infundibular fascia (pouch derived from fascia transversalis), cremaster muscle and fascia, deep layer of the superficial fascia (spermatic fascia), superficial layer of the superficial fascia (fat), and the skin.

If a congenital hernia is present, the vaginal peritoneal process which accompanied the testis in its descent into the scrotum is found patent, unobliterated, reaching downward through the internal ring and along the cord within its sheath (infundibular process) to the bottom of the scrotum.

The coverings of a congenital hernia are the same as those given for the oblique, or external, acquired variety. The difference between the oblique acquired and the congenital is that the acquired must form a peritoneal sac for itself, whereas the congenital finds its sac already present; *i.e.*, the unobliterated vaginal peritoneal process.

The Fovea Inguinalis Interna.—This is the space between the plica epigastrica and the plica vesico-umbilicalis lateralis. After the peritoneum has been stripped away from this part we expose the transversalis fascia. The fovea inguinalis interna is the part which is involved in direct inguinal hernia. It presents no opening. In the event of a direct inguinal hernia, a bulging or pouching of this part of the posterior wall of the inguinal canal occurs, and the hernial sac, composed of the parietal peritoneum, will have as coverings, from within outward, the various layers that form this part of the posterior wall of the inguinal canal, viz., the fascia transversalis, the conjoined tendon, and the triangular ligament, and, in addition, the deep layer of the superficial fascia (spermatic fascia), the superficial layer of the superficial fascia (fat), and the skin.

The neck of the sac in a direct inguinal hernia lies to the inner side of the deep epigastric vessels.

Fovea Supravesicalis.—This is the space between the plica vesico-umbilicalis lateralis and media. Its floor is formed by the rectus muscle. This region is of but little surgical interest, and is not the site of hernial protrusions.

The Femoral Region.—Below Poupart's ligament we have the femoral region. This part is, at times, depressed, and is called the fossa cruralis. If we dissect away the peritoneum, we expose Pou-

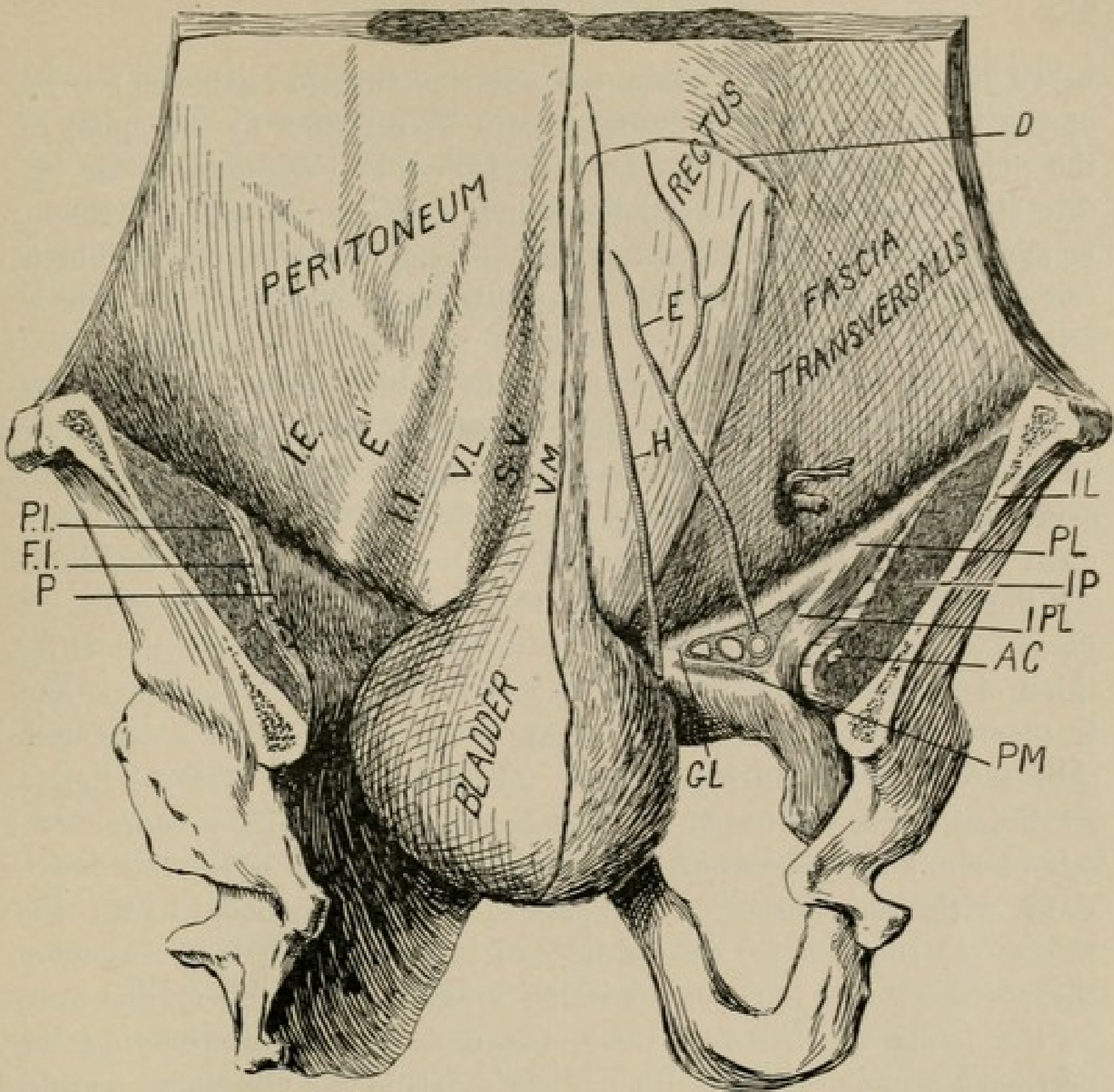

Fig. 276.—The Inguinal and Femoral Regions from Within the Abdomen. Upon the right side the peritoneum has been stripped off, exposing the transversalis fascia. *AC*, anterior crural nerve imbedded in the ilio-psoas muscle; *D*, semilunar fold of Douglas—the lower edge of the posterior layer of the sheath of rectus; *E*, deep epigastric artery; *E*[1], plica epigastrica (the deep epigastric vessels are situated beneath this fold); *F.I.*, cut edge of the fascia iliaca, which invests the ilio-psoas muscle; *GL*, Gimbernat's ligament; *H*, obliterated hypogastric artery; *I.E.*, fovea inguinalis externa; *I.I.*, fovea inguinalis interna; *IL*, sawn surface of the ilium; *IPL*, ilio-pectineal ligament, a thickened portion of the iliac fascia; *P*, cut edge of the peritoneum; *P.I.*, cut edge of the ilio-psoas muscle; *PL*, Poupart's ligament; *PM*, pectineus muscle covered by its fascia, which is here somewhat thickened and is known as the pubic ligament of Cooper; *SV*, fovea supravesicalis; *V.L.*, plica vesico-umbilicalis lateralis (the obliterated hypogastric artery lies beneath this fold); *V.M.*, plica vesico-umbilicalis media (the urachus, which reaches from the fundus of the bladder to the umbilicus, is situated beneath the fold). Above the middle of Poupart's ligament there is an opening in the transversalis fascia—internal inguinal ring—mouth of the infundibular process. The vas deferens and other component parts of the spermatic cord which pass in and out of the abdomen through this orifice have been cut short in the picture; this opening is the exit for indirect inguinal hernia. Beneath Poupart's ligament the femoral vessels, inclosed with their sheath, are seen. These structures have been divided close to Poupart's ligament. The femoral sheath occupies the space described as the femoral space, and is divided into three compartments—the outer for the artery and the middle for the vein; the orifice of the inner compartment is called the crural ring.

part's ligament, passing from the anterior superior spinous process of the ilium inward and downward, to be attached to the spine of the pubes. From the lower border of Poupart's ligament, just before its attachment to the pubic spine, a triangular band of fibers, which is attached to the ilio-pectineal line, is given off. This is called Gimbernat's ligament. Its sharp outer edge may be readily felt.

Between Poupart's ligament and the pubic bones there is a large space through which the ilio-psoas muscle and anterior crural nerve and the femoral vessels pass into the thigh. The ilio-psoas muscle arises within the abdomen and passes down toward Poupart's ligament in one mass, which is invested by a strong fascia, the iliac. At Poupart's ligament, the fascia that covers the outer part of the psoas-iliacus—*i.e.,* that part of it which corresponds to the outer third of Poupart's ligament—is attached to Poupart's ligament, and is thence reflected upward, becoming continuous with the transversalis fascia, which lines the whole posterior surface of the anterior abdominal wall. Internal to this, however, where the femoral vessels pass out under Poupart's ligament, the fascia is continued downward with the muscle underneath Poupart's ligament, into the thigh. As the femoral vessels descend into the thigh they rest upon the pectineus and ilio-psoas muscles, separated from them, however, by the fascia which covers them, the pectineal fascia[1] covering the pectineus muscle, and the iliac fascia covering the ilio-psoas muscle.

The fascia iliaca, immediately beneath Poupart's ligament, is thickened, and is called the ilio-pectineal ligament. It reaches from the junction of the outer and middle thirds of Poupart's ligament to the ilio-pectineal eminence, and serves to divide the space under Poupart's ligament into two portions: that for the ilio-psoas muscle and anterior crural nerve, below and externally, and that through which the femoral vessels pass, above and internally. This latter is called the femoral space. The boundaries of the femoral space are, above, Poupart's ligament; below and externally, the ilio-pectineal ligament (thickened portion of the iliac fascia); below and internally, the pubic ligament of Cooper (the upper thickened portion of the fascia that covers the pectineus muscle); internally, the edge of Gimbernat's ligament.

As the femoral vessels pass down through the femoral space

[1] That part of the pubic portion of the fascia lata that covers the pectineus muscle.

into the thigh, they are inclosed in a connective-tissue sheath, which is prolonged downward from the margins of this space. It is called the femoral sheath. The femoral sheath is divided into three compartments by septa: the outer contains the artery; the middle one, the vein; the innermost, that between the vein and the edge of Gimbernat's ligament, is the so-called crural canal, and gives passage to lymphatics from the thigh to the abdomen. The abdominal orifice of the crural canal is called the crural ring.

In the event of a femoral hernia, a process of peritoneum (hernial sac) is forced into the crural ring and down through the crural canal, appearing below in the upper part of the thigh in the saphenous opening.

The coverings of a femoral hernia, from within outward, are, besides its peritoneal sac, the femoral sheath, the deep layer of the superficial fascia (the cribriform fascia), the superficial layer of the superficial fascia (fat), and the skin.

The Obturator Foramen.—This foramen is located below the brim of the pelvis. It is an opening in the upper part of the obturator membrane, between its upper edge and the lower border of the ramus of the pubes. This foramen gives exit to the obturator artery, vein, and nerve, and is sometimes the site of a hernial protrusion. The obturator artery usually arises from the external iliac, passes forward just below the brim of the pelvis, and out through the obturator foramen into the thigh. Occasionally, however, this artery is derived from the deep epigastric, close to the origin of this vessel from the external iliac (femoral), and in its course to reach the obturator foramen it is found in close proximity to the margin of the crural ring. After its origin from the deep epigastric, in its course to reach the obturator foramen, it either passes around the upper and inner margins of the crural ring or else it descends close to the inner wall of the femoral vein and behind the outer border of the crural ring.

OPERATIONS FOR HERNIA.

Herniotomy.—Incision of the coverings of a hernia, opening into the sac, and the division of constricting rings or bands constitute the operation of herniotomy. The operation is done for the purpose of liberating a strangulated hernia. The constriction may be caused by bands in the body of the sac or by the neck of the sac itself, but in most cases it is probably caused by the firm, unyielding ring by which the neck of the sac is encircled.

At one of the usual sites of a hernial protrusion there is found a tense, elastic tumor. The incision is placed over the most prominent part of the tumor, cutting carefully through the skin and the deeper layers until the sac proper is reached. The sac may then be pinched up with two forceps and incised between them, when there is an escape of serous fluid, and the contents of the sac are exposed.

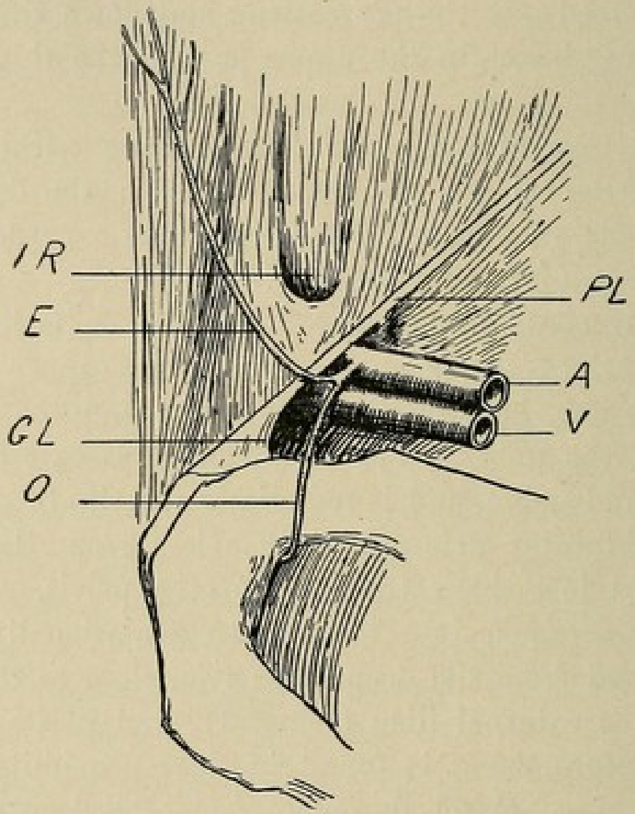

Fig. 277.—Irregular Origin of Obturator Artery. In its course into the pelvis it lies close to the inner side of the femoral vein. *A*, femoral artery; *E*, deep epigastric artery; *GL*, Gimbernat's ligament; *IR*, internal inguinal ring; *O*, obturator artery; *PL*, Poupart's ligament; *V*, femoral vein. The space between the femoral vein and Gimbernat's ligament is known as the crural ring, and through this femoral hernia leaves the abdomen.

The contents vary; they may consist of intestine, large or small; of omentum, or of both; and occasionally there may be other organs, such as the bladder, ovary, etc. After the sac has been freely opened, its contents should be examined. Any constricting bands in the body of the sac should be divided, and an attempt then made to pull the gut down so as to ease it at the point of constriction; but in this effort much force should not be used. An effort is made to insert the finger into the neck of the sac, and, if this is successful, a probe-pointed, curved knife may be introduced upon the finger and the constricting ring incised. If one is unable to insert the finger into the neck of the sac, a director may be carried through, and upon this the ring may be divided. In freeing the constriction, a succession of nicks should be made rather than a single free cut, and these may be repeated until the parts are liberated.

For the relief of an indirect inguinal hernia the incision in the

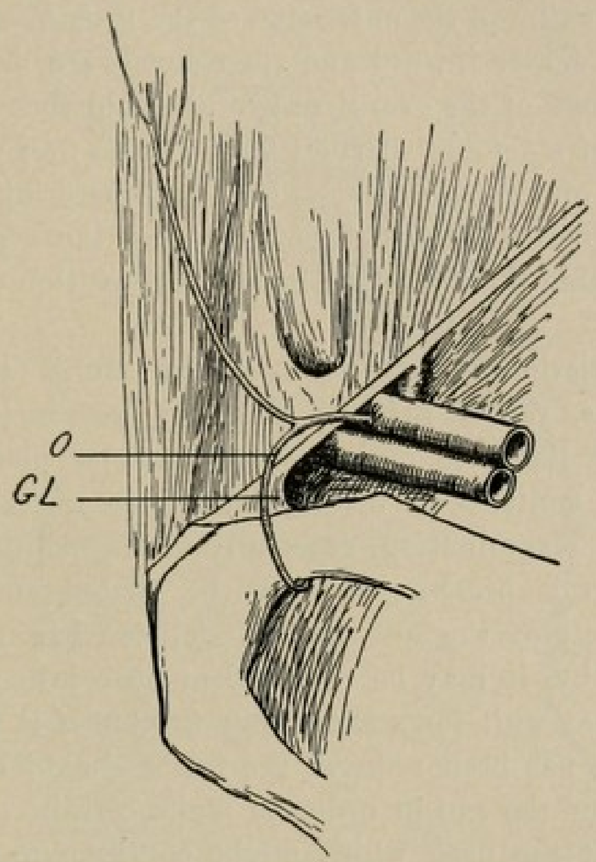

Fig. 278.—Irregular Origin of Obturator Artery. In its course into the pelvis it curves around the upper and inner edge of the crural ring. Letters same as 277.

constricting ring should be directed upward. For a direct inguinal hernia the incision should be directed upward and inward, toward the umbilicus. For a femoral hernia the incision should be directed inward toward Gimbernat's ligament and somewhat upward.

For practical purposes, if in doubt as to the exact variety of the hernia, the direction of the liberating incision for both varieties of inguinal and for femoral hernia may be upward and inward, toward the umbilicus. By cutting in this direction, upward and inward, toward the umbilicus, we work in a line which is parallel with the course of the deep epigastric vessels, and the danger of wounding these is thus obviated.

Occasionally the obturator artery, as described above, is given off from the deep epigastric, and in its course to reach the obturator foramen this vessel would then have a close relationship to the neck of the sac of a femoral hernia. From its origin, at the deep epigastric, the obturator artery either descends close to the inner wall of the femoral vein, and therefore behind the outer margin of the crural ring, and would thus lie to the outer side of the neck of a femoral hernial sac, or else it curves inward and then downward, behind the upper and inner borders of the crural ring, and would then lie above and to the inner side of a femoral hernial sac. In the first case, this vessel would be out of the way in making the liberating incisions at the crural ring, whereas in the second instance the vessel would be jeopardized in making the liberating incisions if caution were not exercised.

If the constriction at the neck of the sac is relieved by a succession of nicks, rather than by a single free incision, we will be very much less liable to divide an abnormally placed obturator artery. After the contents of the sac have been liberated they may be drawn down for examination, especially at the points of constriction. If omentum is present, this may be ligated and amputated. As to the treatment of the gut, careful deliberation must be used. If the gut is healthy, it may be returned at once into the abdomen. If doubtful, one may wait for a short time to note if it tends to clear up. After the gut has been reduced the finger should be introduced through the neck of the sac in order to make certain that there are no adhesions about the neck which might continue to constrict the gut.

If the gut is gangrenous, or too doubtful to return into the abdomen, the incision in the abdomen at the neck of the sac should be enlarged and the gut drawn down and resected; or else the gut may be allowed to remain without disturbing the adhesions about the neck of the sac, and an artificial anus made by incising the strangulated coil of gut, if it has not already sloughed through. The wound, under these circumstances, should be left open and packed.

Radical Operation for Inguinal Hernia (Bassini Method). For an Oblique Acquired Hernia.—An incision is made through the skin, commencing at a point half an inch above and somewhat external to the middle of Poupart's ligament, carrying it downward and inward as far as the spine of the pubes; or it may be prolonged for a short distance downward upon the scrotum, if necessary. This incision penetrates into the subcutaneous fatty layer. In its upper part the incision should be deepened until the fibers of the aponeurosis of the external oblique are plainly visible. The fingers are then introduced into this upper, deeper part of the incision, and it

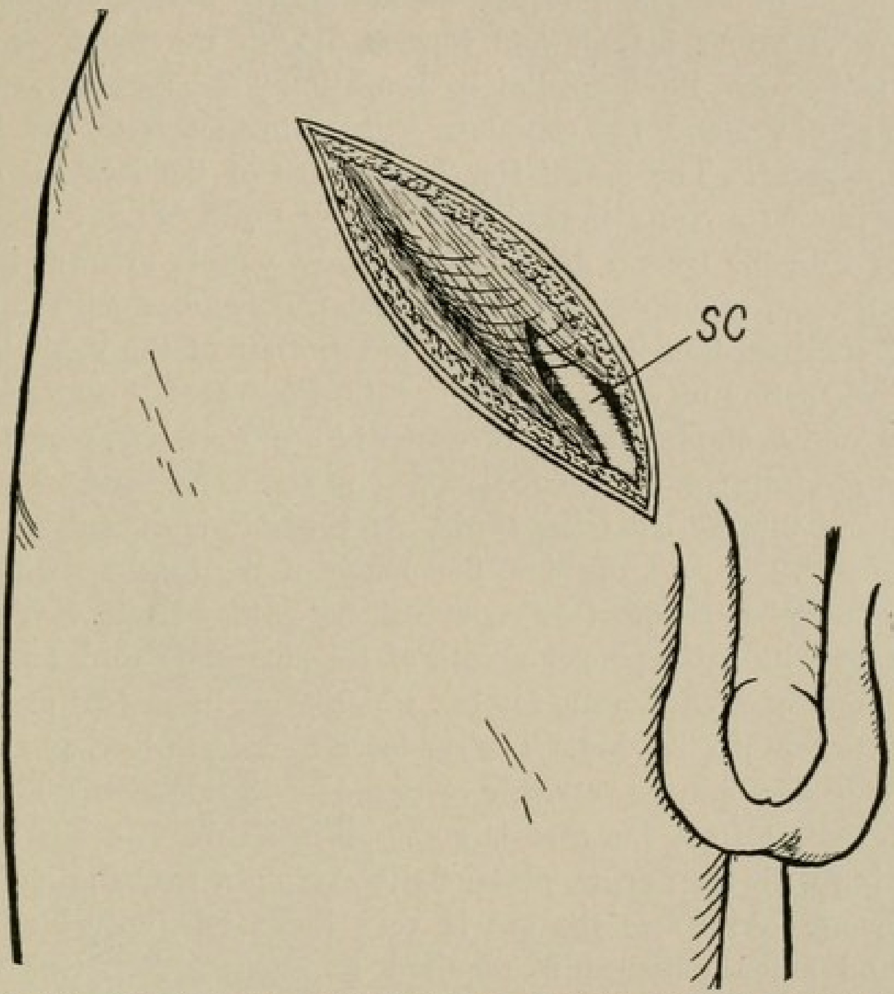

Fig. 279.—Operation for Inguinal Hernia. Incision penetrates through the skin and fat, exposing the aponeurosis of the external oblique. *SC*, spermatic cord emerging from the external inguinal ring.

is torn open down to its lower end. After this has been done the apenourosis of the external oblique and the pillars of the external ring, through which the cord emerges, are exposed.

Any bleeding points are caught in artery forceps; but it is not necessary to ligate them immediately, as the hemorrhage usually ceases after a few minutes' compression.

A blunt director is now passed into the external ring, and carried upward and outward beneath the aponeurosis of the external oblique to a point beyond the middle of Poupart's ligament, the location of the "internal ring," and upon this the aponeurosis is divided. Some obstruction to the introduction of the director through the external ring will be experienced if the deep layer of the superficial fascia, which is attached to the margins of the ring, has not been incised.

The edges of the split aponeurosis of the external oblique are seized with artery forceps and separated with the finger from the structures which lie immediately beneath. The inguinal canal is thus laid open, and the spermatic cord, together with the hernial sac, is exposed. The lower, free fleshy edge of the internal oblique muscle is seen arching inward over the cord and hernial sac. It is blended with the tendon of the transversalis muscle to form the conjoined tendon, which descends behind the cord, and which can be felt as a strong, resistant band attached to the crest of the pubic bone.

The spermatic cord, together with the hernial sac, which is usually found empty unless its contents are irreducible or the patient is straining, is now hooked up, upon the finger, and we proceed to separate the sac from the cord. At times it is difficult to recognize the sac. It is formed of the pouch of peritoneum, with some loose connective tissue (subperitoneal connective-tissue layer) and is situated within the proper sheath of the spermatic cord (infundibular process of transversalis fascia), which must be incised or torn in order to expose it (the sac). The sac has a peculiar, white, aponeurotic appearance, and may be very thin or of moderate thickness. The isolation of the sac from the cord is accomplished chiefly by tearing and separating with the fingers, occasionally cutting a resisting band with the scissors. At times the sac is very intimately united with the cord, and much patience is required to separate it. One should recognize the vas deferens, and constantly be familiar with its location, in order to avoid injuring it. In isolating the sac, one may have considerable hemorrhage from the pampiniform plexus of veins, which runs along with the vas deferens, etc., in the cord. It usually ceases, however, after clamps have been applied to the bleeding points for a few minutes. If one of the arterial branches which run in the cord is torn, it will be necessary to apply a ligature. One may begin the separation of the sac from the cord above at the neck of the sac and work downward, toward its lower part (fundus), or commence at the fundus and work upward, toward the neck. The

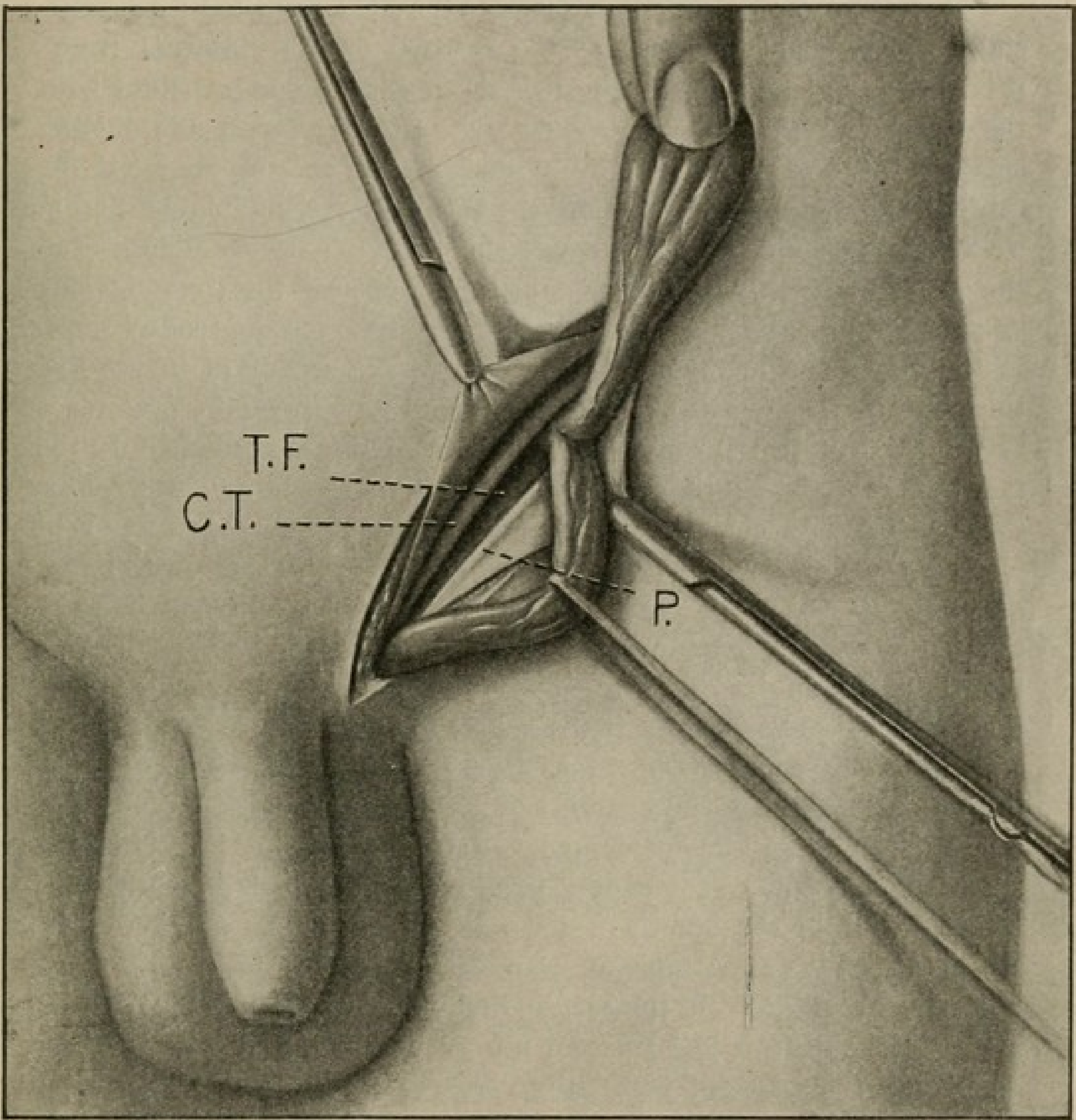

Fig. 280.—Bassini Operation for Inguinal Hernia. The inguinal canal laid open by splitting the aponeurosis of the external oblique. The edges of the split aponeurosis seized with artery forceps and drawn aside. Spermatic cord retracted with a loop of silk. The hernia sac, unopened, has been detached from the spermatic cord and reflected upward and outward; *C.T.*, edge of conjoined tendon; *P.*, edge of Poupart's ligament; *T.F.*, transversalis fascia which forms the posterior wall of the inguinal canal.

operator may assist himself in separating the sac from the cord by incising it in order to introduce the finger into it, and thus inform himself of its limits.

After the sac has been completely separated from the cord, especially above, about the neck at the location of the "internal ring," it is raised, and (if not already incised) is seized by an assistant with the fingers of both hands, or with two artery forceps, and incised between them with the knife. In incising the sac, especially if the contents are adherent, or if operating upon a strangulated hernia when there is much distension, one should use caution not to wound the parts within. After the sac has been opened the contents may be reduced, and, if there are no adhesions, this is very readily done. If there is a considerable amount of prolapsed omentum in the sac, this may be tied off with stout catgut and amputated in preference to returning it to the abdomen. If the contents are adherent to the sac, they must be gently separated before they can be reduced. This can usually be accomplished with the finger, taking care to avoid tearing the gut, and ligating any points that bleed freely. Dense adhesion bands may be first tied double and then divided between the ligatures. If omentum is adherent within the sac, it may be ligated and amputated. The contents should be free, especially at the neck of the sac, in order that they may be properly reduced.

After the sac has been emptied we may tie it off. The finger is introduced into the sac and carried well within its mouth, and a catgut ligature (No. 2) thrown around its neck. As this ligature is drawn tight and tied, one should feel it slip over the end of the finger, which is within the mouth of the sac. It should be applied about the neck of the sac as high up as possible, in order to avoid leaving any pouched portion of the sac to invite the recurrence of the hernia. The ligature is left long for use as a tractor, and the sac is cut away, about one-fourth inch distal from the ligature. Then, after a final examination of the stump of the sac, the ends of the ligature are cut short, and the stump of the sac allowed to retract into the abdomen. If the sac is rather wide-mouthed, instead of simply surrounding it with a ligature one may transfix it with a ligature carried in a curved needle and tie double.

The next step in the operation is the strengthening of the posterior wall of the inguinal canal, and this is done by approximating the free edge of the internal oblique and transversalis muscles (conjoined tendon) above to Poupart's ligament below. While this is

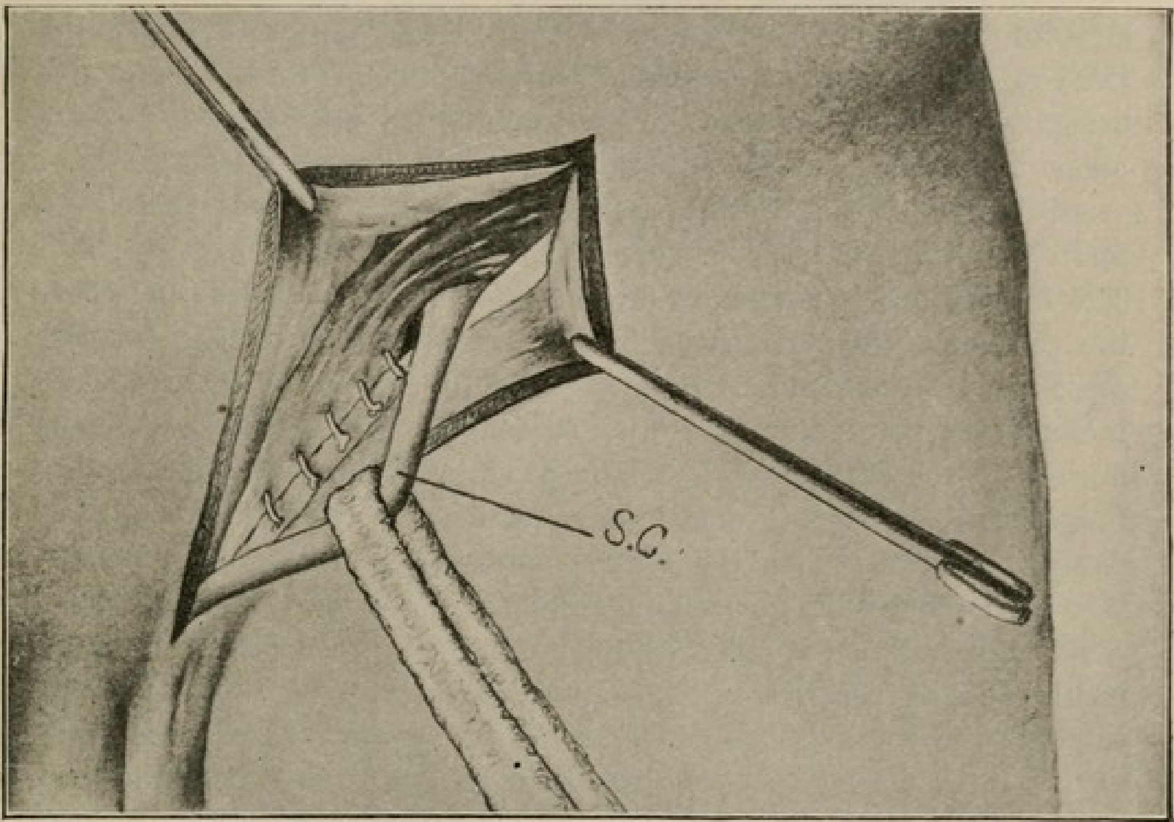

Fig. 281.—The Bassini Operation. The edges of the split aponeurosis held aside with artery forceps. Conjoined tendon sutured to the edge of Poupart's. Spermatic cord (*C.S.*) drawn aside with a tractor.

being done the spermatic cord is held out of the way of the operator upon a strip of gauze, and the upper edge of the divided aponeurosis of the external oblique, which is held in an artery forceps, is retracted, in order that the edge of the internal oblique and transversalis (conjoined tendon) may be made out. These parts can be readily seen and may be plainly felt by the finger in the wound. Poupart's ligament is likewise freely exposed, when the lower edge of the aponeurosis of the external oblique is strongly retracted. This structure may be recognized as a sharp, white band. These parts, the conjoined tendon above and Poupart's ligament below, are now brought together with three to five interrupted sutures of some permanent material, such as silk, silver wire or kangaroo tendon—kangaroo tendon is the most satisfactory material. These sutures are introduced with a large, curved needle grasped in a needle holder. The first suture is placed externally, just to the inner side of where the cord emerges from the abdomen; the last one or two sutures, those nearest the middle line, should take a sufficiently broad bite to include, together with the conjoined tendon, the edge of the rectus muscle. Each suture should take a good, broad bite. In introducing the sutures through Poupart's ligament there is said to be some danger, especially with the middle sutures, of piercing the femoral vein with the needle. This might happen if the needle were inserted too deeply, but this is not necessary, as a good, broad bite of the ligament is easily secured without introducing the needle deep enough to reach the vein. The sutures are left long, and are not tied until all are introduced. Usually three or four sutures suffice; sometimes five are necessary. The most external suture is the most important and should be placed so as to leave just space enough for the cord to emerge comfortably without constriction between the edge of the internal oblique and transversalis above and Poupart's ligament below. When the sutures are tied, the edge of the internal oblique and transversalis muscles (conjoined tendon) and Poupart's ligament are seen to be closely approximated, and in this way there is formed a solid posterior wall to the inguinal canal, upon which the cord rests when it is dropped back into the wound. The edges of the split aponeurosis of the external oblique are now brought together over the cord with a continuous suture of catgut, simple or chromicized, No. 2. This suture is commenced above and externally, and terminates below at the site of the former external abdominal ring. In this way the anterior wall of the inguinal canal is restored, and beneath this the cord is situated. One should take care that the cord is not gripped too tightly between the posterior and anterior walls of the new canal, and that, at the site of the external ring, sufficient space is left for the cord to emerge without danger of its becoming strangulated.

The wound should be dry—free from oozing. No drainage is necessary. The incision in the skin may be closed with a continuous intracuticular catgut suture.

In the female this operation is simplified in that we have no spermatic cord to consider; the round ligament, its analogue, is simply cut away, and the deep sutures which strengthen the posterior wall of the inguinal canal introduced in the manner described above.

For a Congenital Hernia.—In this variety of hernia the sac is formed of the unobliterated vaginal process of the peritoneum, at the bottom of which the testis usually lies. In some cases the testis does not reach the bottom of the scrotum in its descent, and may remain stationary, in any part of the inguinal canal or within the abdomen, when it may be wise to remove it. The incision in the skin and aponeurosis of the external oblique are made as in the foregoing operation. After the inguinal canal has been laid open, the cord, together with the sac, is picked up, upon the finger. The hernial sac is really included within the proper sheath of the cord, infundibular process, and its isolation from the elements of the cord may be somewhat difficult. The sheath of the cord (infundibular process of the transversalis fascia) must be incised or torn through in order to reach the sac. In separating the sac we may commence above at the neck of the sac, and work downward, toward the testis. After the sac has been separated from the cord, vas deferens, etc., to a point which is just above the testis, it is opened and its contents reduced. The sac is then cut across, allowing the lower part, that which corresponds to the testis, to remain to form the tunica vaginalis. The upper part of the sac, after having been thoroughly isolated, is then tied off at the point where it emerges from the abdomen, and the edge of the internal oblique and transversalis (conjoined tendon) sutured to Poupart's ligament, as already described in the preceding operation. The lower part of the vaginal process (hernial sac) which remains, and which corresponds to the tunica vaginalis testis, is then closed with a continuous catgut suture, so that the testis is shut up within its tunica vaginalis. The edges of the split aponeurosis of the external oblique are then brought together over the cord, and the incision in the skin closed. If the testis has been much handled, it may be wise to introduce a thin strip of gauze into the cavity of the tunica vaginalis, through the bottom of the scrotum, for the purpose of drainage; usually, however, this is not necessary.

For a Direct Inguinal Hernia.—In this variety of hernia the peritoneal pouch (hernial sac) does not enter the "internal ring," mouth of the infundibular process, and work its way down along the cord, within the sheath of the cord, but bulges directly forward, into the inguinal canal, to the inner side of the deep epigastric artery, pushing the transversalis fascia, conjoined tendon, and triangular ligament before it, and is found upon the inner side of the spermatic cord as this descends through the inguinal canal. The sac consists of a wide-mouthed pouch of peritoneum and subperitoneal connective tissue, and, as it presents into the inguinal canal, is covered by the transversalis fascia, the conjoined tendon, and the triangular ligament. It is also covered by the aponeurosis of the external oblique, superficial and deep layers of the superficial fascia, and the skin. The mouth of the sac is wide, and may reach from the external edge of the rectus as far outward as the deep epigastric artery, or even beyond this, pushing the artery in front of it, in which case the artery may form a deep groove upon the sac, and thus divide it into two pouches. Under these circumstances it may be necessary to tie the artery double and divide it. There may be no well-formed sac present, but simply a wide, conical bulging of the posterior wall of the inguinal canal. In direct hernia the sac is readily separated from the cord, after which it is opened and its contents reduced. If the sac is very wide-mouthed, it may be necessary to approximate the margins of the opening with a catgut suture, and then cut away what remains of the sac. The operation is completed as described above for the oblique variety. While the cord is held aside, the edge of the conjoined tendon (internal oblique and transversalis muscles) is sutured to Poupart's ligament. The cord is then replaced and the edges of the aponeurosis of the external oblique sutured over it, and finally the incision in the skin closed.

Halsted's Operation for Inguinal Hernia.—The incision reaches from a point 5 cm. above and external to the site of the internal ring, which is located half an inch above the middle of Poupart's ligament. It is carried downward and inward as far as the spine of the pubes (site of the external ring). This incision extends through the skin and superficial fascia, freely exposing the aponeurosis of the external oblique muscle and the external inguinal ring. All bleeding points are clamped. As a rule, it is not necessary to tie them, as the hemorrhage ceases after a few minutes' compression.

The next step in the operation consists in the division of the aponeurosis of the external oblique, the internal oblique and transversalis muscles, and the transversalis fascia. These structures are incised from the external ring below to a point about 2 cm. above and external to the location of the internal ring, or farther if necessary, in order that the upper and outer part of the incision may extend into the fleshy part of the internal oblique and transversalis muscles. The vas deferens is now sought, and together with its vessels, isolated, and then all the veins which accompany the vas deferens except two or three, after being tied off above and below, are excised. In this way the size of the cord is markedly diminished. The remains of the cord are now held to one side, and the isolation of the hernial sac is begun. After this has been completed, the sac is incised and its contents returned into the abdomen. When the transversalis fascia is incised the constriction about the neck of the sac disappears, and its mouth, from a narrow orifice, becomes a wide-open space, through which one may easily introduce several fingers or the whole hand into the peritoneal cavity. The margins of the mouth of the sac are now brought together with a continuous or interrupted suture of catgut, and the sac below this suture line resected. This step of the operation is really like closing any ordinary opening in the parietal peritoneum. During the application of this suture a gauze pad may be introduced, through the opening into the peritoneal cavity, to prevent the intestine from prolapsing into the wound. After the mouth of the sac (peritoneum) has been thus sutured and closed, and the sac cut away, we proceed with the next step of the operation, the approximation of the cut edges of the several layers of the abdominal wall. While this is being accomplished the cord is raised upon a hook and held out of the way, well toward the outer part of the incision. To unite these parts from six to eighteen mattress sutures of silk are required. The layers which are approximated consist above of the aponeurosis of the external oblique, the internal oblique and the transversalis muscles (conjoined tendon), and the transversalis fascia. Below they consist of Poupart's ligament and the aponeurosis of the external oblique and the transversalis fascia, and in part, externally, of the cut edges of the internal oblique and transversalis muscles. The sutures pass through all these layers. Between the two most external of these sutures the cord emerges through the abdominal wall, between the cut edges of the internal oblique and transversalis muscles. The cord should be firmly grasped by these muscles, but not tight enough

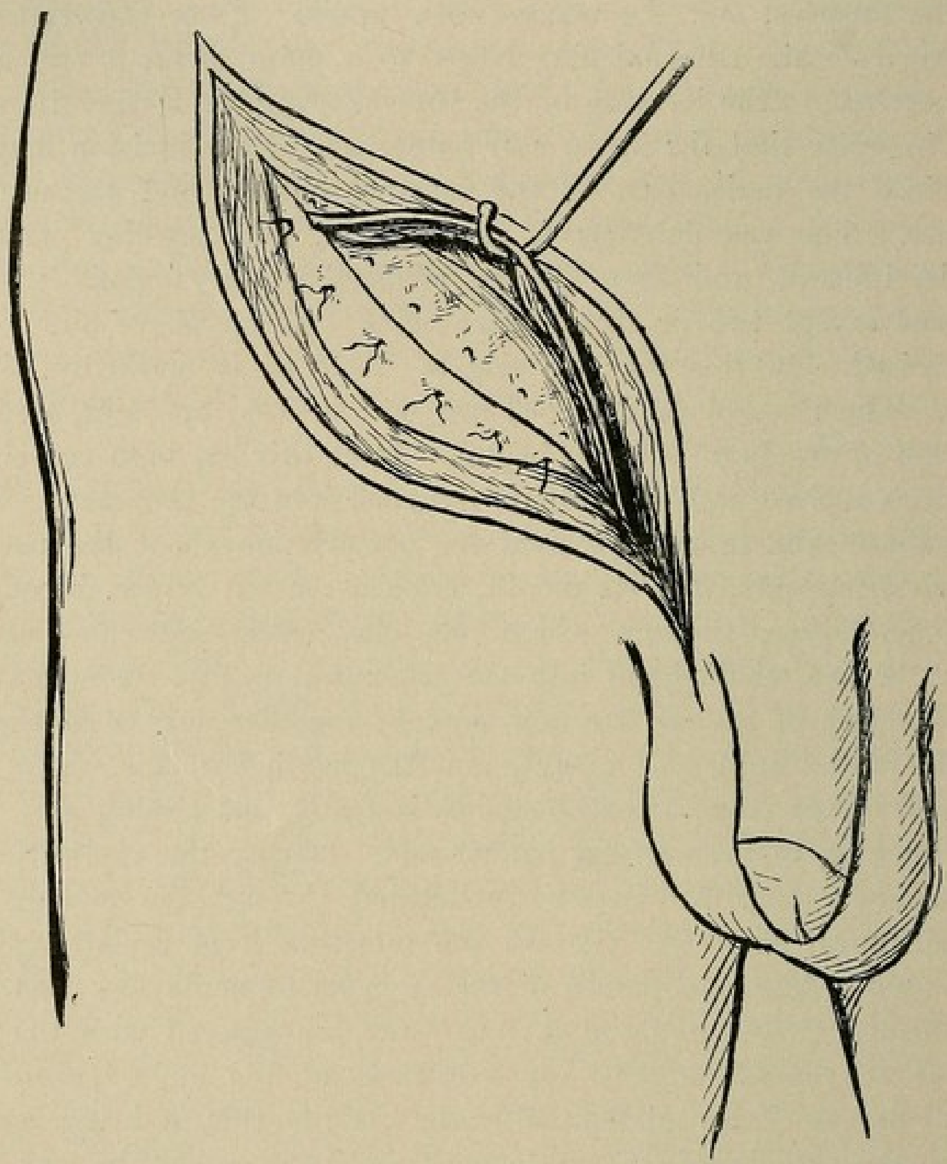

Fig. 282.—Halsted's Operation. The vas deferens, with a few remaining vessels of the cord, drawn aside with a hook. Mattress sutures have been applied, uniting the different layers that have been cut, including the aponeurosis of the external oblique.

to strangle it. The cord, as it emerges through the abdominal wall, in its new position, should be surrounded by the fleshy fibers of these muscles; it should not emerge between the tendinous portions of the muscles. If the incision through the internal oblique and transversalis muscles and the transversalis fascia has not been carried sufficiently far, in a direction upward and outward, to accomplish this, it should be extended farther, so as to reach well into the fleshy portion of these muscles.

After the mattress sutures have been applied and the parts already mentioned approximated, the cord is dropped back into the wound and rests upon the aponeurosis of the external oblique. The edges of the skin are then sutured over the cord with a continuous intracuticular suture, thus completing the operation. The cord is transplanted so that it emerges through the abdominal wall above and external to the site of the "internal ring," where it is surrounded by muscular fibers and lies just beneath the skin, instead of beneath the aponeurosis of the external oblique.

Operation for the Radical Cure of Femoral Hernia.—Femoral hernia descends through the crural canal upon the inner side of the femoral vein, and presents in the thigh, just below Poupart's ligament. In order to expose the sac of the hernia an incision is made below and parallel with Poupart's ligament, the middle of the incision being over the center of the tumor. This incision is carried through the skin and subcutaneous fatty tissue and the deep layer of the superficial fascia (cribriform) down to the sac. Instead of being placed parallel with Poupart's ligament, the incision may be made in an oblique direction from above downward.

The sac is now isolated, and separated from the adjoining parts up to and beyond the level of Poupart's ligament. Special care is required in separating the sac on the side which adjoins the femoral vein. After the sac has been thoroughly isolated it is opened and the contents reduced. The sac is then twisted and tied off as high up as possible. It may be surrounded with a simple catgut ligature, or it may be transfixed and tied double. The portion of the sac below the ligature is then cut away, the ends of the ligature cut short, and the stump of the sac pushed back beyond Poupart's ligament into the abdomen.

We are now ready to close the orifice through which the hernia descended into the thigh. We should first recognize the margins of this orifice, the crural ring. This is bounded above by Poupart's ligament; internally by the edge of Gimbernat's ligament; below by the fascia that covers the pectineus muscle, the upper, thickened portion of which is called the pubic ligament of Cooper, and which extends from Gimbernat's ligament to the pectineal eminence; externally it is bounded by the femoral vein. The edge of the falciform process should also be recognized, and likewise the internal saphenous vein, where it joins the femoral. The crural ring is obliterated by suturing the lower edge of Poupart's ligament to the fascia which covers the pectineus muscle; *i.e.*, to that part of it which covers the upper part of the pectineus—the pubic ligament of Cooper. The stitches are of kangaroo tendon, and should be introduced with a short, full-curved needle. The first suture catches Poupart's ligament just external to its attachment to the pubic spine, and should take a good bite. After the needle is drawn through, Poupart's ligament is pulled upward and backward with a blunt hook in order to permit the needle to catch the pectineal fascia as high up under Poupart's ligament as possible; *i.e.*, near the ilio-pectineal line, from which the pectineus muscle arises. Half a centimeter external to this suture a second suture is introduced in a similar manner, and then, at a distance of another half-centimeter, a third suture. These three sutures suffice to close the opening. The third and last suture is located about 1 cm. to the inner side of the femoral vein. Two sutures will suffice in many cases. When these sutures are tied, the lower edge of Poupart's ligament and the pectineal fascia (the thickened portion, high up near the origin of the pectineus muscle from the ilio-pectineal line) are approximated, and the crural ring is thus obliterated. The opening in the skin is closed in the usual way. No drainage is required.

For Undescended Testicle (Bevan's Operation).—The undescended testicle may be found within the abdomen at the internal ring; in the inguinal canal; or external to the inguinal canal, underneath the skin. In connection with this condition there is almost always associated a patent vaginal process and therefore a condition of congenital hernia either actual or latent. Bevan advises that the time to operate is between the ages of six and twelve years.

An incision three inches long is made from a point half an inch above the middle of Poupart's ligament to the base of the scrotum. The incision divides the integument and the aponeurosis of the external oblique. The edges of the aponeurosis are seized with artery forceps and well retracted, thus exposing the cremasteric fascia, which fills in the space between the lower edge of the internal oblique muscle (conjoined tendon) and Poupart's ligament (see Fig. 284). This layer of fascia is incised together with the underlying fascia transversalis, and there is then exposed to view the peritoneal pouch or sac within which the testis is situated. When this peritoneal pouch or sac

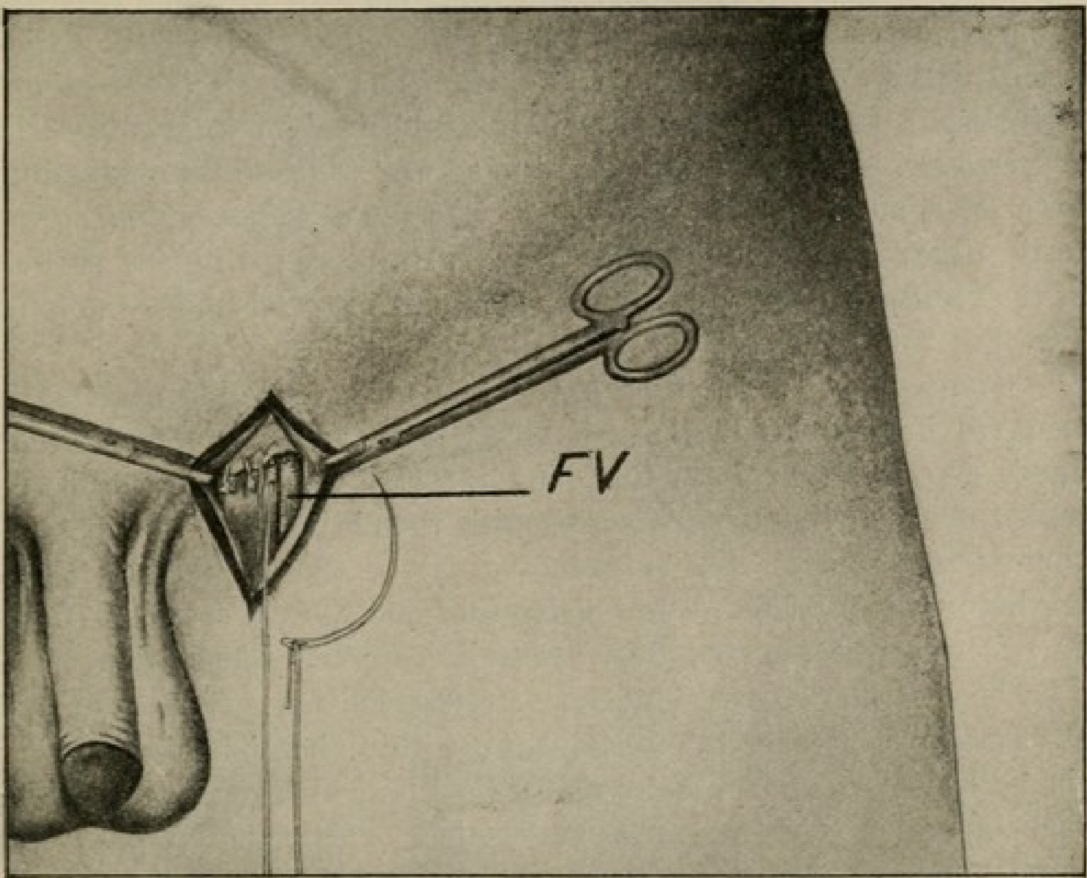

Fig. 283.—Operation for Femoral Hernia. *FV*, femoral vein. Poupart's ligament has been sutured to the upper part of the fascia that covers the pectineus muscle—to the pubic ligament of Cooper.

is incised the testicle is exposed and the operator finds himself within the vaginal process (tunica vaginalis), which is found, as a rule, to communicate direct with the peritoneal cavity (see Fig. 285).

The vaginal process of peritoneum (the peritoneal pouch containing the testicle) is now divided just above the testicle and the upper portion of it peeled upward away from the structures that go to make up the spermatic cord and which lie beneath it; it is then transfixed with the needle and tied high up with a catgut ligature. This portion of the sac should be tied upon the point of the finger placed within it, just as in tying off an ordinary hernia sac so as not to include a process of gut or omentum which might have entered it. A purse-string suture is applied around the edge of the remaining, lower, portion of the vaginal process, the portion corresponding to the testis, drawn tight and tied; the testis is thus inclosed in that portion of the vaginal process which corresponds to the normal tunica vaginalis (see Fig 286).

The testicle is now lifted out of its bed and traction made upon the cord in order to lengthen it as much as possible. Tense, short bands of connective tissue that bind the cord and prevent its being pulled down should be torn across with thumb forceps. The cord is thus stripped of all the surrounding fascia and connective tissue, leaving nothing but the vessels of the cord and the vas deferens. This part of the operation should be done with care and deliberation.

The spermatic vessels and vas deferens, which are situated behind the posterior layer of the peritoneum, within the abdominal cavity, should be separated by careful blunt dissection with the finger within the abdomen. The spermatic vessels take a direction upward and inward and the vas downward and inward, and this divergence can be distinctly appreciated. The cord should be sufficiently lengthened by these manipulations as to permit of the testicle being drawn down upon the thigh, three or four inches below Poupart's ligament (see Fig. 287).

A larger pocket is now torn in the scrotum with the finger and into this, enclosed in its newly made tunica vaginalis, the testicle is dropped, and here it should remain without undue tension on the cord. A purse-string suture is applied to the neck of the pouch in which the testicle has been placed so as to hold it there; this suture, which is of chromicized catgut, includes the superficial fascia, and both edges of the split aponeurosis of the external oblique, and when tied retains the testis securely in its new scrotal pocket.

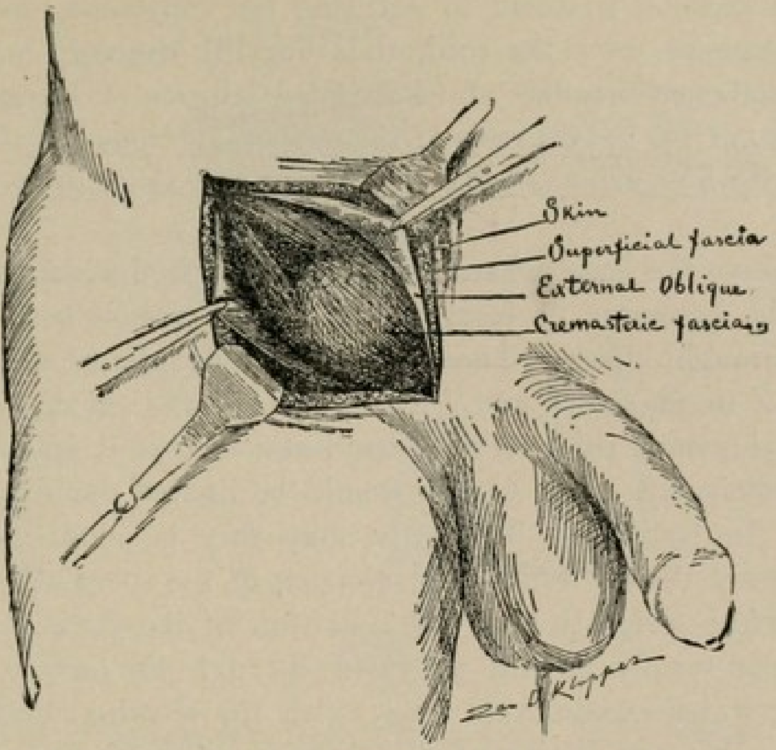

Fig. 284.—For Undescended Testis. Aponeurosis of external oblique has been split and reflected, exposing the cremasteric fascia.

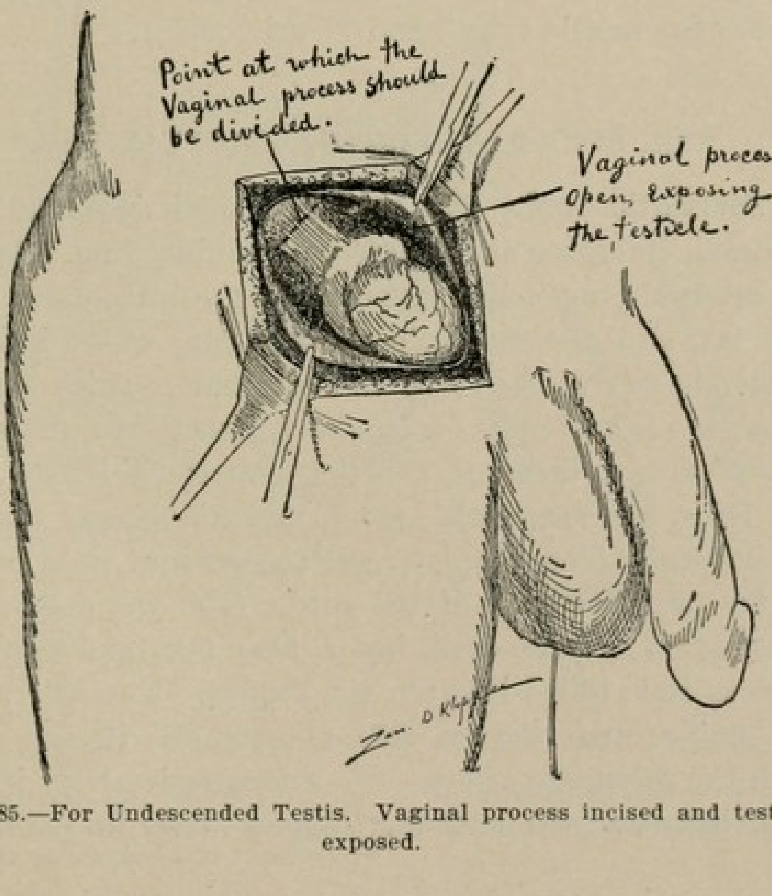

Fig. 285.—For Undescended Testis. Vaginal process incised and testicle exposed.

The incision is closed by suturing the conjoined tendon to Poupart's ligament, over the cord, thus burying the cord beneath them, with a sufficient number of interrupted sutures of kangaroo tendon. The edges of the aponeurosis of the external oblique are then approximated with a continuous suture of catgut and the skin incision finally closed.

In some few cases where the testis is situated within the abdomen it may be necessary to sever the spermatic vessels before the testis can be brought down. These vessels run an almost straight course from and to the aorta and vena cava, etc., and on account of their relative shortness they may fix the testis so that it cannot be pulled down sufficiently. The vessels should be ligated doubly and divided between the ligatures. The testis may then be more readily drawn down toward the scrotum. The division of the spermatic vessels does not interfere seriously with the nutrition of the testis, because sufficient blood-supply is still provided through the artery of the vas deferens, which anastomoses freely with the terminal branches of the spermatic that are destined for the supply of the testis. Special care must be exercised not to injure the artery and veins of the vas deferens nor to include them in the ligatures with which the spermatic vessels are secured, so that the testis will not be deprived of its entire blood-supply (see "Spermatic Cord" and "Varicocele").

THE SPERMATIC CORD, SCROTUM, ETC.

The Spermatic Cord.—The spermatic cord descends through the inguinal canal, emerging at the external inguinal ring. As it emerges from the external ring it lies just beneath the integument in the subcutaneous fat, and descends into the scrotum, where it is joined to the posterior border of the testis. It is about as thick around as the little finger, and is made up of a bundle of structures: the vas deferens, the artery of the vas deferens, and the cremasteric artery, their corresponding veins, the spermatic artery, and a tortuous venous plexus, the pampiniform. The vas deferens, the efferent duct of the testis, occupies the posterior part of the cord. The vas deferens is about as big around as a goose-quill, has a firm feel, and may be readily recognized as it is rolled between the fingers. The artery of the vas deferens ramifies upon the vas deferens, supplies it, and anastomoses below with the spermatic artery. The cremasteric artery is distributed to the constituents of the cord, and suppies its sheath. The spermatic

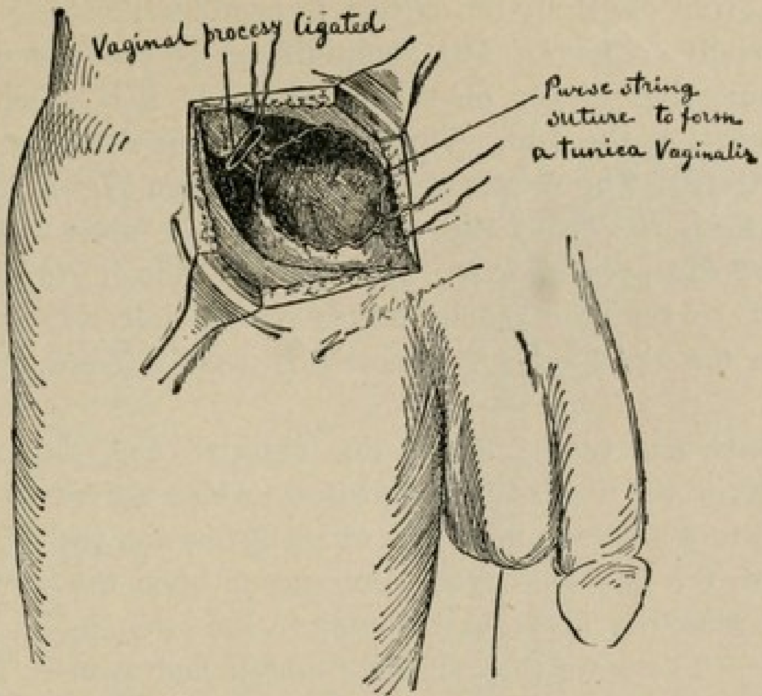

Fig. 286.—For Undescended Testis. Purse-string suture applied around the edge of that portion of the vaginal process which corresponds to the tunica vaginalis.

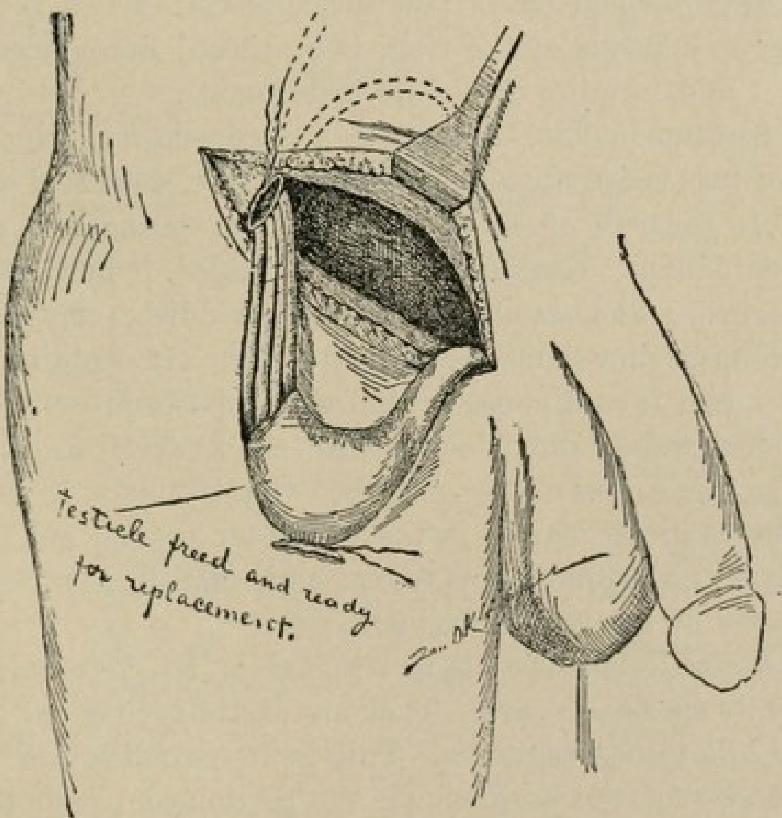

Fig. 287.—For Undescended Testis. Upper portion of vaginal process tied off. Lower portion encloses testicles. Testicle has been freed and drawn down preparatory to placing it in scrotum.

artery is given off from the aorta; it supplies the testis and has a strong current of blood. The pampiniform plexus is a tortuous, intercommunicating plexus of venous channels that accompanies the other elements of the cord. Through this plexus the blood is returned from the testis. The vessels of the pampiniform plexus join together above to form the spermatic vein. This vein upon the right side enters the vena cava directly; upon the left side it empties into the renal vein, so that the venous return on the left side is less direct than upon the right side. Varicocele is usually found upon the left side.

As these structures traverse the inguinal canal they are all contained within the infundibular process, which serves to bind them together into a single bundle and which forms the real fibrous sheath of the cord, the fascia propria. Descending upon the cord is a series of looped, muscular fibers, each joined to the other by an intervening thin fascia. These are the cremaster muscle and fascia. These fibers, that form the cremaster muscle, are derived from the lower border of the internal oblique.

As the cord emerges from the external inguinal ring, the deep layer of the superficial fascia (spermatic fascia), which is attached to the pillars or margins of the ring, is continued down upon the cord, inclosing it and forming one of its investments.

The Scrotum.—The scrotum is a tegumentary pouch which is made up of two compartments, one on each side, separated by a median septum. It consists of several layers from without inward. The skin is redundant, corrugated, and wrinkled. Beneath the skin is the dartos. The dartos is a loose, reddish, contractile layer, which is found immediately beneath the skin. It contains some muscular fibers, and is continuous behind with the two layers of the superficial perineal fascia, and laterally with the same layers in the groin. It sends a septum into the scrotum, which divides it into its two halves. Beneath the dartos is the cremaster muscle and fascia, and beneath this the infundibular fascia, and, finally, most internal, the parietal layer of the tunica vaginalis.

The Testes.—The testes are situated in the scrotum, each suspended by its spermatic cord. They are partially invested by a closed, serous sac, the tunica vaginalis. This is the unobliterated part of the vaginal process of the peritoneum, the peritoneal pouch that accompanies the testis in its descent from the abdomen into the infundibular process, the scrotum, before birth.

CT, cavity of the tunica vaginalis testis.
CV, cremaster artery and artery of the vas deferens and their corresponding veins, all in close proximity to the vas deferens.
IR, internal inguinal ring—the mouth of the original infundibular process—through which the structures that constitute the cord escape (the infundibular process becomes contracted around the elements of the cord and forms their proper sheath —the fascia propria [red line]).
P, peritoneum that lines the interior of the abdomen.
S, symphysis pubis.
SAV, spermatic artery and veins (below, along the course of the cord, the spermatic veins consist of a plexus of intercommunicating branches—the pampiniform plexus).
TF, transversalis fascia.
VD, vas deferens.
VP, remains of the obliterated vaginal process of peritoneum that accompanies the testis in its descent into the scrotum (the arrow indicates the site of the former opening or mouth of this process).

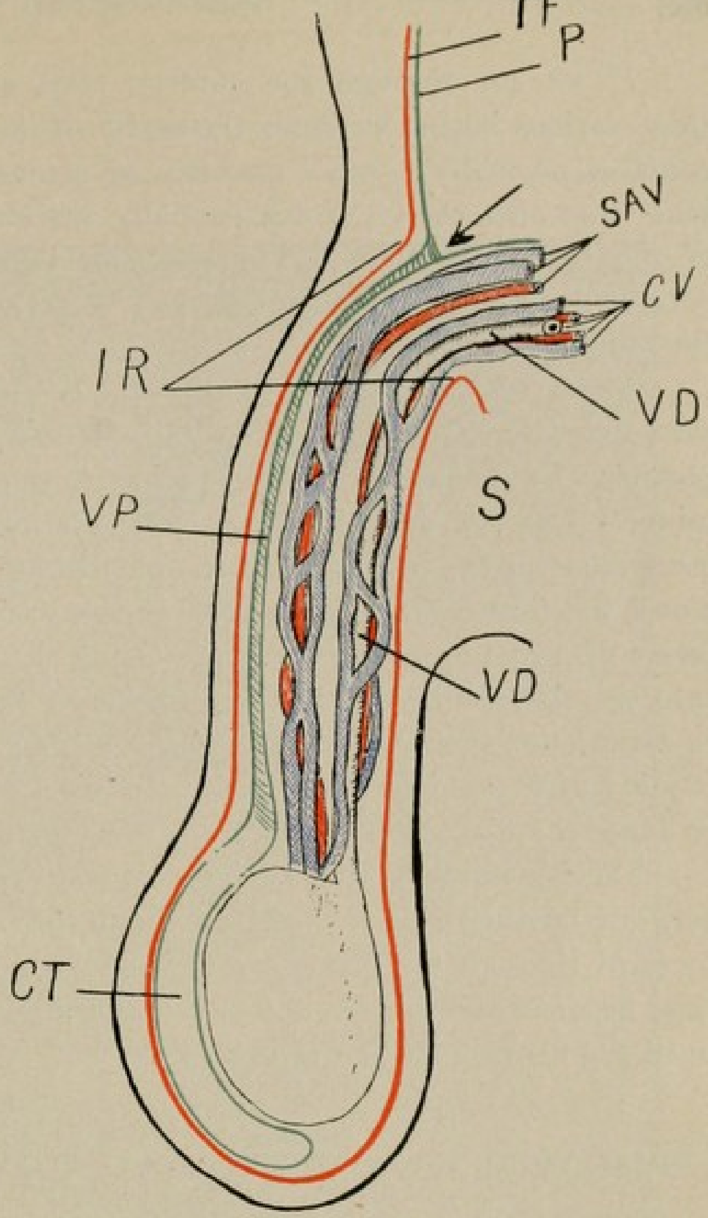

Fig. 288.—Spermatic Cord.

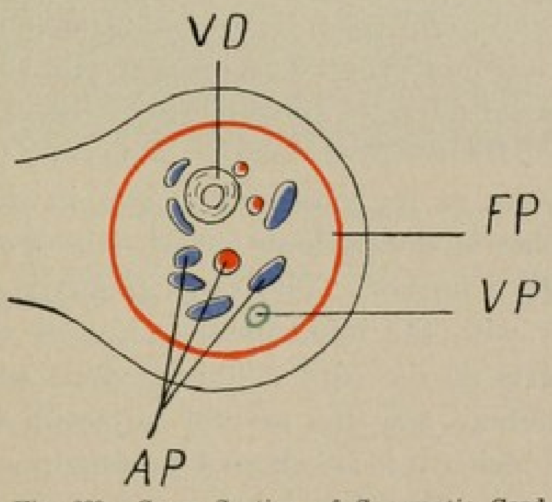

Fig. 289.—Cross Section of Spermatic Cord.

AP, spermatic artery and pampiniform plexus.
FP, fascia propria (sheath of the cord and original infundibular process).
VD, vas deferens surrounded closely by the cremaster artery and artery of the vas deferens and their corresponding veins.
VP, remains of the obliterated vaginal process.

If we cut through the anterior wall of the scrotum, through these various layers, we enter the cavity of the tunica vaginalis, which contains normally a small quantity of serous fluid. The testis presents into this cavity, being partially invested by the visceral layer of the tunica vaginalis. The posterior border of the testis is not covered by the tunica vaginalis, and is excluded from the cavity of the tunica vaginalis.

Along the posterior border of the testis is the epididymis. It surmounts the testis above like a cap. It has a body, an upper, larger portion, the globus major; and a lower, smaller portion, the globus minor. The vas deferens is the continuation of the epididymis. It commences at the lower end of the globus minor, and, passing upward along the posterior, inner border of the testis, is found in the posterior part of the spermatic cord, passing through the "internal ring" into the abdomen. Within the abdomen it dips down into the pelvis, to terminate between the base of the bladder and the rectum, where it joins with the duct of the seminal vesicle of the corresponding side to form the ejaculatory duct.

The Ejaculatory Ducts.—The ejaculatory ducts are two in number, one on each side. They are about three-fourths inch long, pass forward through the prostate gland, one on either side of the middle line, between the middle and lateral lobes of the prostate, and open upon the floor of the prostatic urethra.

OPERATIONS UPON THE SPERMATIC CORD, SCROTUM, ETC.

For Varicocele. Open Operation.—An incision is made, about one and one-half inches long, into the upper part of the front of the scrotum, commencing just below the spine of the pubes, and passing through the skin into the subcutaneous fatty layer. This incision can be made by pinching up the skin and transfixing it with a sharp-pointed knife or by cutting it with the scissors. The cord is then hooked up, upon the finger, out of the loose, fatty layer in which it lies, and with one or two strokes of the knife its sheath (the spermatic fascia and the fascia propria) is opened. The vas deferens is sought and recognized, and together with the immediately adjacent veins is separated from the other parts of the cord. This is done with the fingers, holding the vas deferens and the several adjacent vessels, artery and veins of the vas, which are to be allowed to remain securely between the finger and thumb of the left hand, while the work of

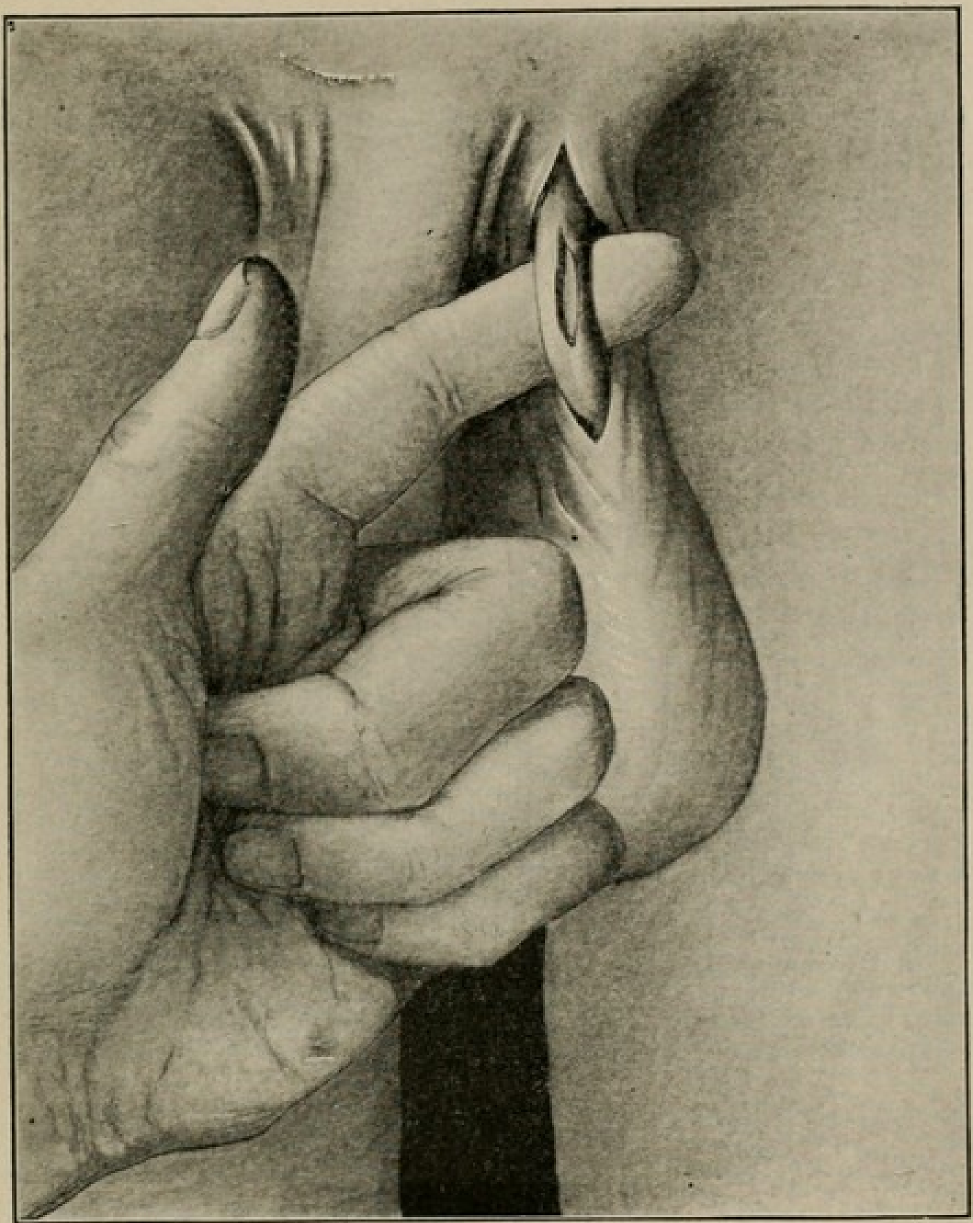

Fig. 290.—Exposure of Spermatic Cord. The spermatic cord has been hooked up out of the incision upon the finger, and its sheath incised preparatory to separating the vas deferens and adjoining vessels from the other structures of the cord.

separating the other structures of the cord, veins of the pampiniform plexus and the spermatic artery, from the vas deferens, may be accomplished with the fingers of the right hand (see Fig. 292).

After the vas deferens, together with the several immediately adjacent veins, has been isolated for a distance varying from one to two inches, depending upon the laxness of the scrotum and the length of the cord, etc., a double catgut ligature is passed with an artery forceps and then cut so that we have two ligatures. These ligatures, which surround all those structures of the cord that have been sepa-

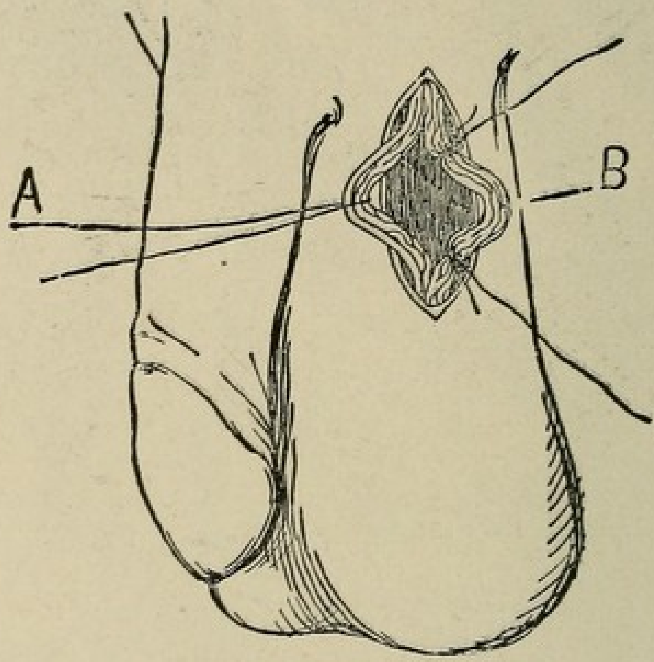

Fig. 291.—Varicocele. The vas deferens and adjoining vessels (*A*) have been separated from the other structures of the cord—from the spermatic artery and pampiniform plexus (*B*). Ligatures have been tied about *B* above and below preparatory to excising the intervening portion.

rated from the vas deferens, etc., are tied, one above and the other below. The portion intervening is excised with the scissors, not too close to the ligatures, and the ends of the ligatures, which have been purposely left long, are then tied together, in this way bringing the ends of both stumps into apposition. The ends of these two portions may be still further secured by one or two catgut sutures, which should take a good bite through the whole thickness of each stump.

The portion of the cord which is stripped away from the vas deferens, and which is ligated and excised, is composed of all the veins of the pampiniform plexus and the spermatic artery. When the vas is isolated, the artery of the vas deferens, which anastomoses

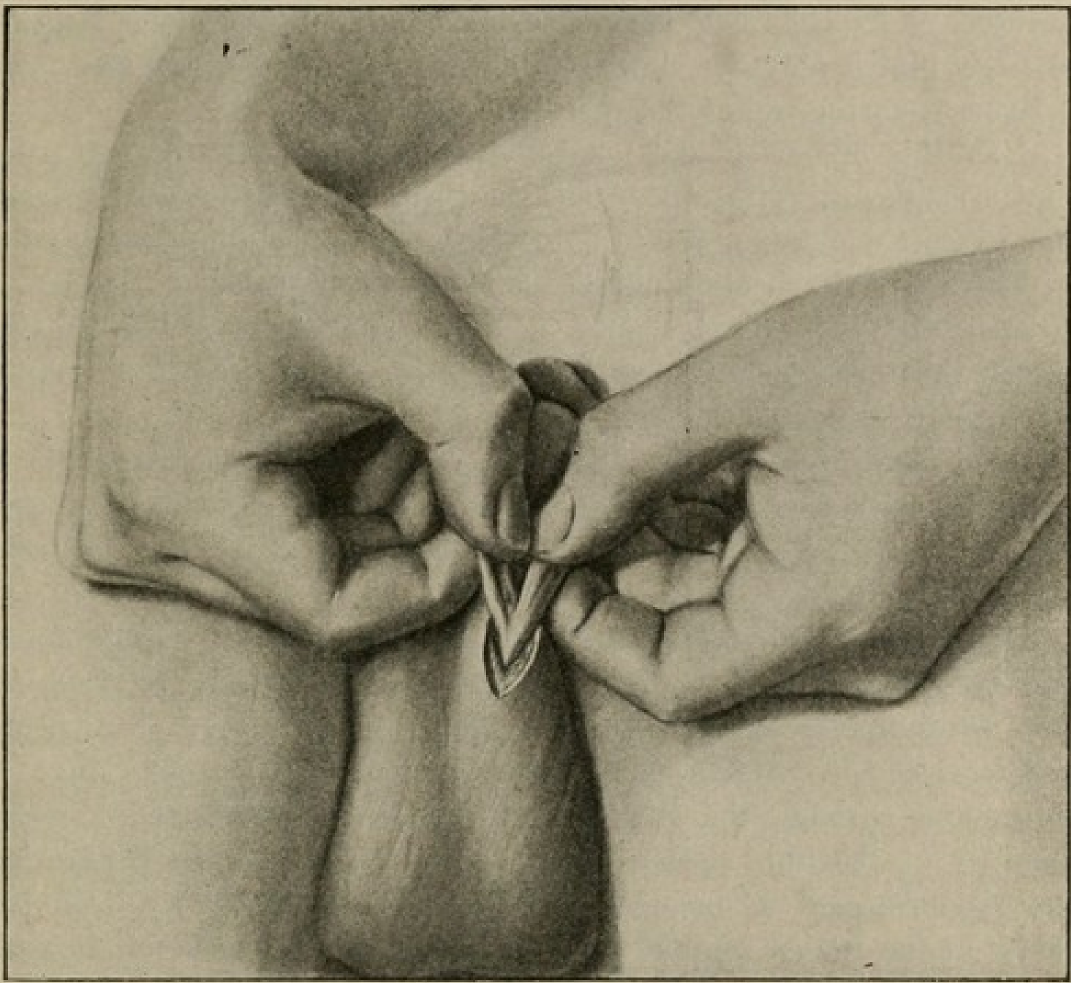

Fig. 292.—Varicocele. Cord separated into two segments. Finger and thumb of left hand grasp vas and adjacent vessels, artery and veins, of vas deferens. Finger and thumb of right hand grasp spermatic artery and veins of pampiniform plexus.

below with the spermatic artery, and the cremasteric artery, together with their corresponding veins, go with it; these vessels are therefore not interfered with, and they are sufficient to provide for the nutrition of the testis after the pampiniform plexus and the spermatic artery have been ligated.

For the ligatures, plain catgut, not too thick (No. 1 or 2), may be used, and special care should be taken to apply the upper ligature securely that it may not slip, as this would result in a very free hemorrhage from the end of the spermatic artery.

In this operation one not only ties off the veins of the pampiniform plexus, but also shortens the cord, and thus draws the testis up, a result which is much to be desired. Before closing the incision in the skin all bleeding points should be clamped and ligated or twisted, and the wound should be dry. The edges of the incision in the skin are brought together with a continuous stitch of catgut, which may be intracuticular.

For Hydrocele.—A condition in which the tunica vaginalis is distended with serous fluid. The testis is usually found in the lower, back part of the sac, the fluid being collected above and in front of it.

PUNCTURE AND INJECTION.—This is suitable for simple cases, and for those where tapping has not been previously resorted to. The scrotum is grasped in the left hand, in order to make it tense and to steady it. A fine needle, attached to a hypodermic syringe, is introduced through the anterior wall of the scrotum, and a small quantity of the fluid drawn off, both for the purpose of confirming the diagnosis and to demonstrate the fact that the needle is in the cavity of the tunica vaginalis. The hypodermic needle is left *in situ,* its end free in the cavity of the tunica vaginalis. A fairly large trochar is then thrust through the bottom of the scrotum rather toward the front, and in an upward direction into the cavity of the tunica vaginalis. In doing this one should remember that the testis occupies the lower back part of the sac. With the trochar in the cavity of the tunica vaginalis one should be able with it to touch the hypodermic needle previously introduced into the sac above. The sac is allowed to empty itself through the cannula, and this is then withdrawn.

The barrel of the hypodermic syringe is now filled with the fluid to be injected. Twenty minims of a 95-per-cent. carbolic-acid solution may be used, with satisfactory results, for this purpose.

This is thrown into the cavity of the tunica vaginalis through the hypodermic needle, and then this needle is also withdrawn. The fluid that has been thus introduced into the cavity of the tunica vaginalis is distributed over the whole cavity by manipulating the scrotum. The punctures made by the instruments are covered over with a thin coat of collodion, and a very thin film of absorbent cotton.

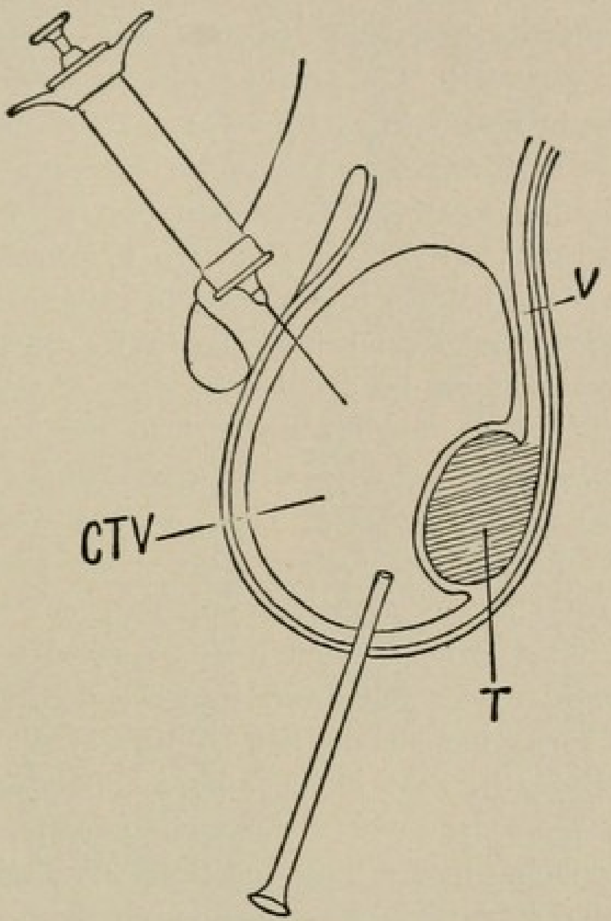

Fig. 293.—Hydrocele, Tapping. *CTV*, cavity of the tunica vaginalis testis; *T*, testis; *V*, vas deferens. Hypodermic needle introduced into the upper part of the sac; trochar cannula into the lower part.

This operation is usually followed by some effusion into the sac, and with but little or no pain. After a few days' rest in bed with the scrotum supported, these symptoms subside. The operatoin is not painful, but the part where the trochar is to be introduced may be anesthetized with ethyl chloride if desired.

Open Operation (Volkmann).—This operation is suitable for those cases that have already been tapped many times or where the operation previously described has been tried and has failed.

The scrotum is grasped by an assistant in order to make it tense and to steady it. An incision is made through the anterior wall of the scrotum, opening into the cavity of the tunica vaginalis. The length of the incision depends upon the size of the tumor, but is usually two or three inches. When the tunica vaginalis has been opened, and while the fluid is escaping, the edge of the parietal layer of the tunica vaginalis—*i.e.*, the inner lining of the scrotal sac—is seized on either side with an artery forceps, and with the finger this is torn away from its attachment to the inner aspect of the scrotum, and excised in part with the scissors. If the tumor has been very large, it will be necessary to excise more of the tunica vaginalis than if the tumor is smaller. The tunica vaginalis may be much thickened. In trimming away this redundant portion of the tunica vaginalis one must take care to leave enough to conveniently cover the testis and also avoid cutting into the epididymis. It is rather better to excise too little than too much of the tunica vaginalis. After this part of the operation has been done the edge of that portion of the tunica vaginalis which remains is fixed to the corresponding edge of the skin incision all around with a continuous or with several interrupted fine catgut sutures. Then, with a wad of cotton on a stick, the whole interior of what remains of the tunica vaginalis, including that covering the testis, is swabbed out with 95-per-cent. carbolic acid. The cavity is then loosely packed with sterile gauze. The strips should reach well down into the deepest recesses of the cavity, but the packing should not be tight. A loose dressing is applied, which may be held in place by a T-bandage. The packing should be removed at the end of forty-eight hours, simply retaining a strip in the opening in the skin, and the parts allowed to granulate. If too much of the tunica has been removed, there will be too much inversion of the skin, and this will delay the healing process.

Excision of the Tunica (von Bergmann).—After the tunica vaginalis sac has been opened and its contents evacuated, the parietal layer of the tunica vaginalis is seized and stripped away from its attachment bluntly with the fingers as far back as the posterior border of the testis, or rather epididymis, and then excised in its entirety with the scissors. After all bleeding has been controlled with forceps and ligatures, the wound in the skin is closed with sutures, without any drainage whatever. As a rule, the skin incision heals by first intention, and the patient is able to be around in about twelve days.

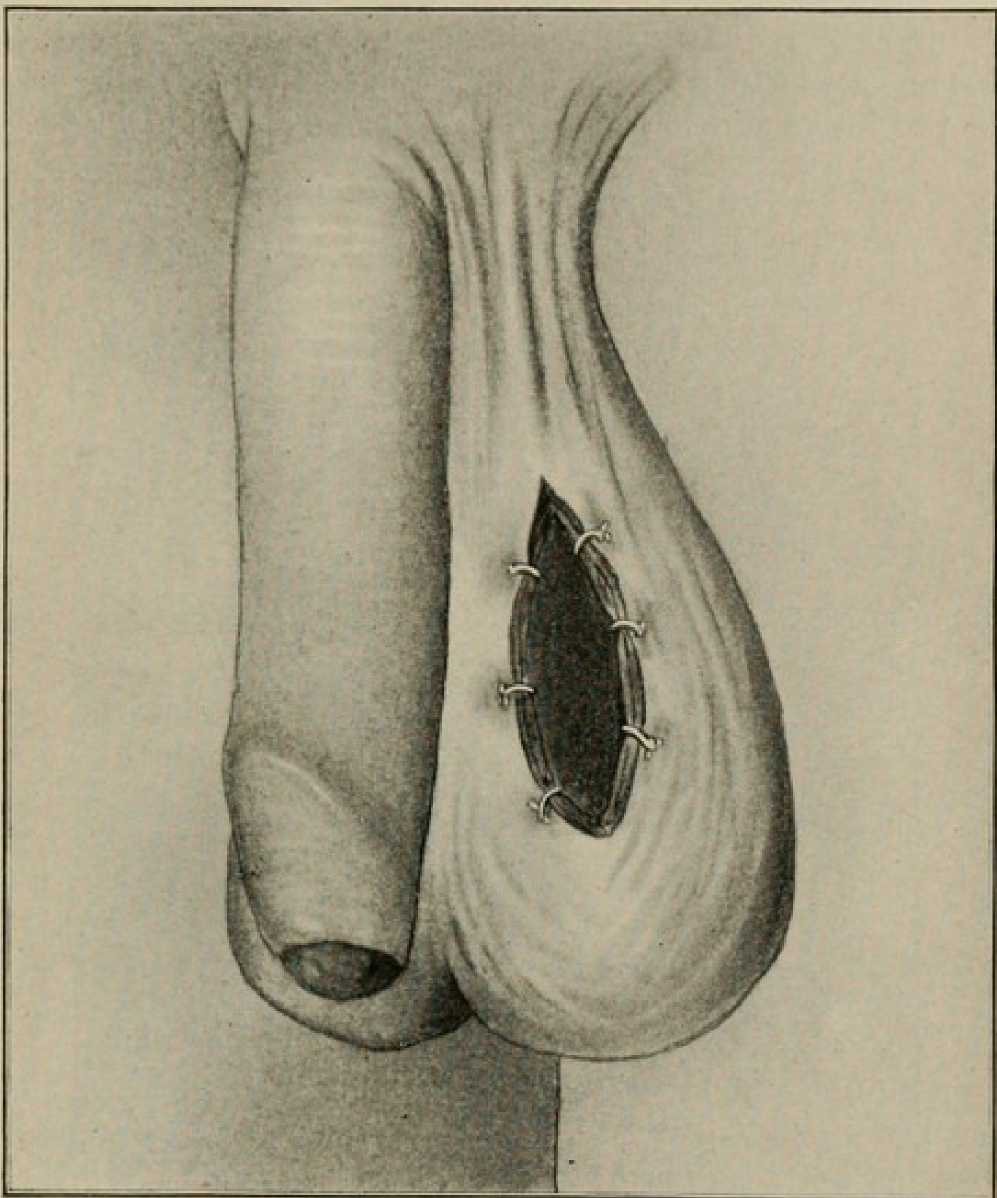

Fig. 294.—Volkmann Operation for Hydrocele. Edge of tunica vaginalis sutured to the edges of the skin incision.

This method is very satisfactory, and is especially applicable to those cases where the tunica vaginalis is excessively redundant after the evacuation of a large hydrocele, or when the tunica is markedly thickened.

Retroversion of the Tunica Vaginalis.—This method has been variously ascribed to Jaboulay, Doyen, Garampozzi, and Winkelmann. An incision is made in the front of the scrotum, usually about two inches in length, into the cavity of the tunica. Through

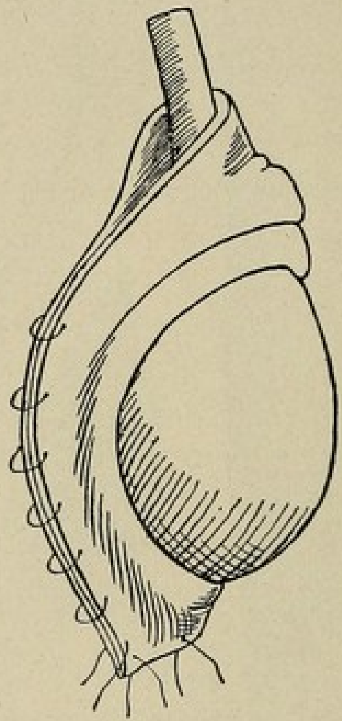

Fig. 295.—Hydrocele. Retroversion of the tunica vaginalis. The tunica has been turned back beyond the epididymis and fixed there by sutures.

this opening the fluid contents of the distended tunica vaginalis escape, and the testis is then drawn forward out of the scrotum.

As the testis is drawn forward out of the scrotum, the vaginal layer of the tunica is reflected backward,—turned inside out, as it were,—so that the opening in the parietal layer of the tunica, through which the testis has been drawn, gets to lie behind the testis, encircling the cord and covering over the epididymis, and in this position it is fixed by joining its edges together with several catgut sutures so that it may not again slip forward over the testis. The edges of the incision in the scrotum are now sufficiently detached to allow the integument of the scrotum to be drawn forward and cover

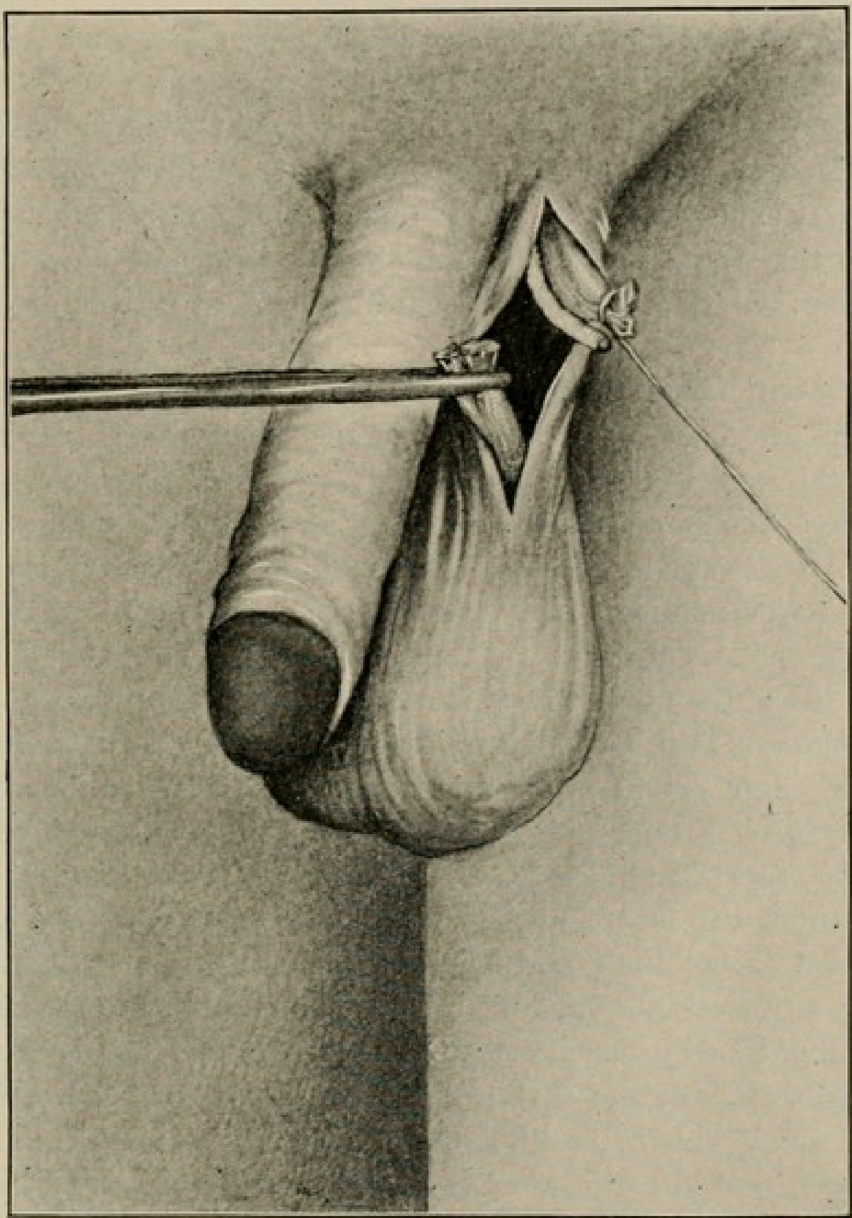

Fig. 296.—Castration. Cord has been divided. The end of the lower portion grasped with an artery forceps. A ligature has been tied around the end of the upper stump. It will be noticed that the vas deferens is not included in the ligature.

over the testis and reflected tunica vaginalis, and they are thus united to each other without drainage, in this way completing the operation.

The result of this operation is that the free secreting surface of the tunica vaginalis which has been turned inside out is brought into contact with the raw internal wound surface of the scrotum, to which it becomes united, effecting the cure.

If the tunica vaginalis is very redundant after evacuating a large hydrocele, a part of the tunica may be excised with the scissors, leaving just enough to complete the operation as described above; but for those very large hydroceles, and those with a markedly thickened tunica, the von Bergmann is probably the more satisfactory operation.

Castration (Extirpation of the Testis).—An incision, about two inches long, is made upon the front of the upper part of the scrotum through the skin and fat, commencing at a point just below the external ring—the spine of the pubes. If operating for malignant disease, and if the skin is involved, the incision may be arranged so as to circumscribe that part of the skin which is involved. In the upper part of the incision the cord is found, and hooked up, upon the finger, and just below the point where it emerges from the external ring its sheath is incised with the point of the knife. The vas deferens is then recognized, and should be separated from the rest of the cord. A catgut ligature is then passed about those parts of the cord which have been separated from the vas deferens, and tied so tightly that it cannot slip off. This ligature should include all the elements of the cord except the vas deferens. The ends of this ligature are left long, to serve as a tractor; the cord, including the vas deferens, is then divided with the scissors, at least half an inch below, distal to the ligature. Before dividing the cord it is grasped, below the point at which it is to be divided, with an artery clamp. The cord having been divided, the lower end, that which is held in the grasp of the artery forceps, together with the testis, and including the tunica vaginalis, is enucleated from the scrotum, usually without opening into the cavity of the tunica vaginalis, and almost entirely by blunt dissection. Where the knife or scissors is used to assist in this enucleation one should take care not to cut through the septum into the other half of the scrotum, and one should also avoid button-holing the skin.

After the testis has been enucleated we return to the stump of the cord. This may be brought into view by drawing upon the ligature, which was left long to serve as a tractor, and if there is no bleeding this ligature may be cut short and the stump of the cord allowed to retract up into the inguinal canal. Should there be any bleeding points, these may be clamped and ligated. One should avoid including the stump of the vas deferens in the ligature, as it may result in disagreeable symptoms; *e.g.*, colicky pain, etc.

The wound is large, and may be closed with catgut sutures; in most cases, however, it is well to place a drain in the lower end of the wound. If operating for tuberculosis, the cord should be divided as high up as one can reach.

PART VIII.

THE URINARY SYSTEM.

The Surgical Anatomy of the Kidney.—One kidney may be absent in apparently normal subjects, the left more frequently than the right. This is said to occur once in about two thousand four hundred subjects. When one kidney is absent that which is present is usually larger and assumes the function of both kidneys.

There may be two kidneys present, joined together below or above, horseshoe kidney, or both above and below, either with connective tissue or kidney tissue. This condition is met with about once in one thousand subjects.

The position of the kidneys is not fixed. They move normally within certain limits with respiration, descending with each inspiration. The kidneys are situated in the upper back part of the abdomen, one on each side of the vertebral column, occupying the space from the twelfth dorsal to the third lumbar vertebra. The right kidney is located one inch lower than the left on account of the presence of the thick border of the liver on the right side. The upper part of the left kidney lies under the eleventh and twelfth ribs; the upper part of the right kidney under the twelfth rib. In the female both kidneys are situated somewhat lower than in the male. The lower pole of the kidney reaches to within one or two inches of the crest of the ilium. The kidneys are placed somewhat obliquely in the abdomen so that the upper poles are rather closer together than the lower poles. The kidneys are extraperitoneal organs; they lie behind the peritoneum.

The kidneys are provided with a fibrous capsule, which is usually quite dense and closely adherent to the organ. The kidneys are lodged within a bed of loose fat and connective tissue, out of which they may be readily enucleated. The anterior surface of the kidney is directed forward and outward, and is covered by the peritoneum. The colica dextra artery and vein pass outward across the front of the right kidney underneath the peritoneum, and the colica sinistra artery and vein across the front of the left kidney underneath the peritoneum to supply the ascending and descending portion of the colon. The descending part of the duodenum lies in front of the right kidney, the pancreas in front of the left kidney.

The upper part of the posterior surface of the kidney is separated from the eleventh and twelfth ribs by the diaphragm and pleura; the lower part of the posterior surface of the kidney rests upon the quadratus lumborum muscle which is covered by the anterior layer of the lumbar fascia.

The inner border of the kidney is concave and is directed toward the psoas muscle and the vertebral column. The inner border of the kidney really rests upon the edge of the psoas muscle and the organ

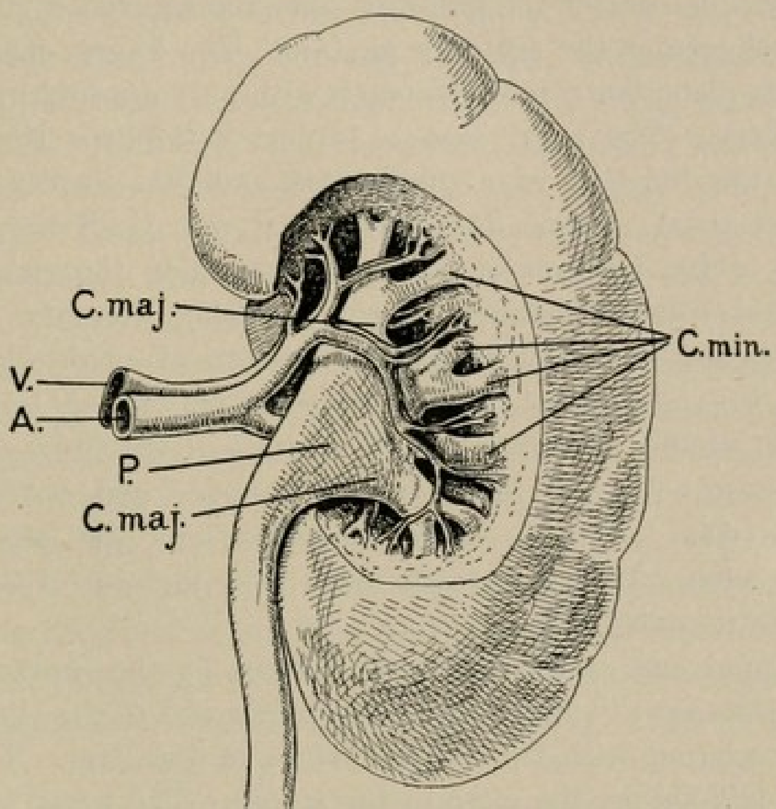

Fig. 297.—Right Kidney from Behind. Posterior part of the kidney cut away to show the sinus and structures contained therein. *A.*, renal artery; *C.maj.*, calices majores; *C.min.*, calices minores; *P.*, pelvis of the kidney; *V.*, renal vein.

is thus tilted somewhat outward. This border of the kidney presents a long, slit-like opening, the hilum. Through the hilum the renal vessels, etc., pass into a comparatively large, narrow space between the two halves of the kidney, called the sinus. The sinus lodges the renal vessels and the pelvis of the kidney. Within the sinus the pelvis of the kidney occupies a position posterior to the renal artery and vein. The renal artery enters the hilum and divides, within the sinus, into two groups of branches: an anterior group, the larger, and a posterior group, the smaller. These two sets of branches are disposed within the sinus in front of, and behind, the tubules that join to form the pelvis of the kidney. Each set of branches, five or six in number, penetrate the substance of the kidney to supply the corresponding anterior and posterior portions of the organ. The terminal branches of the two groups of branches into which the renal artery divides do not anastomose with each other; hence there is a plane between the two separately vascularized portions of the kidney which may be incised without much hemorrhage. This is called the bloodless zone of Hyrtl. It corresponds to a line drawn along the outer border of the kidney, somewhat nearer the posterior than the anterior surface, about one-half inch nearer the posterior surface. The kidney may be split through this plane down into the pelvis with only a minimum amount of hemorrhage. The renal vein is formed within the sinus of the kidney by the junction of a number of branches corresponding to those of the renal artery. The right renal vein is shorter than the left owing to the position of the vena cava upon the right side of the vertebral column, hence the right kidney presents a shorter pedicle than the left kidney in the operation of nephrectomy. At the hilum the relation of the structures from before backward is vein, artery, ureter. The ureter is the lowest of the three structures.

The outer border of the kidney is rounded and convex and is related, the right, with the ascending colon, and the left with the descending colon. The colon really lies a little in front of the kidney, as well as to its outer side.

The upper end of the kidney is covered by the suprarenal capsule, which sits upon it like a cap. The upper end of the right kidney is in close relation with the under surface of the liver. The upper end of the left kidney lies close to the spleen. The lower end of the kidney reaches to within one or two inches of the crest of the ilium.

The kidneys are imbedded in a mass of loose fatty tissue—the fatty capsule. The fatty capsule is arranged in two layers supported by septa of fibrous tissue. Occasionally the kidneys become quite loose, especially after the loss of a considerable amount of the intra-abdominal adipose tissue and may then become abnormally movable. They can be felt to descend with each deep inspiration, between the hands. One hand is placed behind, in the lumber region, pressing upward, and the other hand is placed in front, pressing upon the abdominal wall anteriorly. At times the kidney becomes so loose that it leaves the lumbar region entirely and drops down into the iliac fossa so that it rests upon the brim of the pelvis. Under these circumstances the renal vessels may become twisted and the ureter may become kinked so that the flow of urine is obstructed, thus giving rise to a condition of hydronephrosis—distention of the pelvis of the kidney—associated with symptoms, pain, hæmaturia, etc., that greatly resemble attacks of renal colic.

THE PELVIS OF THE KIDNEY.—The pelvis of the kidney is a pyramidal-shaped, thin-walled, membranous sac into which the urine is discharged as it is excreted from the kidney. It is continuous below with the ureter, which conducts the urine from the pelvis of the kidney to the bladder. The pelvis of the kidney is contained almost wholly within the sinus of the kidney—the narrow space within the kidney between the two, anterior and posterior, segments. It occupies a position, within the sinus, posterior to the renal vessels. The pelvis of the kidney is formed by the junction of two or three thin-walled tubes,—the *calyces majores.* Each calyx major is in turn made up of several smaller tubes,—the *calyces minores.* The calyces minores are ten or twelve in number. Little cone-shaped bodies, the papillæ, project into the calyces minores—usually two or three into a single calyx. The summit of each papilla is marked by a number of minute openings, the *foramina papillaria,* which are the orifices of the secreting tubules.

THE URETERS.—The ureter is a long, thick-walled duct, about eleven inches long, flattened from before backward, which leads from the pelvis of the kidney to the bladder. It descends in the back part of the abdomen, behind the peritoneum, and dips into the pelvic cavity over the brim of the pelvis near the corresponding sacro-iliac synchondrosis. As it dips into the pelvis it crosses the bifurcation of the common iliac artery or the external iliac artery just after this branch is given off from the common iliac.

The abdominal portion of the ureter is about five inches long. It passes downward and slightly inward, lying upon the psoas muscle, in close company with the spermatic and ovarian vessels and the genito-crural nerve. The right ureter lies close to the vena cava. The ureters are situated behind the peritoneum, to which they are quite closely adherent. Upon the left side the line of attachment of the mesentery of the sigmoid flexure (pelvic colon) crosses the ureter. The inferior mesenteric artery and vein are in close relationship with the left ureter as it crosses the iliac vessels to dip into the pelvic cavity.

The pelvic portion of the ureter is about five inches long. In the pelvis the ureters lie close to either lateral wall of the pelvic cavity, immediately underneath the peritoneal layer that lines the cavity. After descending a short distance upon the lateral wall of the pelvis they curve forward and inward to reach the bladder. In the male the vas deferens passes across the ureter from behind forward and to its inner side, just before the latter (ureter) reaches the bladder. As the ureters pierce the wall of the bladder, they are about two inches apart. They pierce the bladder just above and anterior to the upper extremity of the seminal vesicles. In the female the ureter passes inward and forward, close to the floor of the pelvis between the layers of the broad ligament, to reach the bladder. In its course it lies about three-quarters of an inch to the outer side of the cervix and very close to the upper part of the wall of the vagina—just external to the lateral fornix of the vagina. A stone in the lower part of the ureter in the female may be felt through the vaginal wall and may be removed through an incision in the wall of the vagina. The ureter also has an important relation to the uterine artery. The uterine artery arises from the anterior division of the internal iliac and passes inward between the layers of the broad ligament, to reach the uterus at about the junction of the cervix with the body, where it ascends upon the side of the uterus to supply it. The uterine artery in its course to the uterus passes across the front of the ureter about three-quarters of an inch to the outer side of the cervix.

The ureters penetrate the wall of the bladder very obliquely—traversing the muscular layer of the bladder for nearly three-quarters of an inch before they open upon the inner surface of the bladder. The openings are slit-like and protected by a little valve-like fold of mucous membrane so that there is quite some hindrance to the backward passage of fluid from the bladder into the ureters. When the bladder is distended the distance between the orifices of the ureters becomes increased. They are then about two inches apart. The lumen of the ureter will permit passage of a No. 9 French bougie. The ureter is constricted at several points and somewhat dilated between these. It is constricted about the middle of the abdominal portion, about two inches below the pelvis, where it has a diameter of about one-seventh inch, again at the pelvic brim, junction of the abdominal and pelvic portions, where the diameter is about one-quarter inch, and again at the lower end, just before it opens into the bladder, within one-half inch of the bladder orifice, where it is narrowest, the diameter being about one-tenth inch. These constrictions represent the favorite sites for lodgment of a calculus.

Either ureter may be represented by two tubes, through all or part of its course. In the former case there will be two openings in the bladder upon the corresponding side. The presence of, at least, one ureteral orifice on each side of the bladder, from which urine is seen to escape, is quite positive evidence of the presence of two kidneys.

OPERATIONS UPON THE KIDNEY.

Nephropexy.—Suture or fixation of a movable or floating kidney. A movable kidney is one that enjoys a limited range of motion

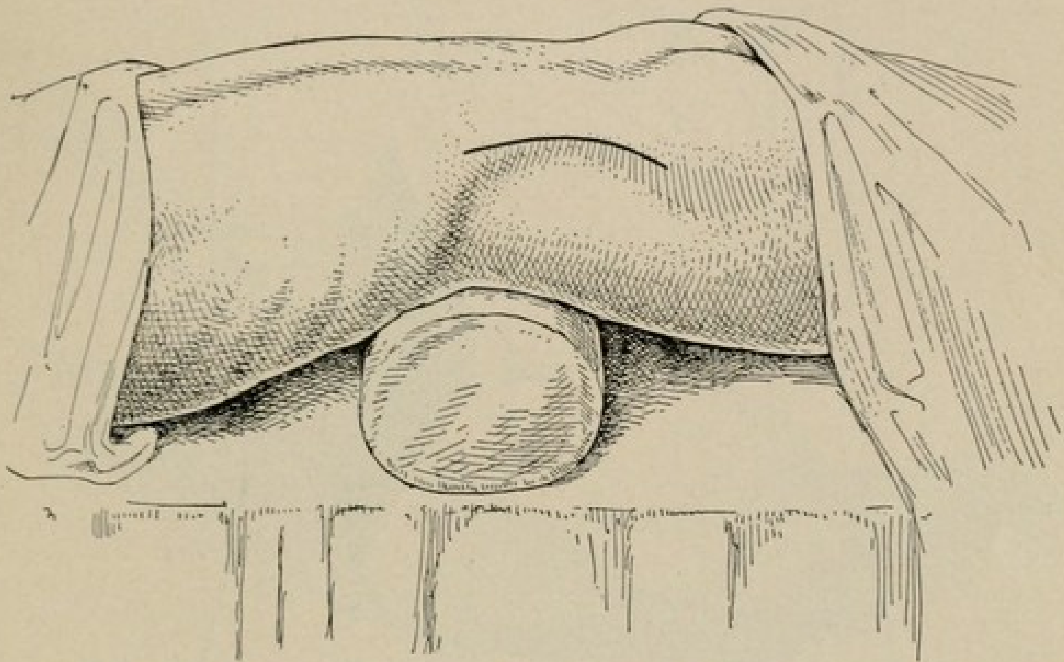

Fig. 298.—Incision for Exposure of the Kidney. Patient lies prone, with Edebohls' rubber cushion under the abdomen.

in the posterior part of the abdomen, but which does not leave the lumbar region. A floating kidney is one that enjoys a considerable range of motion and is capable of leaving the lumbar region entirely. It may be more or less completely invested with a peritoneal coat and provided with a more or less complete mesonephron. As a result of the displacement of the kidney the renal vessels may become twisted and the ureter acutely kinked, the flow of urine obstructed and a condition of hydronephrosis with accompanying pain, etc., produced. The indication for nephropexy will depend upon the degree of discomfort, etc., that the loose kidney causes.

The patient lies prone upon the table with an Edebohls rubber cushion under the abdomen. A sandbag placed under the upper part of the chest will materially relieve the embarrassment of respiration which occurs in this position.

The incision corresponds to the outer border of the erector spinæ muscle, commencing, above, at the twelfth rib, about two and a half inches from the middle line. It passes downward, curving somewhat outward, and terminates just above the crest of the ilium. This incision should extend through the skin and subcutaneous fat down to the surface of the aponeurosis of the latissimus dorsi muscle. The incision is then carried through the aponeurosis, when the outer

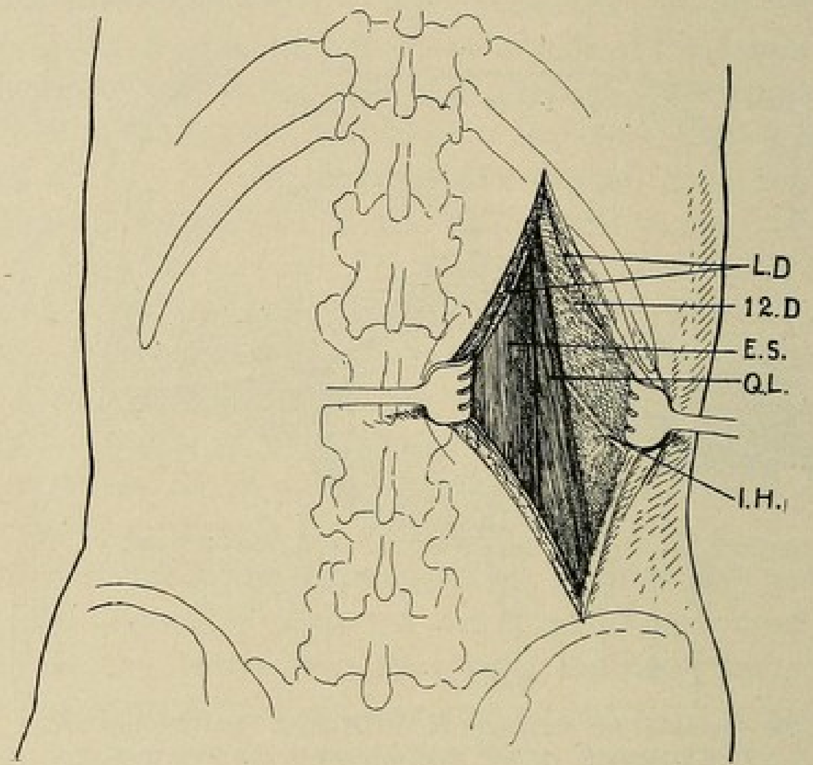

Fig. 299.—Lumbar Incision for Exposing the Kidney. *E.S.*, erector spinæ; *I.H.*, ilio-hypogastric nerve; *L.D.*, edges of the aponeurosis of the latissimus dorsi; *Q.L.*, quadratus lumborum; 12.*D.*, twelfth dorsal nerve.

border of the erector spinæ muscle is recognized. This muscle is drawn toward the middle line with a blunt tractor. The quadratus lumborum, covered by its proper layer of the lumbar fascia, is then exposed in the bottom of the incision. The fascia that covers the quadratus lumborum is incised along the edge of the erector spinæ. The quadratus extends a little beyond the edge of the erector spinæ. The outer edge of the quadratus is thus exposed and this muscle is likewise drawn inward, toward the middle line, with the tractor. The ilio-hypogastric nerve appears at the outer edge of the quadratus lumborum, about the middle of the incision and the twelfth dorsal nerve at the outer edge of the muscle in the upper part of the incision. These nerves pass obliquely downward and outward across the front of the quadratus lumborum and are usually readily recognized after the edge of the muscle has been exposed. These nerves should not be cut but rather drawn to one side, out of the way, with the fingers. Later, in introducing sutures, the nerves should also be avoided, not included in the loops of the sutures. The several layers of fascia, as they are encountered in the incision, should be split for the full length of the skin incision, upward to the lower border of the last

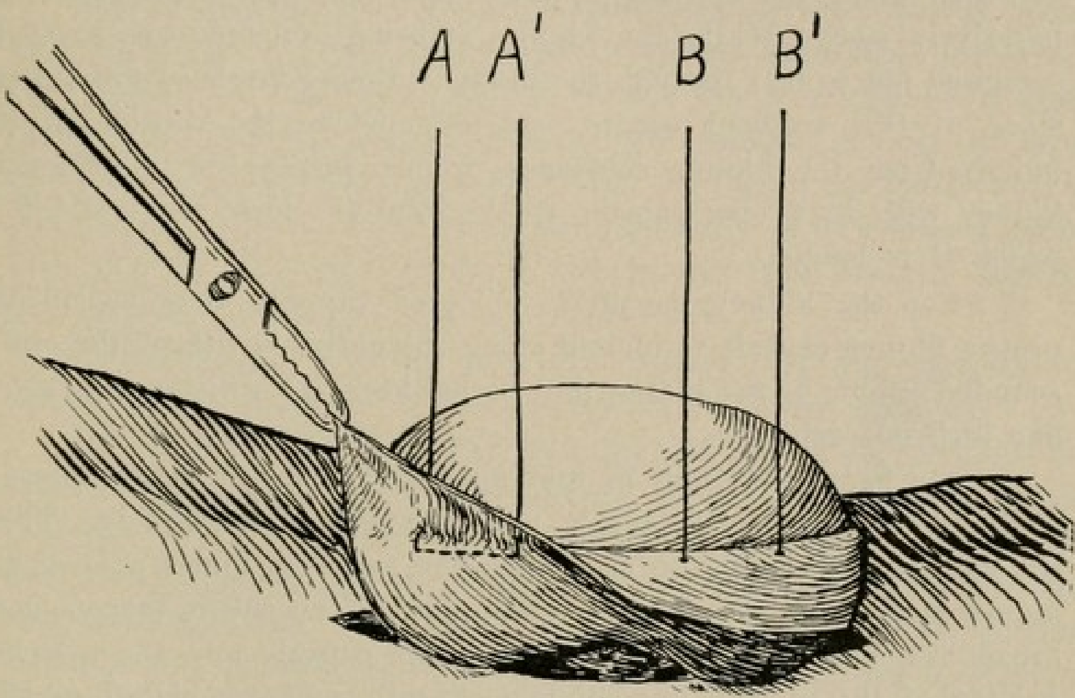

Fig. 300.—Nephropexy. Kidney delivered through an incision in the back. Proper fibrous capsule reflected and two fixation sutures introduced, one above (*A,A'*) and one below (*B,B'*). These sutures pass through the reflected and attached portions of the capsule close to the line of reflection. The two sutures that secure the capsule upon the opposite side of kidney are not seen.

rib and downward as far as the crest of the ilium. There remains now only the deepest and last layer of the lumbar fascia to be incised. This layer is picked up with tooth forceps and incised with the knife and then split, upward toward the last rib and downward toward the crest of the ilium, with the scissors or with the fingers. After this last layer of the lumbar fascia has been incised the fatty capsule, in which the kidney is embedded, is encountered. This is separated from the kidney bluntly with the fingers and the kidney freed and detached all around so that it may be brought up out of the incision. The isolation of the kidney is accomplished with gentleness, sweeping the fingers around the kidney, between it and the fatty capsule; around the free outer border, over the upper and lower poles and avoiding the inner border, the vessels at the hilum. Rough handling and pulling upon the kidney is to be avoided. If the kidney is displaced, movable, it is easy to reach it as it lies lower in the abdomen. The right kidney is situated lower than the left. When the kidney has been sufficiently separated it can be brought up into the incision and out upon the back for the subsequent steps of the operation. The prone position of the patient and the rubber bag under the abdomen make the delivery of the kidney out of the incision comparatively easy. While the kidney is being isolated care must be exercised not to tear through the proper fibrous capsule of the kidney, since, if this accident occurs, one may detach the capsule of the kidney from the kidney substance proper, instead of isolating the kidney with its proper capsule intact from the loose mass of fat in which it is lodged.

After the kidney has been delivered through the incision the proper fibrous capsule is incised along the entire length of the outer, rounded border of the kidney and peeled back for a distance of about one inch on each side.

Four fixation sutures of medium-sized kangaroo tendon are introduced in the reflected capsule, upon the sides of the kidney. These sutures are placed two on each side, one near the upper pole of the kidney and the other near the lower pole. Each suture takes a good broad bite in the reflected portion of the capsule and the attached portion of the capsule immediately beneath, and are placed parallel with and quite close to the margin that corresponds to the line of reflection of the capsule. After these four fixation sutures have been introduced the kidney is returned into the abdomen.

The ends of the fixation sutures, one after another, are threaded in a large, curved, Hagedorn needle, and carried, mattress fashion, through the muscles that correspond to the edges of the incision. The sutures are tied without drawing them too tight, and serve to suspend the kidney by its capsule to the edges of the incision.

There are usually no large vessels encountered during the operation, but all spurting points should be clamped and ligated. The wound should be perfectly dry. No drainage is necessary. The incision is closed by a line of suture of fairly thick chromic catgut, which unites the edges of the divided aponeurosis of the latissimus dorsi. This suture is continuous, the stitches close together, and should unite the edges of the aponeurosis securely and accurately. The edges of the skin are approximated with a continuous suture of plain catgut.

For Perinephritic Abscess.—Pus in the loose fat and connective tissue around about the kidney. The kidney itself may or may not be the site of the primary infection. The patient is placed in the prone position, with the Edebohls bag under the abdomen. The presence of pus will usually have already been demonstrated by the exploring needle.

The incision is made as already described in the previous operation, exposing the edge of the erector spinæ, quadratus lumborum, etc. When the deep layer of the lumbar fascia is exposed a small incision is made through which the pus escapes, usually in large quantity. This opening is enlarged with the finger, the cavity washed out with salt solution and packed, not too tightly, with iodoform gauze. The edges of the upper part of the incision are brought together with several interrupted sutures of heavy silk.

Nephrotomy.—Cutting into the kidney for the purpose of evacuating an abscess or to explore the pelvis of the kidney.

The position of the patient and the incision are as described for nephropexy (page 655). The patient is placed prone, with the Edebohls cushion underneath the abdomen. The incison is carried down, step by step, until the last layer of the lumbar fascia has been cut and the kidney is reached. If operating for nephritic abscess, we may find, as soon as the kidney is exposed, that the indications of the abscess immediately present themselves, or it may be necessary to search with an exploring needle. When pus is located, the cavity containing it is incised with the point of the scalpel and enlarged with dressing forceps, which are introduced closed and expanded as they are withdrawn. At times the entire kidney substance is destroyed, and simply a bag of pus remains. We may or may not find a stone. The kidney may be very firmly adherent, so that great difficulty would be experienced in loosening it to bring it up into the incision for examination. Under these circumstances it is probably wise not to persist in the effort to loosen the kidney, but to be content with opening and draining the abscess.

The abscess cavity is irrigated and packed loosely with iodoform gauze, the end of which emerges through the lower part of the incision in the loin. The incision is closed as described in nephropexy, first the edges of the aponeurosis with heavy, chromic catgut sutures, and then the skin. The lower part of the incision is left open for drainage.

At times, in order to explore the pelvis of the kidney or to drain it, it may be necessary to bisect or split the kidney from its posterior rounded border right through into its pelvis. In doing this care should be exercised to divide the kidney a little behind the middle of the outer, rounded border, the section passing through a plane a little nearer the posterior surface than the anterior surface, through the non-vascular zone of Hyrtl. There will be much less hemorrhage. The kidney must be brought out through the incision in the back for this purpose. It is usually sufficient if the incision in the kidney extends through only a part of its length—through its lower pole—an incision just large enough to admit the finger will suffice in many cases.

In this way the pelvis and calyces may be explored. The ureter should be palpated as far down as possible, and may be sounded by passing a rubber bougie. Stones which would otherwise escape detection may thus be discovered and removed, or, if there is no stone present, and the symptoms are due to an inflammatory condition of the pelvis, this may be drained through the kidney by leaving a small tube or a strip of iodoform gauze, which reaches from the pelvis of the kidney and emerges through the incision in the loin. A resulting urinary fistula usually closes spontaneously, provided the ureter is not obstructed.

The vessels at the hilum may be compressed in order to avoid considerable loss of blood that would necessarily occur during the examination of the pelvis, etc., after the kidney has been split open for a considerable portion of its length. The vessels may be compressed between the finger and thumb of an assistant, or they may be compressed between the rubber-sheathed blades of a clamp. The clamp must not be applied too tight. For the purpose of controlling the hemorrhage after the examination has been completed, the cut surfaces of the kidney are brought together with several deep sutures passed through the kidney substance from one side to the other. For these sutures plain, fairly thick catgut is used. The sutures are passed with a large, curved surgeon's needle, and should not be drawn too tight when they are tied. Occasionally in order to control the hemorrhage from the kidney it may be necessary, in addition to the sutures, to pack iodoform gauze in between the cut surfaces of the kidney.

If the kidney has been incised it is wise to leave a gauze drain in the incision in the back for at least forty-eight hours.

Nephrolithotomy.—Cutting into the kidney for stone.

The steps of this operation are like those already described in the preceding operation. After the kidney has been reached and brought up and out through the incision it may be palpated in order to locate the stone. The stone may be found in the pelvis of the kidney, in one of the calyces, or in the substance of the kidney near the surface. The ureter should be traced downward as far as possible, palpating it between the finger and thumb. A stone in the pelvis may, as a rule, be readily detected when the pelvis is grasped between the fingers and thumb. If a stone is felt in the substance of the kidney an incision is made down upon the stone and the stone removed. A stone in the pelvis may be removed by incising the posterior wall of the pelvis,—pyelotomy. The fat is scraped off the posterior surface of the pelvis—the blood-vessels lie in front of the pelvis—and the pelvis incised and the stone removed. The incision in the pelvis is made from above downward, parallel with the course of the ureter and should be large enough to admit the finger for exploration, etc. This plan is adapted to those cases where the stone is small and the pelvis free from infection. The stone may be removed from the pelvis by incising the kidney as described in the preceding operation, cutting through the substance of the kidney from its free, rounded border down into the pelvis. This latter is the more satisfactory plan for most, if not all, cases The stone is removed with the finger, forceps or scoop. If one is unable to discover a stone by palpation of the kidney tissue, pelvis, etc., and the symptoms indicate that a stone is present, then the kidney should be incised as described in the preceding operation so that the finger may be introduced and the interior of the pelvis, calyces, etc., may be explored for the presence of a stone or some other condition in the pelvis to account for the symptoms. The ureter should be traced down as far as possible with the fingers and examined by palpation for possible impacted stone. A rubber bougie may be passed through the pelvis of the kidney into the ureter and down through the ureter in order to test the patency of its canal. A stone in the ureter may be stripped up into the pelvis and removed. As a rule pus is associated with stone, and it is usually wise, therefore, to drain the kidney, leaving a strip of iodoform gauze in the kidney for this purpose. If there is little or no infection of the pelvis and the ureter is certainly patent, the drainage may be omitted and the incision in the kidney closed with one or more through and through catgut sutures. If the stone has been removed through the pelvis of the kidney the incision in the pelvis may be closed with several plain catgut sutures introduced with a small, full-curved needle in a holder. It is well to provide drainage for the incision in the back, a strip of gauze being packed into the wound down to the site of the incision in the kidney or pelvis of the kidney.

Nephrectomy.—Extirpation of the kidney. The kidney is removed for disease, malignant, suppurative, tuberculous; for wounds; uncontrollable hemorrhage, etc. If probable removal of a kidney is in question it is necessary for the operator to have assured himself positively that the patient has two kidneys and that the kidney which is to remain is capable of carrying on the function. Preliminary cystoscopic examination of the bladder will demonstrate the presence of two ureters, at least one ureteral opening on each side. By catherization of the ureters urine may be obtained from each kidney separately. Examination of the urine thus obtained will indicate the functional capacity of each kidney.

The kidney can be removed through an incision in the lumbar region; or else through an incision in the anterior abdominal wall—the transperitoneal route.

Lumbar Nephrectomy.—This is the preferable method for removal of the kidney; the peritoneal cavity is not opened. This method is applicable to practically all cases except where the kidney is very large or where the kidney is exposed during the course of an abdominal exploration.

The position of the patient is the same as that already described for nephropexy. The steps of the operation are as above indicated down to the point of exposing the kidney. The incision is the same as that described for nephropexy (page 655) and should reach from the last rib to the crest of the ilium. If necessary, we may obtain more room by continuing the incision forward, above and parallel with the crest of the ilium as far as, or beyond, the anterior superior iliac spine.

The isolation of the kidney must be thorough, and this is accomplished with the hand in the wound, working patiently, with the fingers, around the kidney, care being taken not to tug upon the kidney, as one may tear the vessels at the hilum. The suprarenal capsule may be left behind, although, if diseased, it may be removed also. Occasionally the kidney is found to be very adherent to the adjacent structures, and great care and patience must be exercised in detaching and isolating it. After the kidney has been freed, all around, it is brought well up into the incision, or, as may be done in most cases, the kidney is brought entirely out through the incision. The ureter is traced as far down as possible and clamped with two artery forceps and cut between them. The stump of the lower portion is ligated with ten-day chromic catgut, the forceps removed and the end touched with pure carbolic on a probe. A heavy, plain catgut ligature (No. 3 or 4) is tied around the pedicle, which consists of the renal artery and vein. The proximal end of the ureter which is still grasped with the artery clamp is held up out of the way so that it may not be included in the ligature. The ligature must be tied very tight, the first loop of the knot being double, so that it cannot slip. The ends of the ligature are left long to serve as a tractor to bring the stump of the pedicle up into the incision for final inspection. In cutting away the kidney the division should not pass through the pedicle, which is made of the vessels, but, if possible, should pass through the kidney tissue near the hilum, in order to leave a little mass of kidney tissue as a cap, or knob, to prevent the slipping of the ligature.

The wound is treated as in the foregoing operation. It is probably wise to introduce a drain, which is left for forty-eight hours.

Abdominal Nephrectomy.—This route is selected for those cases in which the kidney is represented by a large tumor mass in the abdominal cavity. Occasionally during an exploratory laparotomy for indefinite intra-abdominal injury the kidney is found to be so badly damaged that it has to be removed.

The patient lies flat upon the back. The incision is made through the middle of the rectus muscle, about four inches long, the middle of the incision corresponding to the level of the umbilicus. It may be necessary, later, to lengthen the incision. If the kidney is large it presents prominently into the incision. The great omentum and transverse colon are pushed upward toward the diaphragm, the small intestines inward toward the middle line, and the ascending or descending colon (according to whether the right or left kidney) outward, toward the outer part of the abdominal cavity. The intestines are held thus out of the way with gauze pads. The kidney is covered upon its anterior surface by the peritoneum. Passing outward, across the front of the kidneys, behind the peritoneal layer, are the arteria colica dextra across the right kidney and the arteria colica sinistra across the left. If the kidney is not considerably increased in size it will be necessary to seek for it in its proper position, in the upper, back part of the abdomen.

In order to expose the kidney it is necessary to incise the peritoneal layer that covers its anterior surface. This should be done bluntly, tearing with the finger-nail or forceps or the blunt end of a scissors in order not to injure the colica artery and vein which pass across the front of the kidney to reach the ascending or descending colon. After the peritoneal layer has been opened the kidney may be freed all around, working with the hand close to the kidney surface in the pocket in which it is lodged, until the organ can be lifted up out of the abdominal incision. The fat and connective tissue about the hilum are scraped away. The pedicle is seen to consist of the renal artery and vein and the ureter. The ureter may be palpated as the lowest of the three structures forming the pedicle and may be traced downward for some distance toward the bladder. The ureter is followed downward toward the bladder as far as possible, when it is clamped with two hæmostats and divided between these. The end of the distal portion is tied off with ten-day chromic catgut, the clamp removed and the end of the stump touched with pure carbolic acid on a probe. The ends of the ligature are cut short and the stump dropped into the abdomen. A heavy, plain catgut ligature (No. 3) is thrown around the pedicle of the kidney—renal artery and vein—but not including the ureter, and the ligature tied. This ligature must be tied very tight, the first loop double, so that, when the kidney is cut away, the ligature will not pull off. Too much traction must not be made upon the ligature while the kidney is being cut away. In cutting the kidney away from the pedicle, cut as far away from the ligature as possible so as to leave a little cap of tissue to prevent the ligature from slipping off.

In closing, if the case has been a clean one, the edges of the torn peritoneum corresponding to the pocket out of which the kidney has been removed, are sutured together with a few stitches of plain catgut and the incision in the abdominal wall then closed without drainage. If the operation has been done for a septic or tuberculous condition it will be necessary to drain the pocket out of which the kidney has been enucleated. This pocket may be drained by sewing its edges to the edges of the abdominal incision, leaving the latter open in part and introducing a plug of strip gauze; or the pocket may be drained by making an incision in the lumbar region, cutting down upon the blunt point of a dressing forceps which is introduced from within. A plug of strip gauze is passed from the pocket out through the incision in the back and the edges of the peritoneal pocket then united with a catgut suture. The abdominal incision may then be closed without drainage.

Decortication of the Kidney (Edebohls).—This operation was first suggested for the cure of chronic Bright's disease, by Edebohls. The real value of the procedure in this condition is still undetermined. Whatever beneficial effect it may have is, no doubt, due to the increased supply of blood that is brought to the kidney through the new vascular connections that are formed between it and the adjacent parts. The splitting of the dense, non-yielding capsule of the kidney relieves the tension and compression exercised upon the kidney tissue, and oftentimes results in the cure of certain forms of hemorrhage from the kidney and of nephralgia.

Nitrous oxide and oxygen with a minimum amount of ether is a satisfactory anæsthetic mixture for these cases. Spinal analgesia would, no doubt, be appropriate in some cases where the condition of the patient is such as to counterindicate the use of a general anæsthetic.

The patient lies prone upon the table with an Edebohls rubber cushion under the abdomen. The incision is the same as that described for nephropexy and corresponds to the edge of the erector spinæ, quadratus lumborum, etc. The kidney is recognized in the mass of fat, fatty capsule, that incloses it.

With the fingers in the wound the fatty capsule is separated bluntly from the surface of the kidney as far as the pelvis. The kidney, inclosed within its own proper fibrous capsule, is then drawn up and out through the incision, upon the back.

Corresponding to the middle of the outer, rounded border of the kidney, the capsule proper is incised and divided upon a director along the entire length of the outer, rounded border of the organ, and around its extremities, above and below. Each half of the capsule is then stripped away from the surface of the kidney toward the pelvis, taking care not to break or tear the kidney substance proper, which may be friable and firmly adherent to the capsule. The stripped-off capsule is finally cut away near the pelvis of the kidney, and removed. Any portion of the capsule that still remains may be rolled back toward the pelvis of the kidney, where it remains coiled up, upon itself.

The kidney is finally replaced in the abdomen, and the incision closed without drainage. At the time of operation it may appear that but one kidney is the seat of chronic Bright's disease, but it is probably wise in all cases to decapsulate both kidneys at the same sitting.

OPERATIONS UPON THE URETER.

Ureterolithotomy.—Incision into the ureter for the removal of a calculus. Calculi escape from the pelvis of the kidney into the ureter. Small stones may pass on through the ureter and escape into the bladder. Larger stones may become impacted in the ureter and wedged tight and thus block the ureter permanently and completely, or they may shift their position, now and then, "ball-valve" fashion, in a dilated portion of the ureter, and thus occasionally allow the urine to flow past them. The ureter becomes dilated and its wall thickened behind the obstruction. The pelvis of the kidney becomes dilated (hydronephrosis), and if the elements of infection are added we have a condition of pyonephrosis.

The diagnosis of stone in the ureter is very materially aided by the X-ray and by the introduction of a wax-tipped catheter into the ureter. The wax-tip, examined under the magnifying glass, will show minute scratches caused by contact with the calculus.

The ureter may be approached through the retroperitoneal route, or it may be exposed by entering the abdominal cavity from in front and incising the peritoneal layer that covers it,—the transperitoneal route. The former is by far the preferable method.

Retroperitoneal Method.—The patient lies flat upon the back. An incision is made which reaches from near the tip of the twelfth rib to a point about one inch above the anterior superior iliac spine. If more room is necessary the incision may be continued forward and inward, above and parallel with Poupart's ligament as far as the middle of the ligament. The incision divides the various layers down to the peritoneum. The peritoneum is not incised. If the peritoneum is opened accidentally, the opening should be closed immediately with a continuous catgut suture. The peritoneal layer is peeled up, away from the posterior wall of the abdomen, working inward toward the middle line until the psoas muscle is reached. As the peritoneal layer is lifted up, away from the psoas muscle, the ureter is likely to go with the peritoneal layer, since it is quite intimately attached to the peritoneum. The ureter dips down into the pelvic cavity over the brim of the pelvis, passing across the bifurcation of the common iliac or the commencement of the external iliac. The ureter is readily recognized if it contains a stone and if it is dilated and its wall thickened. The identification of the ureter is greatly facilitated if a catheter has been previously passed up into it through the bladder with the aid of the cystoscope. A longitudinal incision is made in the ureter and the stone removed. Before the incision is made the ureter is seized with a rubber-sheathed clamp well above the location of the stone, in order to prevent escape of urine when the ureter is opened. The incision is made, not directly over the calculus, but rather above the location where the stone is impacted, where the ureter is likely to be more or less dilated. The lumen of the ureter is investigated with a probe or bougie for the presence of additional stones and to test its patency. The incision in the ureter is closed with several sutures of fine, chromic catgut, in a fine, curved needle. These sutures should not penetrate the entire thickness of the wall of the ureter; they should not appear within the lumen of the tube. If any difficulty is experienced in introducing the sutures they may be omitted because the incision in the ureter heals without difficulty provided the ureteral canal is patent. A plug of strip gauze is left in the incision, reaching down to the incision in the ureter to provide for drainage in the event of leakage. The incision in the abdomen is closed with interrupted, deep sutures of silk-worm gut except where the gauze drain emerges.

TRANSPERITONEAL ROUTE.—An incision is made in the anterior abdominal wall—through the middle of the rectus muscle. The intestines are pushed aside and held out of the way with gauze pads. The ureter is found behind the peritoneal layer, resting upon the psoas muscle and dipping into the pelvic cavity across the bifurcation of the common iliac artery. The peritoneal layer is incised, the ureter opened, and the stone removed. The opening in the ureter is accurately closed with a sufficient number of non-penetrating sutures of fine chromic catgut. The incision in the peritoneal layer that covers the ureter is also sutured. A cigarette drain is left in the abdomen reaching down to the site of the opening in the ureter. Satisfactory drainage may be provided by making an incision in the skin, behind, in the lumbar region, and poking a dressing forceps through from within the abdomen, through the muscles of the lumbar region. Strip gauze may be drawn through and thus drain the site of the incision in the ureter. Under these circumstances the incision in the anterior abdominal wall may be closed without drainage.

A stone impacted in the lower end of the ureter, at or near the vesical orifice may be removed, in the male, through a supra-pubic cystotomy. The ureteral orifice may be incised if necessary in order to reach the stone. In females stones impacted in the lower part of the ureter may be removed through an incision in the wall of the vagina. The ureter is thus exposed and incised and the stone removed.

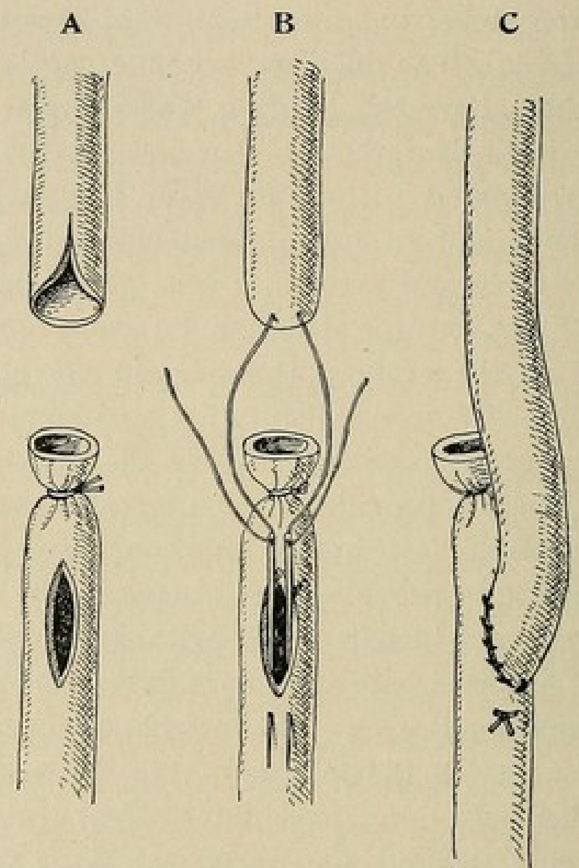

Fig. 301.—Uretero-ureterostomy (*Van Hook*). A. The end of the upper renal segment is incised and the corners rounded off. The lower, vesical segment of the ureter has been ligated and an incision made in it near the end. B. The end of the upper segment is drawn into the incision in the lower segment with the tractor suture. C. The end of the upper segment has been drawn into the incision in the lower, vesical segment and fixed in position by tying the tractor suture. A row of sutures is applied which unites the implanted end of the upper segment to the edges of the incision in the lower vesical segment.

Uretero-ureterostomy, END-TO-SIDE ANASTOMOSIS (VAN HOOK). —This operation is done for the purpose of restoring the ureteral canal. The lower, vesical end of the ureter is found and ligated. About one-quarter of an inch below the ligatured end a longitudinal incision is made in the ureter. This incision is equal in length to twice the diameter of the ureter. The upper, renal end of the divided ureter is secured and its end incised, notched, for a short distance, about one-quarter inch, and the corners of the incision then rounded off.

A fine, straight needle is threaded in each end of a fine, plain catgut suture. This suture secures the end of the upper, renal segment of the ureter, quite close to its edge and at a point opposite where the notch has been cut in it. This stitch does not penetrate into the lumen of the ureter. The two needles are passed into the lower, vesical segment of the ureter, through the slit that has been made in it and then out through the wall of the ureter just beyond the distal end of the slit. When traction is made with the suture

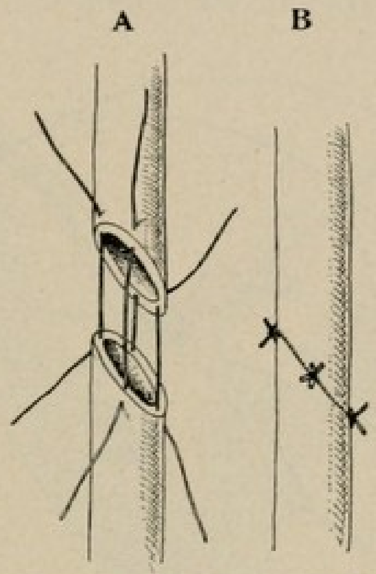

Fig. 302.—Uretero-ureterostomy (*Bovee*). A. The ends of the ureter cut obliquely. Four sutures introduced which do not penetrate through entire thickness of wall of ureter. B. The sutures tied and the ends of the divided ureter joined together. Additional sutures may be introduced as necessary.

the open end of the upper, renal segment of the ureter is drawn into the slit which has been made in the side of the lower, vesical segment. The suture is tied and the end of the ureter thus secured in position. A continuous suture of very fine silk is applied, which secures to the edges of the incision in the lower, vesical segment to the end of the implanted, renal segment.

End-to-end Anastomosis (Bovée).—The two ends of the ureters are cut obliquely to allow for subsequent contraction, and are then joined together with non-penetrating sutures of fine silk placed fairly close together.

Uretero-Cystostomy.—Implantation of the end of the ureter into the bladder. The ureter will usually have been damaged or caught in a ligature during a hysterectomy.

The bladder is moderately distended with boric acid solution and the abdominal cavity is opened through an incision in the anterior abdominal wall.

The ureter is sought for where it dips into the pelvic cavity at the brim of the pelvis and is exposed by incising the peritoneal layer which covers it. Traction is made upon the ureter to indicate its further course and position in the pelvic cavity. An incision is made in the peritoneum covering the ureter as low down, as near the bladder, as possible and the ureter thus exposed. A chromic catgut ligature is tied around the ureter low down, near the bladder end.

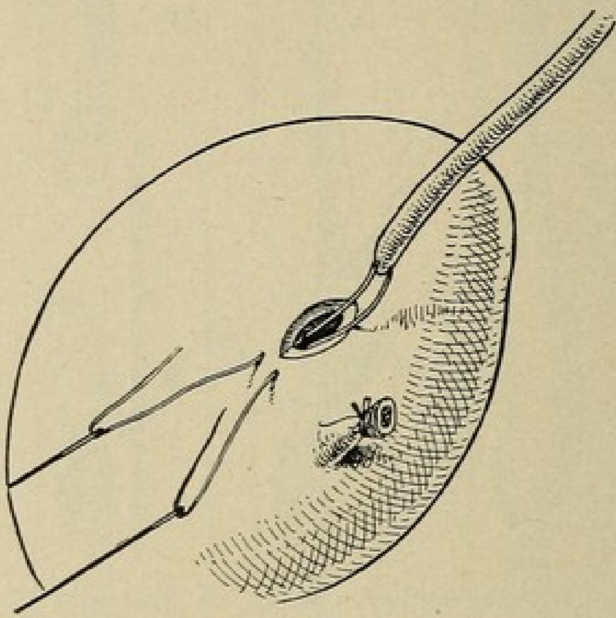

Fig. 303.—Uretero-cystostomy. Vesical end of ureter ligated close to the bladder. The end of the ureter is drawn into the small incision in the bladder with a tractor suture.

The ureter is secured with a rubber-sheathed clamp just above the ligature, and then divided between the ligature and the clamp.

A small incision is made in the bladder as near the original site of the ureteral orifice as possible. This incision is made upon the point of a metal sound which is introduced into the bladder through the urethra. The end of the ureter is incised, notched, for a short distance, and the corners rounded off to provide for possible subsequent contraction of the orifice. A guiding or traction suture of fine catgut is introduced which secures the end of the ureter in a manner similar to that employed in the Van Hook operation described above. The needles carrying the tails of the traction suture are introduced into the bladder through the opening which has been made, and then out through the wall of the bladder just beyond the edge of the incision. When the suture is drawn taut it pulls the end of the ureter into the incision in the bladder. The suture is tied and the edges of the incision in the bladder sewed all around to the end of the implanted ureter with interrupted sutures of fine silk. The ureter for about one inch of its length is then buried beneath two folds of the bladder wall, which are sutured over it in a manner similar to that used in the Witzel gastrostomy.

Uretero-Enterostomy.—One or both ureters may be implanted into the bowel—usually into the sigmoid flexure. This operation is sometimes done for exstrophy of the bladder. There is danger of infection traveling up the ureters and involving the kidneys. If the

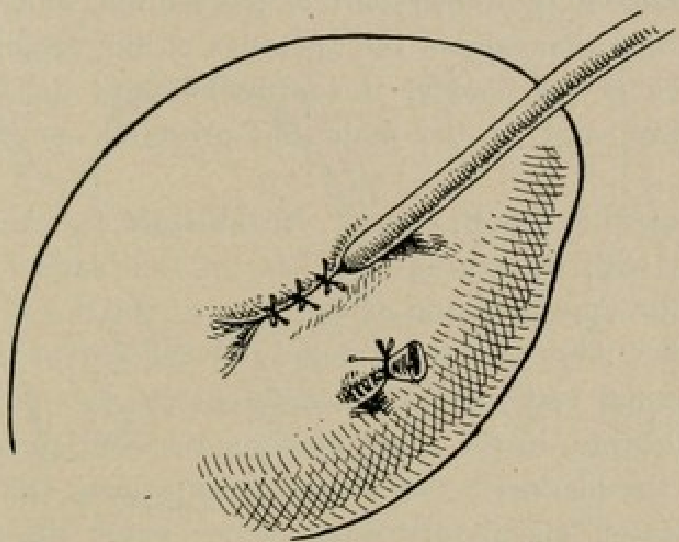

Fig. 304.—Uretero-cystostomy. The bladder wall is raised in two folds and sutured over the end of the ureter.

portion of the bladder wall immediately adjacent to the ureteral orifices is resected with the ureters in order to retain the sphincter-closing apparatus, and this piece carrying the two ureteral orifices then sutured into the intestine there will be less danger of infectious elements gaining entrance to the ureters and affecting the kidneys.

THE BLADDER.

Surgical Anatomy of the Bladder.—The bladder is a hollow muscular organ whose function is to receive and hold the urine during the intervals of micturition. It has a capacity ordinarily of about sixteen ounces. In the contracted state the wall of the bladder is seen to be quite thick.

In the infant the bladder is rather conical, and projects into the abdomen above the level of the symphysis.

In the adult the bladder, when empty, lies deep within the pelvis behind the symphysis, its cavity obliterated and its walls collapsed and in contact with each other. When distended moderately, it reaches as high as the symphysis, farther distension causing it to rise up, out of the pelvis, into the abdominal cavity a varying distance toward the umbilicus. When it is distended with about a pint of fluid, the bladder is pear-shaped, and reaches for a distance of about four inches above the symphysis.

The body of the bladder is free, and, when the organ is distended, rises out of the pelvis into the abdomen, toward the umbilicus.

The base of the bladder in the male is in close relation with the anterior surface of the upper part of the rectum, and upon its inner aspect, on either side, shows the openings of the ureters.

The neck of the bladder is continuous with the commencement of the urethra, and in the male the prostate surrounds it like a collar.

Relations of the Bladder. *In the Male* the bladder is in relation, behind, with the rectum, the base of the bladder lying directly in front of the upper portion of this part of the bowel, the two being joined together more or less intimately by connective tissue.

The seminal vesicles and vas deferens are located on either side of the middle line, in the space between the contiguous walls of the rectum and the bladder; they converge anteriorly and join to form the two common ejaculatory ducts which enter the prostate gland at the base. The prostate gland is readily palpable through the rectum, above the anal portion.

In the Female the uterus and vagina are located behind the bladder.

In both sexes the bladder lies immediately behind the symphysis pubis, from which it is separated by a space, which is filled with loose connective tissue more or less firmly connected with the anterior wall of the bladder, and which is called the space of Retzius. When the bladder is distended it reaches above the symphysis and is then in relation, in front, with the anterior abdominal wall.

Passing from the summit of the bladder to the umbilicus is the urachus, which occasionally remains patent after birth.

The peritoneum covers the sides, part of the posterior surfaces, and the summit of the bladder, but does not cover its anterior surface, being reflected from the summit of the bladder over on to the posterior surface of the anterior abdominal wall. When the bladder is well distended, it rises upward into the abdomen; its summit, as it approaches the umbilicus, carries the peritoneum with it and its anterior surface, which is devoid of peritoneum, then comes into relation with the abdominal wall; so that under these circumstances the bladder may be entered through an incision in the anterior abdominal wall, low down, close to the symphysis, without molesting the peritoneum or entering the peritoneal cavity.

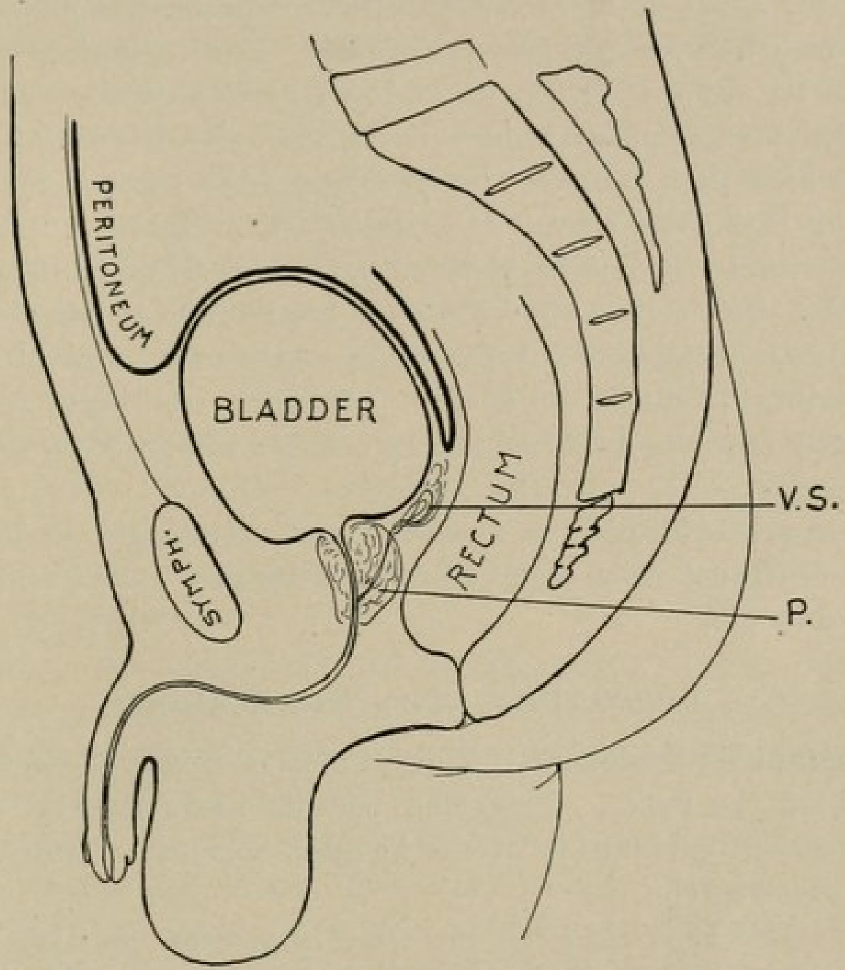

Fig. 305.—An Antero-posterior Section Showing Relations of the Peritoneum to the Bladder, etc. Bladder moderately distended. *P.*, prostate gland surrounding commencement of the urethra (neck of the bladder), course of the ejaculatory duct; *V.S.*, vesiculæ seminales.

The higher the bladder ascends into the abdomen, the larger the area of its anterior, non-peritoneal surface which is presented for operation.

The Interior of the Bladder.—In the contracted state the wall of the bladder is seen to be very thick, and the cavity is practically obliterated, the walls being almost in direct contact with each other. The mucous lining of the bladder is but loosely connected with the muscular coat by a loose, elastic, submucous layer, and in the contracted state is thrown into numerous folds and rugæ. The floor of the bladder presents a triangular area which is smooth, devoid of rugæ, and which is more firmly attached to the muscular coat. This smooth, triangular area is called the *trigonum.* It represents an equilateral triangle, the sides of which, in the contracted state of the bladder, measure about one inch in length. The apex of the triangle is above at the urethral orifice. The base is indicated by a line drawn between the ureteral orifices. Corresponding to the line between the ureteral orifices there is a smooth elevation or bar which is caused by the presence in this position of a bundle of muscular fibers which pass transversely underneath the mucous layer. This elevation is slightly curved so as to be convex forward and is called the *torus uretericus.* The ureters pierce the wall of the bladder very obliquely. The orifices of the ureters are minute, elliptical in shape. The mucous membrane corresponding to the outer edge of each ureteral orifice is raised in a thin, semilunar, valve-like fold which effectually prevents fluid backing up into the ureters when the bladder is distended.

When the bladder is distended the ureters get to lie farther apart—separated from each other for a distance of one and one-half inches or more.

OPERATIONS UPON THE BLADDER.

Suprapubic Cystotomy.—The bladder is opened through an incision above the pubes. This plan permits ready removal of calculi and thorough exploration of the bladder, removal of tumors, access to the prostate, etc.

The patient is placed in the usual laparotomy position, upon the back, and fully anæsthetized so as to relax the abdominal muscles. A soft rubber catheter is introduced into the bladder, and, through this, the bladder is washed out with boric-acid solution, 10 to 12 ounces being allowed to remain; the catheter is then withdrawn, and a band tied about the penis to prevent the escape of the fluid. The fluid which is thrown into the bladder causes it to ascend into the abdomen, carrying the peritoneum with it; so that the anterior surface of the bladder, uncovered by peritoneum, is exposed for several inches for operation. Some advantage is gained if the table is tilted somewhat so that the patient occupies the Trendelenburg position to a moderate degree.

The incision, which is placed in the middle line, linea alba, commences below, at the symphysis pubis, and reaches upward, toward the umbilicus, for a distance of about three inches and extends through the skin and fat down to the deep fascia. Bleeding vessels in the skin are clamped.

The incision is carried down through the linea alba, between the edges of the recti and pyramidales, until the layer of connective tissue which is found in front of the bladder is reached. The edges of the incision are drawn apart with retractors and the finger poked into the incision and down behind the symphysis pubis so that the posterior surface of the symphysis can be plainly felt and recognized. The layer of connective tissue which covers the anterior wall of the bladder is scraped upward, toward the umbilicus, with the fingernail; so that, in case the fold of peritoneum reaches abnormally low, or the bladder has not been sufficiently distended, we may thus still separate it and carry it upward toward the umbilicus. The smooth muscular wall of the bladder is then easily recognized, especially if the organ is distended. The distended organ that lies immediately posterior to the symphysis cannot be anything else but the bladder. A plexus of veins, more or less visible, which ascends upon the anterior wall of the bladder from below, may help still further to identify the bladder.

With a curved surgeon's needle two sutures of plain catgut are introduced, one on either side of the middle line, through the whole thickness of the bladder wall and these are used as tractors to steady the bladder while it is being incised.

In cutting into the bladder the point of the knife is introduced between the two catgut stitches about one inch above the symphysis and the bladder incised in a direction downward, toward the symphysis. When the bladder is opened the fluid contained within it escapes in part. The incision should be large enough to permit the introduction of one or two fingers for the purpose of exploration, etc.

The incision in the bladder may be enlarged sufficiently to allow necessary manipulation. Caution should be exercised in extending the opening in the bladder, in an upward direction, toward the umbilicus for any considerable distance, to draw the fold of peritoneum upward out of the way.

If a stone is present, it may be removed with the forceps, guided by the finger; if the stone is very large, it may first be crushed. One should search the bladder carefully for stones which have become almost completely encysted in the pockets in the bladder wall. If the operation is done for ulcer of the bladder, the diseased area may be scraped or cauterized, etc. With the patient in the Trendelenburg position and the edges of the wound drawn asunder with broad retractors, the interior of the bladder may be illuminated and made visible. A tumor may be excised or an hypertrophied prostate may be enucleated through the suprapubic opening.

It is wise, in all cases of suprapubic cystotomy, to drain the bladder. For this purpose a large rubber tube is introduced and fixed to the edge of the incision in the bladder by carrying the corresponding catgut tractor suture through the tube with a needle. The suture is tied and fixes the tube so that it cannot escape from the bladder. The rubber tube should be one-half to three-quarter inch in diameter. The end which presents into the bladder should be smooth and rounded and, besides the hole in the end, there should be a second in the side of the tube near the end. The tube should not present into the bladder for more than one to one and one-half inch of its length. If the incision in the bladder is quite large it may be sutured in part so as to close it fairly snugly about the rubber tube. The sutures of chromic catgut (No. 1 or 2) which approximate the edges of the incision in the bladder should penetrate through all the layers of the bladder wall except the mucous coat. They should not present within the cavity of the bladder (see Fig. 27). The incision in the abdominal wall is left open for part of its extent and is packed with iodoform gauze. The gauze pack reaches down around the tube to the incision in the bladder, and also down into the space behind the symphysis, between the symphysis and bladder,—the space of Retzius. The tube from the bladder is connected with another tube which reaches over the side of the bed into a bottle partly filled with some antiseptic solution. The urine is drained from the bladder through the tube into the bottle. If the tube becomes blocked a small quantity of fluid may be injected through it into the bladder, and the tube then stripped with the fingers to start the flow by siphonage. The gauze packing is changed as often as necessary and the drainage-tube removed, as a rule, after six or seven days. The suprapubic opening closes spontaneously shortly after the tube has been removed, provided there is no obstruction along the course of the urethral canal.

Puncture of the Bladder may be made in the middle line just above the symphysis. It is done for the purpose of drawing off the urine when the patient is unable to empty the bladder through the urethra. One should first satisfy himself by percussion, etc., that the bladder is actually distended.

A medium-sized curved trochar is introduced above the symphysis; it should be thrust through the anterior abdominal wall in the middle line just above the symphysis, and in a direction backward and downward, toward the sacrum, for a distance of two or three inches.

THE PENIS.

Surgical Anatomy of the Penis.—The penis when erect is prismoid in shape. It is composed of the corpora cavernosa and the corpus spongiosum.

The corpora cavernosa are two cylinders of erectile tissue which run parallel with each other and occupy the upper part of the organ. They consist of a mesh-work of vascular spaces, which may readily become distended with blood, thus bringing the penis into a condition of erection. They are each provided with a strong, fibrous envelope, the tunica albuginea, and behind, diverge, to be attached to the rami of the pubes.

The corpus spongiosum also consists of erectile tissue, and is situated below the corpora cavernosa forming the under part of the penis. The urethra passes through the corpus spongiosum. The end of the penis is enlarged, rather bulbous, and is known as the glans; this is really the enlarged extremity of the corpus spongiosum. Behind, in the perineum, the corpus spongiosum is enlarged and forms the bulb. The penis at its root is firmly connected to the symphysis by a fibrous band, the suspensory ligament.

The three cyclinders which together form the penis are bound together by a fibrous sheath, and covered with a soft, loose, movable envelope of skin, which, at the extremity, is reflected over the glans for a greater or less distance, forming the prepuce. The constriction behind the glans is called the corona.

Passing forward upon the dorsal surface of the penis, in the groove between the corpora cavernosa, are two arteries, one on each side, the dorsal arteries of the penis, branches of the internal pudic, and lying between the two arteries is the single dorsal vein.

The urethral canal, from the internal urethral orifice to the external meatus, is about eight inches long. It is described as consisting of three parts: the spongy, the membranous, and the prostatic. The spongy portion of the urethra is about six inches long.

It is surrounded for its whole length by the erectile tissue of the corpus spongiosum, which is represented behind by the bulb and anteriorly by the glans. The membranous portion is short—about three-fourths inch in length—non-dilatable. It is contained between the two layers of the triangular ligament, and is surrounded in this situation by the fibers of the compressor urethræ muscle. The prostatic portion of the urethra is rather more than one inch long and is very roomy (see page 694).

OPERATIONS UPON THE PENIS.

Forcible Dilatation of the Prepuce for Phimosis.—This may be practiced in many cases, especially in newborn and young children,

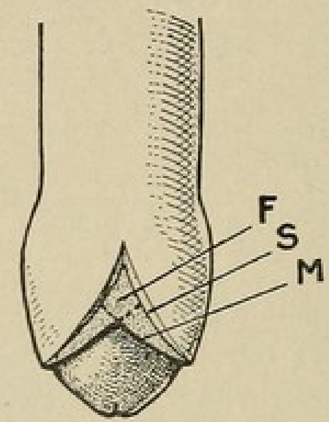

Fig. 306.—Dorsal Section (*Roser*). The little triangular flap, *F*, is turned back and sutured to the corner of the skin. *M*, edge of mucous membrane; *S*, edge of skin.

instead of a dorsal section or circumcision. An anæsthetic is unnecessary. The skin of the prepuce is seized and peeled forcibly backward over the glans as far as the corona. This is readily done in most cases, even when the orifice of the prepuce is quite narrow. The margin of the prepuce stretches and suffers slight tears here and there about its circumference; it should be drawn back and forth several times, and again repeated daily for several days. When the prepuce is drawn back, any hardened smegma that has accumulated should be removed, and the glans washed and smeared with oil or vaselin; the skin is then again drawn forward over the glans, since the constriction of the narrow prepuce might cause some inconvenience if allowed to remain back behind the glans. After the foreskin has been drawn back and forth over the glans a dilator may be introduced into its orifice, and it may then be forcibly and thoroughly dilated. In most cases this is unnecessary.

Dorsal Section.—This operation is done for phimosis in the young, when one is unable to retract the skin and when it is not desirable to do a complete circumcision, and in adults in all cases where it is necessary to expose the glans for treatment.

The skin of the penis is rolled slightly back toward the root of the organ with the finger and thumb and one blade of a blunt-pointed scissors introduced beneath the prepuce, between it and the glans, as far back as the corona, and the foreskin then divided along the middle line, steadying it so that it will not roll or slip. The

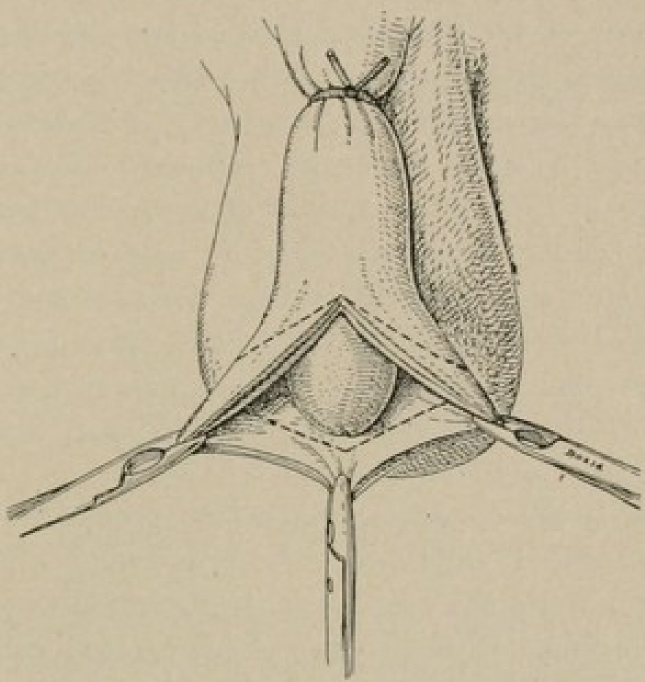

Fig. 307.—Circumcision. Dorsal section has been made. The corners of the divided prepuce are grasped with artery forceps and the prepuce seized with a third forceps opposite the frænum, preparatory to trimming it away with the scissors. The dotted line represents the line of incision.

scissors should be sharp, especially toward the ends. The prepuce should not be divided for its whole length, but only to within a short distance of the corona.

Care should be exercised not to introduce the blade of the scissors into the urethral canal instead of between the glans and prepuce; this might happen if the prepuce were intimately adherent to the surface of the glans, as is sometimes the case.

Instead of using the scissors the section may be made with a sharp-pointed, curved bistoury, guided upon a grooved director, which is introduced underneath the prepuce, between it and the glans. As a rule, there is but little hemorrhage.

If the parts are not infected, one or two catgut stitches may be introduced on either side. Usually no suture is necessary in the child.

Roser's Method of Dorsal Section.—After the dorsal section has been made, the mucous membrane not being cut as far back as the skin, an oblique incision is made, on either side, from the corner of the mucous membrane backward and outward as far as the edge of the skin. The little triangular mucous membrane flap which is thus formed is then turned up into the angle in the skin, to insure rapid healing in the corner of the incision; it may be held in place with one stitch in the angle of the incision. One or two stitches may also be introduced on either side of the incision proper.

Circumcision.—In children an anæsthetic is necessary; in adults the operation may be done under the influence of cocain, which is injected into the prepuce after a strip of gauze has been tied fairly tight about the body of the penis near its root to prevent diffusion of the cocain. One should avoid cutting the skin too short. After the parts have healed there should be a little redundancy of the skin marking the previous reflection of the prepuce and this is best accomplished by drawing the skin a little backward, toward the root of the penis, before applying the constricting band. The first step in the operation is the dorsal section of the prepuce. One blade of a scissors is introduced underneath the prepuce to a point just anterior to the corona and the prepuce is then divided to within a short distance of the corona. Either corner of the divided prepuce is seized with an artery clamp close to the edge of the incision. The prepuce is seized with a third clamp which is placed midway between the two already mentioned, opposite the frænum. The redundant portion of the prepuce is trimmed away with the scissors. The entire length of the prepuce should not be amputated; about one-fourth its length should remain.

As a rule, the bleeding stops when the ligature around the penis is removed and after a few minutes' compression. All bleeding should be checked before suturing, if necessary applying fine catgut ligatures.

The edges of the skin and mucous membrane are united with interrupted plain catgut sutures, the first being applied in the middle line above, the next in the middle line below, then one on each side, and finally in the intervals between these, making eight sutures in all.

In the child, as a rule, the four sutures are sufficient.

Circumcision with the Clamp.—After the parts have been anæsthetized, etc., the edge of the prepuce is seized above in the middle line and below in the middle line with artery forceps, and drawn forcibly forward over the glans. That part of the prepuce which is thus pulled beyond the glans is grasped between the blades of a long, straight clamp, which is applied obliquely from above downward and forward; the clamp should seize the foreskin firmly and care should be observed that the glans is not included; this accident, however, is not likely to occur.

The part of the prepuce which protrudes beyond the blades of the clamp is trimmed off with a sharp knife or with the scissors plane

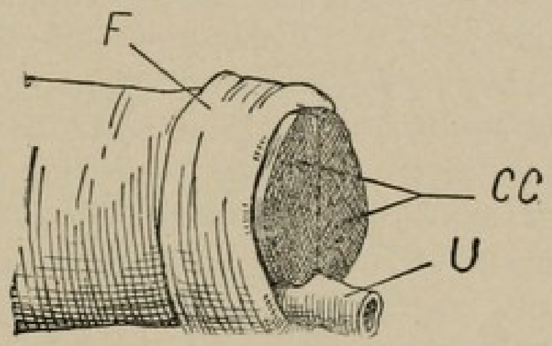

Fig. 308.—Amputation of the Penis. *CC*, corpora cavernosa; *F*, skin flap turned back; *U*, urethral portion cut long.

with the surface of the clamp, and the clamp then removed. The hemorrhage is controlled and the sutures applied as above.

Amputation of the Penis.—This operation is done for malignant disease. A sound is passed into the urethra, and, supported upon this the penis is lifted away from the body. An elastic ligature is placed about the organ close to its root.

A circular incision is made through the integument and a flap reflected sufficiently long to cover over the stump of the penis; it should be equal in length to half the diameter of the penis plus one-third for shrinkage. After the flap has been turned back like a cuff the portion of the penis that is to be amputated is cut away. The urethral portion of the penis should be cut about one-fourth inch longer than the part that corresponds to the corpora cavernosa.

The blade of the scalpel is thrust flatwise through the penis between the urethral portion, which may be recognized by the sound within, and the corpora cavernosa, and carried a good one-fourth inch forward toward the glans, when the urethral portion is cut through with a circular sweep of the knife down upon the sound contained within. The corpora cavernosa are then divided upon a plane farther back, corresponding to the base of the skin flap, so that the urethral portion will project about one-fourth inch beyond the cut surface of the corpora cavernosa.

The tourniquet is now removed from the root of the penis. The dorsal arteries bleed, and require to be clamped and ligated. The arteries of the corpora cavernosa usually require no ligatures; if they spurt, they may be clamped or touched with the Paquelin. A few minutes' compression usually sufficies to check bleeding from any remaining sources.

The edges of the urethra are seized with two artery clamps and the urethra is then split upon its under aspect for a distance of about

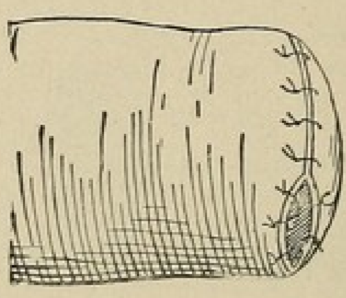

Fig. 309.—Amputation of the Penis. Edges of skin flap united to each other over the ends of the corpora cavernosa and to the edges of the split urethral portion.

one-fourth inch. The skin flaps are turned over the end of the stump and are united from before backward with several interrupted sutures and the edges of the split urethral orifice are sewed to the adjoining edges of the skin flaps.

The object of cutting the urethra long and splitting it is to provide a larger orifice to allow for subsequent contraction.

A soft rubber, self-retaining catheter is introduced into the bladder and allowed to remain for several days.

THE PERINEUM AND ISCHIO-RECTAL REGION.

The Floor of the Pelvis from Without Inward.—This space is lozenge-shaped; its front portion is limited on either side by the rami of the pubes and ischium; its posterior part is limited on either side by the edges of the great sacro-sciatic ligaments. The anterior angle corresponds to the symphysis pubis, the posterior angle to the tip of the coccyx, and on either side the tuber ischii may be felt.

There is a more or less complete fibrous raphé running from before backward in the middle line, and also one from side to side where all the layers of the perineal fascia are blended together. Where these lines intersect there is a point where muscles are attached and take origin and where all the fasciæ are joined. This is known as the central tendinous point of the perineum. The space in front of the transverse raphé is the perineum proper; the space behind it is occupied by the anus and upon either side by the ischio-rectal fossa, and is known as the ischio-rectal region.

The Superficial Layer of the Superficial Perineal Fascia.—Beneath the skin there is a layer of loose fascia which is continuous with the superficial fascia of the thighs and buttocks. This is the superficial layer of the superficial fascia of the perineum and ischio-rectal regions; it corresponds to the subcutaneous fat, and is continuous in front with the dartos layer of the scrotum, and behind, upon either side of the anus, it is packed into the ischio-rectal fossa as a pyramidal plug of fat and loose connective tissue.

The Deep Layer of Superficial Perineal Fascia.—If we remove the superficial layer of fascia and fat, including the mass from the ischio-rectal fossa, we come down upon a second layer of fascia, the deep layer of the superficial fascia of the perineum. Corresponding to the perineal region proper, the fascia is attached upon each side to the edge of the pubic arch and behind to the transverse raphé; in front it is continuous with the dartos of the scrotum; behind, in the ischio-rectal region, it is continuous with the anal fascia, which covers the perineal surface of the levator ani muscles.

Anteriorly this fascia is dense, and serves to close in the structures proper to the perineum. If fluid is injected underneath this layer of fascia, it will not spread backward beyond the transverse raphé, because this layer of fascia is attached along this raphé with the next underlying fascial layer; it will not escape laterally, owing to the attachment of the fascia to the margins of the bony pelvic arch; but anteriorly it will escape, passing into the dartos tissue of the scrotum and thence upward upon the front of the pubes.

The Ischio-rectal Region.—This is the region which lies behind the transverse raphé—that part which corresponds to the anus and the ischio-rectal fossa.

In the middle is the anus, surrounded by its external sphincter muscle. This muscle arises from the tip of the coccyx behind, and, passing forward, is attached, in front of the anus, to the middle tendinous point of the perineum, which corresponds to the junction of the sphincter from behind, the transversus perinei from each side, and the bulbo-cavernosus from in front.

On either side of the anus there is a pyramidal space, the ischio-rectal fossa; this space is occupied by a mass of fat and loose connective tissue, the base of which corresponds to the superficial layer of superficial perineal fascia, and reaches from the tuberosity of the ischium to the anus. This space is about two inches deep. Its outer wall is formed by the tuber ischii and the obturator internus muscle, which muscle is covered over by a layer of fascia, the obturator fascia. Passing forward upon this outer wall of the ischio-rectal fossa, beneath the obturator fascia and about one and one-half inches above the tuberosity of the ischium, are the internal pudic vessels and nerve. The inner wall of the ischio-rectal space is formed by the levator ani (to be described later). The superficial surface of this muscle, which looks into the ischio-rectal space, is covered by the anal fascia, which is derived from the obturator fascia along the line of origin of the levator ani from the side of the pelvis. This anal fascia is attached in front to the transverse fibrous raphé and is continuous there with the deep layer of the superficial perineal fascia.

The ischio-rectal space is thus walled off from the perineal space proper and from the rectum. It is the seat of the so-called ischio-rectal abscess, and when this breaks through into the rectum it forms the fistula in ano.

Some small vessels and nerve branches cross this space transversely just beneath the skin, passing from the tuberosity of the ischium toward the anus, and these are cut when incisions are made into the space.

The Perineum.—Upon removing the deep layer of superficial perineal fascia we open into the proper perineal space.

Occupying the middle of the space is a thin muscle, the bulbo-cavernosus; it arises from the middle tendinous point of the perineum, and, passing forward, covers the bulb of the urethra, which is the posterior enlarged portion of the corpus spongiosum, joining, with fibers from the muscle of the opposite side upon its upper surface, in a strong aponeurosis. The most anterior fibers of the bulbo-cavernosus muscle are attached on either side to the crus penis, some entirely encircling these bodies and joining upon the upper surface of the root of the penis, in such a way as to bind down the dorsal vessels of the penis, obstructing the return flow through the vein. This muscle shows a median fibrous raphé. Upon either side, arising from the ascending ramus of the ischium, is the ischio-cavernosus. The fibers of this muscle partly cover the crus penis and are attached to its sheath. The crus penis is the posterior portion of the corpus cavernosum and is attached to the ramus of the ischium and pubes.

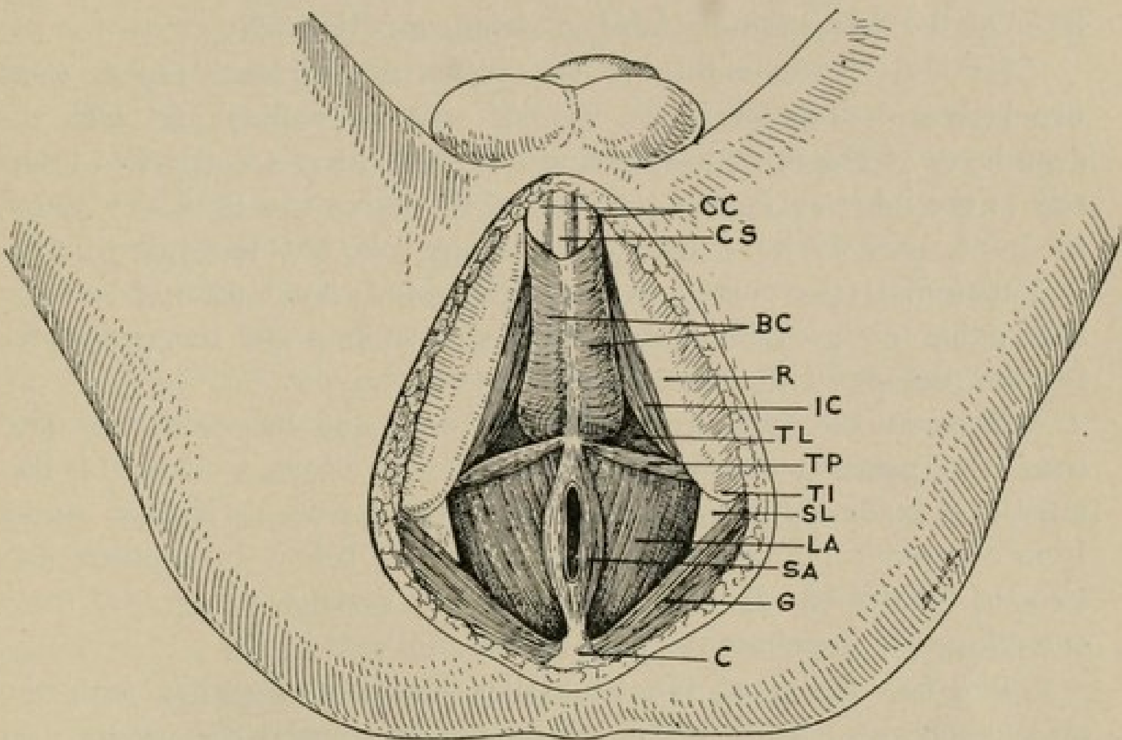

Fig. 310.—The Perineum and Ischio-rectal Region. The superficial and deep layers of the superficial perineal fascia have been removed. The space in front of the transversus perinei (*TP*) corresponds to the perineum; that behind the transversus perinei to the ischio-rectal region. The floor of the space (*TL*) corresponds to the anterior layer of the triangular ligament. *BC*, bulbo-cavernosus muscle; *C*, tip of coccyx; *CC*, corpus cavernosum (crus penis); *CS*, corpus spongiosum (the posterior part of the corpus spongiosum is called the bulb of the urethra); *G*, edge of gluteus maximus muscle; *IC*, ischio-cavernosus muscle; *LA*, levator ani muscle; *R*, ramus of the pubes and ischium; *SA*, sphincter ani; *SL*, edge of great sacro-sciatic ligament; *TI*, tuberosity of the ischium; *TL*, superficial or anterior layer of the triangular ligament; *TP*, transversus perinei muscle.

Forming the posterior border of this space on either side is the transversus perinei muscle. This muscle arises from the inner surface of the tuberosity of the ischium; it passes inward and forward to the central tendinous point of the perineum, where it is attached, joining with the muscle of the opposite side and the other muscles already described.

Passing forward through this space are the superficial perineal vessels and nerve, and directed inward along the border of the transversus perinei is the transverse perineal artery.

The floor of this space is formed by a dense layer of fascia, the superficial layer of the deep perineal fascia, or, better, of the triangular ligament. This layer of fascia is perforated by the urethral canal about one and one-half inches below the symphysis. Beneath this layer of fascia there is a second layer, similar in structure, the deep layer of the deep perineal fascia or triangular ligament.

Behind, corresponding to the transverse perineal raphé, these two layers of deep fascia are blended with each other and with the deep layer of the superficial perineal fascia. They are attached laterally to the inner surface of the rami of the pubes and ischium; above, in front, they do not reach to the symphysis, but terminate in the ligamentum transversum pelvis, a ligamentous band passing between both pubic rami, leaving a space above, between it and the symphysis, for the passage of the vena dorsalis penis.

Between the two layers of the triangular ligament the deep transverse perineal muscle, the compressor urethræ, is located; this muscle is made up chiefly of striped muscular fibers passing across from one pubic ramus to the other above and below the urethra, and also of unstriped fibers which pass in various directions, some encircling the membranous part of the urethra.

The two layers of the triangular ligament, together with the muscle contained between them, form the uro-genital diaphragm. In the space between the two layers of the triangular ligament, besides the muscle, are contained the urethra, its membranous portion, and behind, on either side, Cowper's gland, the duct of which is seen passing forward to enter the bulbous portion of the urethra. Posteriorly, close to the lateral border of the space, is seen the internal pudic artery. It gives off the artery of the bulb, and passing forward divides into the artery of the crus penis, which enters the crus, and the dorsal artery of the penis, which perforates the suspensory ligament and runs forward along the upper surface of the penis.

As the urethra perforates the superficial layer of the triangular ligament it is provided with a fibrous prolongation, which is continued forward upon the bulb of the urethra.

The posterior or deep layer of the triangular ligament is really the very much thickened portion of the pelvic fascia which fills in the space between the two levatores ani muscles. The levatores ani muscles form the major part of the floor of the pelvis.

The prostate gland, which encircles the neck of the bladder and contains the prostatic portion of the urethra, is situated in the pelvic cavity. It rests upon the upper, pelvic surface of the triangular ligament and levatores ani muscles.

The vesiculæ seminales and the vasa deferentia lie within the pelvis, between the rectum and the base or trigone of the bladder, above the base of the prostate. They may be brought into view by separating the rectum from the base of the bladder and drawing it, the rectum, backward toward the coccyx.

The Pelvic Cavity from Within.—Examining the pelvic cavity from within, after removal of the bladder and rectum, we find it bounded in front by the pubic bones, behind by the coccyx and sacrum, laterally by the pubes and ischium and the sacro-sciatic ligaments. The lateral wall of the pelvic cavity is partly covered by the obturator internus muscle, which arises from the inner surface of the pubes and ischium around the margin of the obturator foramen. The obturator internus is covered by a thick fascia, which is attached above to the margin of the brim of the pelvis, being continuous above with the fascia that covers the psoas and iliacus muscles (the fascia iliaca).

THE LEVATORES ANI form the major part of the floor of the pelvis. The fascia that covers the obturator internus is marked by a thick, white, fibrous band which extends along the lateral wall of the pelvis, from before backward, from the posterior surface of the pubic bone in front, to the spine of the ischium, behind. This line is called the "white line" or the *tendo arcuatum*. The levatores ani arise from the posterior surface of the pubic bones and from the whole length of the "white line" upon either lateral wall of the pelvis. The muscles pass in a general direction obliquely downward, backward and inward. Anteriorly a wide space intervenes between the inner edges of the two muscles. More posteriorly they pass underneath the prostate, which they support in a sling-like manner. Still more posteriorly they grip the rectum between them, some of the fibers being inserted into the rectal wall. Behind the rectum the fibers of both muscles join together in the middle line to close in this part of the pelvic floor, and are then finally attached to the tip and sides of the coccyx. Anteriorly the space between the edges of the two muscles is filled in by a dense fascia—the posterior or deep layer of the deep perineal fascia or, as it is sometimes called, the triangular ligament. This fascia is also called the *trigonum uro-genitale*.

The back part of the floor of the pelvis, posterior to the levatores ani, is formed by the coccygeus muscles. These muscles look like a continuation of the levatores ani and serve to close in the back part of the outlet of the pelvis. The muscles are fan-shaped and are attached by their apices to the spines of the ischium and by their broad bases to the lateral margins of the coccyx.

Lying upon the same plane, but still farther above and behind, and corresponding to the upper border of the coccygeus muscle, is the pyriformis. This muscle arises from the sides and from the anterior surface of the sacrum, and passing outward leaves the pelvis through the great sacro-sciatic notch, and closes the pelvic cavity behind.

Thus, taking part in the formation of the floor of the pelvis, there is a muscular layer which is formed in front and upon the sides by the levatores ani, behind this by the coccygei, and still farther behind and above by the pyriformi.

The fascia that fills in the space anteriorly between the edges of the levatores ani, the posterior or deep layer of the triangular ligament, is perforated in the male by the urethra, in the female by the urethra and vagina.

THE PELVIC FASCIA covers the obturator internus muscle and, corresponding to the "white line," *tendo arcuatum,* which marks the origin of the levator ani, is continued upon the upper, pelvic surface of the levator ani. It bridges across the space which exists between the levator muscles anteriorly, and forms the deep layer of the triangular ligament (already mentioned, and which is perforated by the urethra in the male and the urethra and vagina in the female). In the back part of the pelvic cavity this same fascia covers over the surface of the coccygeus and the pyriformis muscles. Thus the entire interior of the pelvic cavity is lined by the pelvic fascia in a manner similar to that in which the interior of the abdominal cavity is lined by the transversalis fascia.

Where the pelvic fascia, after covering the pelvic surface of the levatores, strikes the prostate gland and the rectum and the vagina in the female, it is reflected upward upon the sides of these organs. and serves to materially strengthen them. It is gradually lost in the wall of the rectum and vagina. It forms a strong, fibrous sheath for the prostate gland. Above the base of the prostate the fascia is continued on to the wall of the bladder. It gradually thins out and is lost on the wall of the bladder.

A process of the pelvic fascia is reflected inward between the rectum and the base of the bladder, and serves to bind the seminal vesicles and the vasa deferentia to the base of the bladder.

The under surface of the levator ani, which is directed toward the perineum and ischio-rectal fossa, is also covered by a thin layer of fascia which is derived from the obturator fascia along the line of origin of the levator ani. This is called the anal fascia. The anal fascia is continued backward upon the under surface of the coccygeus muscle, and anteriorly is continued forward into the deep layer of the superficial perineal fascia, joining along the transverse septum, or raphé, with all the other fasciæ of the perineum.

OPERATIONS UPON THE PERINEUM, ETC.

Perineal Section (External Urethrotomy) With a Guide.—This operation is performed for stricture of the deep urethra or for the purpose of draining the bladder. The patient is placed in the lithotomy position and a tunneled sound introduced through the urethra into the bladder.

An assistant steadies the sound with the right hand, throwing the groove as much as possible toward the surface of the perineum, and at the same time drawing the whole urethra upward, away from the rectum toward the symphysis. The scrotum is drawn up toward the symphysis, out of the way of the operator.

An incision is made in the middle line from the base of the scrotum backward to within a short distance of the anus. This incision reaches through the skin and fat down to the deep layer of the superificial perineal fascia.

The edges of the wound are drawn asunder with small, sharp retractors, and with another stroke of the knife the deep layer of the superficial perineal fascia is incised and the bulb of the urethra exposed in the forward part of the wound. Then, with the finger in the wound, the groove in the tunneled guide within the urethra is recognized and the point of the knife, guided upon the finger-nail, is placed in the groove of the sound, piercing the membranous part of the urethra just behind the bulb. The knife is then shoved backward, carrying the point of the blade along the groove of the sound toward the neck of the bladder and raising the handle, at the same time, toward the symphysis. Having carried the point of the knife beyond the location of the stricture, into the prostatic portion of the urethra, the handle is depressed, the knife at the same time being withdrawn and cutting as it is withdrawn; in this way the membranous portion of the urethra is laid open and the stricture divided.

While the urethra is being incised upon the grooved sound the sound should be lifted straight up toward the symphysis, carrying the urethra with it, and thus drawing it farther away from the rectum. If some urine or fluid is in the bladder, its escape will demonstrate the fact that the bladder has been entered.

A director gorget may now be introduced into the bladder along the groove of the sound and the latter withdrawn. A soft rubber catheter of large caliber is introduced through the opening into the bladder, and fixed in place to the edge of the incision in the skin with a silk stitch, and the wound then packed about the catheter with strip gauze to control hemorrhage.

Usually there are no vessels to tie, although spurting arterial branches should be clamped and twisted and, if necessary, ligated. One should avoid wounding the bulb of the urethra if possible, and, for a certainty, the rectum and anus.

Before dismissing the patient, a large metal sound, at least a No. 30 F., should be passed through the anterior urethra and into the bladder to make certain that no remaining obstruction exists in any part of the canal.

Perineal Section Without a Guide.—This is a difficult procedure.

All attempts to introduce a guide through the constricted part of the urethra into the bladder fail. One should not be satisfied with a single attempt, but should try, if possible, to at least get a small whalebone or rubber guide through. After having made the attempt and found it impossible to get any guide whatever past the stricture, a tunneled sound may be introduced as far as the obstruction.

As described in the preceding operation, an incision is made in the perineum and the urethral canal opened upon the guide just in front of the stricture. After all the bleeding has been arrested, the edges of the wound, including the edges of the incised urethra, are retracted with small, sharp hooks, and an effort then made to find the opening through the stricture into the posterior part of the urethra by inspection or by attempting to pass a fine probe-pointed director or a fine whalebone guide.

If we do not succeed in getting through the stricture by these means an effort may be made to open into the urethra behind the stricture, and then, if this is successful, the stricture may be divided from behind. It is difficult, however, to locate the deep urethra (membranous portion) without a guide. It lies between the layers of the triangular ligament, reaching from the bulbous portion of the urethra to the apex of the prostate gland. Occasionally the urethra is diverted from the middle line or a false passage may be encountered which will still further confuse us.

At times, especially if the bladder contains fluid and pressure be made above the pubes, the urethra may be felt as a rounded, compressible tube, occupying the middle line and perforating the triangular ligament about one and one-half inches below the symphysis.

The prostatic urethra, which is the continuation of the membranous urethra, is surrounded by the prostate gland, and, if one finger is introduced into the rectum and the thumb placed in the incision in the perineum the operator may get the prostate between them, and the apex of the prostate may thus serve as a clue to the location of the membranous urethra. One should refrain from blindly jabbing in the wound in the hope of accidentally striking the urethra.

If all these measures fail, a suprapubic cystotomy may be performed and a guide passed from within the bladder into the urethral canal, in this way locating the posterior part of the deep urethra for the purpose of incision.

If it becomes necessary to do a suprapubic cystotomy, this may be more conveniently done with the patient in the Trendelenburg position.

Median Lithotomy.—This operation is performed for small calculi. The bladder should be washed out with boric-acid solution, 5 or 6 ounces being allowed to remain in the bladder. The operation is practically the same as the preceding perineal section (with a guide) except that the incision into the urethra is made rather more extensive, cutting through the anterior part of the prostatic as well as through the membranous portion of the urethra. The incision should not extend entirely through the prostate. Oftentimes after the bladder has been opened a small stone will of itself drop out of the wound, or it can be removed with forceps, scoop, etc. It may be necessary to enlarge the internal urethral orifice somewhat with a dilator or with the finger. If necessary, a large stone may be crushed before removal.

The finger should be introduced into the bladder to search for partially encysted stones, etc. Finally the bladder is washed out and a large, rubber catheter introduced through the perineal wound and fixed to the edge of the skin with a silk stitch. The wound is packed about the catheter and left open.

Lateral Lithotomy.—The bladder is washed out with boric-acid solution, 4 or 5 ounces being left remaining in the bladder. A tunneled sound is introduced through the urethra into the bladder and steadied by an assistant. An incision is made through the skin and fat, commencing in front at the base of the scrotum and passing backward and outward to a point midway between the tuberosity of the ischium and the anus. A second sweep of the knife incises the deep layer of the superficial perineal fascia. The index finger of the left hand is then introduced into the wound, and the finger-nail placed in the groove of the sound in the front part of the wound, just behind the bulb of the urethra. The sound is then drawn upward toward the symphysis, thus lifting the whole urethra away from the rectum, and the point of the knife placed in the groove of the sound, cutting through the membranous urethra. The handle of the knife is then elevated and the point shoved backward along the groove of the guide into the prostatic urethra. The handle of the knife is then depressed, at the same time withdrawing the blade and cutting as it is withdrawn. In this way the membranous urethra and the side of the prostate itself, are incised, the division of these deep structures being made along the line of the skin incision.

In making this last incision upon the sound the superficial transverse perineal muscle, and the artery of the bulb, together with the membranous urethra, the prostate gland, and the triangular ligament are cut. It is usually necessary to clamp and tie the artery of the bulb, and sometimes, if the incision extends too far backward and outward, the internal pudic may be divided; this branch bleeds profusely, and must be tied. After the bleeding has been controlled and the stone removed, a catheter is introduced into the bladder and fixed to the edge of the incision. The wound is packed about the catheter and left unsutured.

The perineal operations are rarely performed at the present time for the removal of the stone from the bladder. The suprapubic operation offers a much more satisfactory route.

THE PROSTATE.

Surgical Anatomy of the Prostate.—The prostate is a glandular organ about the size and shape of a horse-chestnut. It is lodged in the pelvic cavity behind and below the symphysis. It surrounds the neck of the bladder and prostatic portion of the urethra. The prostate is situated deep in the pelvic cavity, beneath the deep perineal fascia (triangular ligament), above the level of the levatores ani muscles. It is partly supported by the edges of the levatores and rests with its apex upon the upper surface of the deep, posterior, layer of the deep perineal fascia. The posterior surface of the prostate rests against the lower part of the upper portion of the rectum, above the anal portion. The gland may be readily palpated with the finger in the rectum, especially if it is enlarged.

The prostate measures about one and one-half inches in its transverse and one inch in its antero-posterior diameter at the base and is three-fourths of an inch in depth. It is held in position by the anterior ligaments of the bladder (pubo-prostatic) and by the posterior layer of the deep perineal fascia (triangular ligament), which is reflected upward and backward around the gland forming its external fibrous sheath. The prostate rests upon the anterior portions of the levatores ani, which pass downward, backward and inward from their origin upon either side of the internal aspect of the symphysis pubis and sides of the pelvis, some of their fibers being attached to the sides of the prostate and others joining with their fellows in the middle line, sling-like, underneath the prostate. Those portions of the levatores ani that pass underneath and support the prostate are sometimes called the levatores prostatæ.

The base of the prostate is directed upward and backward toward the neck of the bladder. The narrow end, apex, is directed forward and downward toward the deep perineal fascia. The posterior surface rests against the lower part of the upper, ampulla portion of the the rectum—just above the anal portion. This surface is marked above, at the base, by a deep notch, the interlobular notch, where the ejaculatory ducts enter. The anterior surface is marked by a slight longitudinal furrow, is notched above and below, and lies about one inch distant from the symphysis pubis.

The prostate is composed of glandular and unstriped muscular tissue. It is enclosed within its own proper capsule and is made up of two lateral lobes and a middle portion or, as it is sometimes called, a "middle lobe." The two lateral lobes are symmetrical and separated behind, at the base, by the interlobular notch, at which point the ejaculatory ducts penetrate the organ. The middle portion or "middle lobe" corresponds to that part of the base of the gland that joins the two lateral lobes across the middle line. It is usually represented by a small, rounded prominence that presents into the base of the bladder immediately behind the internal urethral orifice. This is the portion of the prostate which is most likely to become affected in hypertrophy of the gland. It presents as a prominent rounded mass into the bladder, posterior to the urethral orifice; or may become partly separated from the principal prostatic mass and, without being much increased in size, may interfere with micturition by blocking the internal urethral orifice, "ball-valve" fashion.

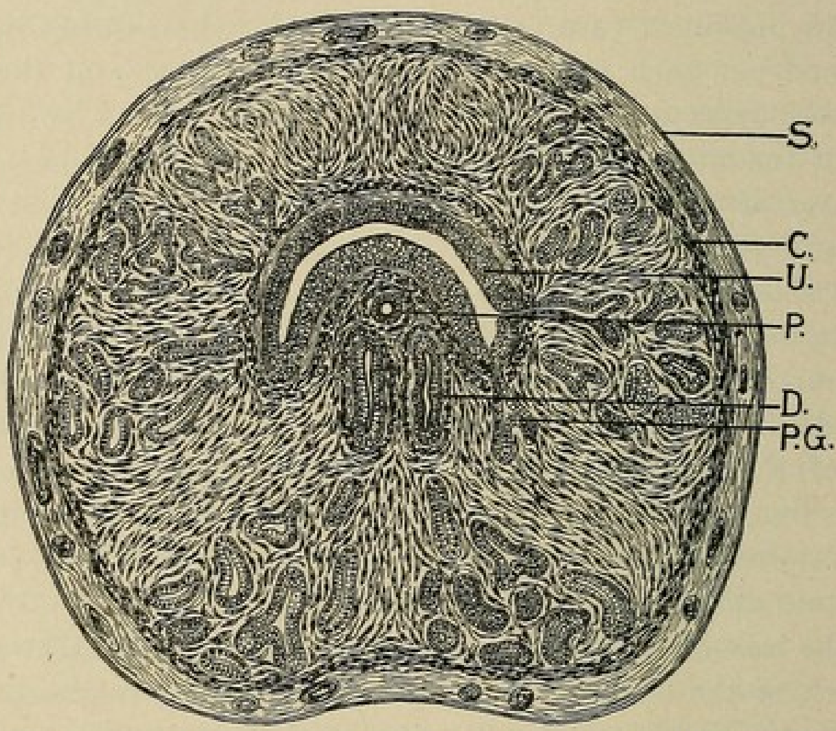

Fig. 311.—Transverse Section of Prostate through the Verumontanum. *C.*, capsule of gland; *D.*, ejaculatory ducts; *P.*, sinus pocularis; *P.G.*, a prostatic follicle opening upon floor of urethra; *S.*, outside fibrous sheath of prostate gland; *U.*, urethra. In the space between the capsule and outside fibrous sheath the veins of the prostatic plexus are seen on section.

The prostate is traversed by the urethra and the ejaculatory ducts. The prostatic portion is the widest and most dilatable portion of the urethral canal. It penetrates the entire length of the gland from base to apex, and is situated nearer the upper than the lower surface. The prostatic urethra is about one and one-quarter inch long and is made up of mucous membrane and an underlying layer of connective tissue which contains unstriped muscular fibers and elastic tissue. The floor of the prostatic urethra is marked by a longitudinal elevation, nearly one inch in length, the verumontanum. At the anterior end of the verumontanum is the mouth of the sinus pocularis, a *cul-de-sac* which extends backward underneath the verumontanum for about one-fourth inch. Upon or near the margins of the mouth of the sinus pocularis are the narrow, slit-like orifices of the ejaculatory ducts. The floor of the prostatic urethra presents upon either side of the verumontanum the orifices of the ducts of the prostatic follicles, from twenty to thirty in number.

Above and behind the prostate body, closely applied to the base of the bladder, between the bladder and the rectum, are the vesiculæ seminales and vasa deferentia. Each vas has a vesicula seminalis lying to its outer side. The vasa, as they pass downward and forward toward the base of the prostate, approach each other and just before they enter the prostate they join with the ducts of the corresponding vesiculæ seminales to form the common ejaculatory ducts. The common ejaculatory ducts, thus formed, pierce the prostate, side by side and close together, at the deep interlobular notch that marks the under part of the base of the gland. They pass forward through the prostate, being situated just beneath the urethral canal, one on either side of the middle line, and empty upon the floor of the prostatic urethra close to, or just within, the margins of the sinus pocularis.

The prostate gland is inclosed in its own fibrous capsule, the capsule proper, which is composed of condensed connective tissue and is separate and distinct from the fibrous sheath or envelope that is reflected around it from the posterior layer of the deep perineal fascia (triangular ligament). The capsule proper of the prostate is found to be considerably thickened in pathological conditions affecting the gland. The fibrous layer which is derived from the deep perineal fascia invests the prostate, forming its external fibrous sheath or envelope, and is continued upward, beyond the base of the prostate, upon the bladder, covering in the vesiculæ seminales and serves to retain these latter organs in close relationship with the bladder.

Blood-supply.—The prostate is supplied by branches from the internal pudic, vesical, and hemorrhoidal arteries. Its veins form a plexus around the base and sides of the gland, receiving in front the dorsal vein of the penis and terminating in the internal iliac veins. The venous plexus is situated beneath the fibrous sheath, between this layer and the true capsule of the gland.

OPERATIONS UPON THE PROSTATE.

Prostatectomy.—Extirpation of the prostate gland. For the purpose of relieving the obstruction offered by the hypertrophied gland to the proper evacuation of the bladder.

The prostate may be removed either from within the bladder through a suprapubic incision or else through an incision which is made in the perineum.

SUPRAPUBIC PROSTATECTOMY.—The operation of Belfield, McGill, Fuller, and Freyer. Especially adapted for cases of enormous hypertrophy and particularly of the middle portion of the gland and for tumors high up and projecting decidedly into the bladder. The mortality is greater following suprapubic prostatectomy than perineal prostatectomy.

The patient is placed flat upon the table and the bladder washed out with boric-acid solution. Eight or ten ounces of the fluid are allowed to remain in the bladder. The rubber catheter is permitted to remain in order to indicate the position of the internal urethral orifice and the position and course of the urethra. The end of the catheter is closed with a hæmostat to prevent the fluid escaping from the bladder.

A suprapubic cystotomy is made as already described, with the patient lying upon the back. The incision in the abdomen and bladder may be held open with long, broad retractors and the interior of the bladder explored. Calculi may be discovered in the bladder. These are removed with the forceps or scoop. The enlarged, prominent prostate is readily recognized when the finger is introduced into the bladder. The end of the catheter is felt in the bladder and serves to locate the position of the urethral orifice.

The table may now be tilted so that the patient occupies the Trendelenburg position, and an incision is made in the wall of the bladder, over the most prominent portion of the hypertrophied prostate. Usually a transverse incision is made over the so-called middle lobe, just behind the internal urethral orifice; or an antero-posterior incision may be made over one or both lateral lobes. The incision is made with the long, sharp-pointed scissors and extends through the entire thickness of the bladder wall down to the proper capsule of the prostate. The fingers of the left hand are introduced into the bladder to guide the scissors in making the incision. Instead of the scissors the sharpened finger-nail may be used to scrape through the wall of the bladder. The bladder wall over the most prominent part of the prostate mass is usually very thin, consisting of the mucous layer only, and is thus easily penetrated. Through the opening which is made the finger is introduced and, working between the wall of the bladder and the prostate, with the finger closely applied to the capsule of the prostate all the time, the entire hypertrophied gland enclosed in its proper capsule is enucleated. The gland may

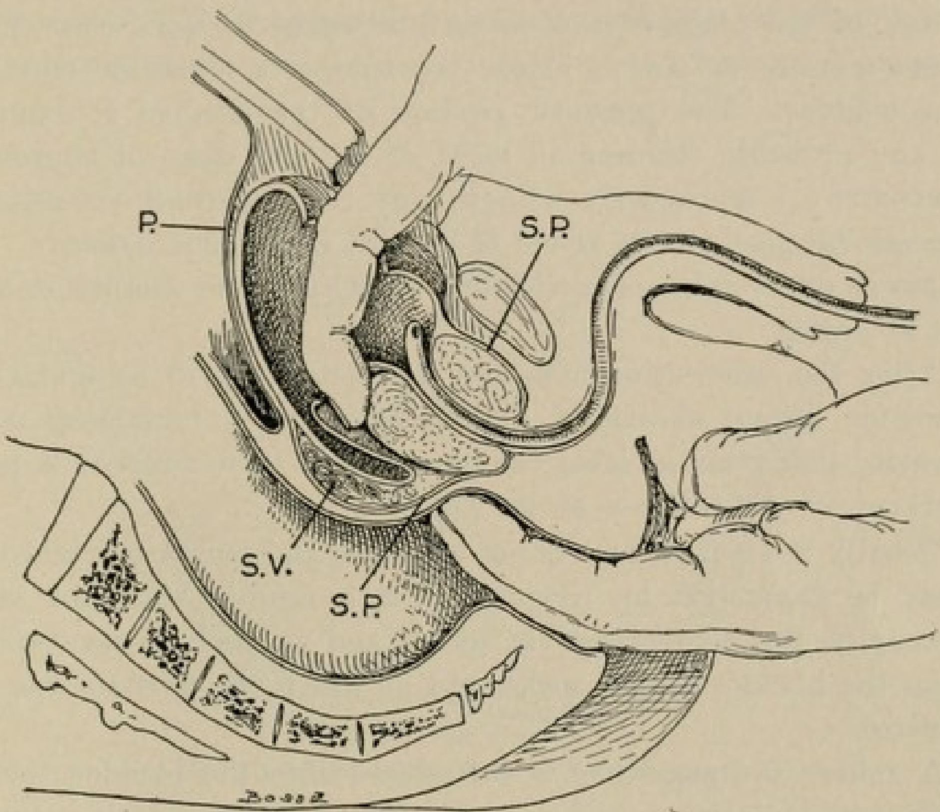

Fig. 312.—Suprapubic Prostatectomy. The wall of the bladder is incised over the prominent portion of the prostate. Two fingers of the left hand are introduced into the rectum to make counterpressure and facilitate the work of enucleating the prostate. The prostate is enucleated out of its fibrous sheath. *P.*, peritoneal layer; *S.P.*, sheath of the prostate is continued upward from the base of the prostate, enclosing the seminal vesicles, etc., and finally thins out and is lost upon the wall of the bladder. The sheath of the prostate forms a strong protecting barrier against injury to the rectum while the prostate is being enucleated. *S.V.*, seminal vesicles.

be removed in one single mass or in several pieces, two or three. It can usually be removed through a single incision. Occasionally it will be necessary to make an additional incision over a second prominent portion of the gland before the entire organ can be removed. While the gland is being enucleated by the fingers of the right hand working within the bladder, two fingers of the left hand, gloved, are introduced into the rectum to push the prostate mass up toward the hand working in the bladder.

Especial care must be exercised, in working upon the posterior aspect of the prostate, not to injure the rectum. Working within the fibrous sheath of the prostate, close to the capsule proper of the gland, the danger of injuring the rectum is minimized because the strong, fibrous sheath forms a strong, resistant barrier between the fingers and the rectum. In detaching the prostate mass from around the neck of the bladder it is important again to work close to the prostate mass so as not to injure the sphincter muscular apparatus of the bladder. The prostatic portion of the urethra is damaged, torn, and probably removed in most, if not all, cases of suprapubic prostatectomy. Apparently without any harm beyond necessitating the occasional passage of a sound to prevent subsequent stricture. The ejaculatory ducts are necessarily torn away from the urethra in most, if not all, cases.

After the enucleation has been completed it will be found that the outside fibrous sheath of the prostate is left remaining intact. The cavity that remains after the prostate has been removed is partly obliterated by the collapse of its walls.

Usually the hemorrhage is not excessive and ceases spontaneously, or may be controlled by irrigation for a minute with hot saline. Occasionally the hemorrhage is severe and it may be necessary to tampon the bladder or the pocket out of which the prostate has been enucleated.

A rubber drainage-tube is introduced into the bladder through the suprapubic incision and secured with a single catgut suture to the edge of the incision in the bladder. The incision in the bladder if unusually large, may be closed in part. (See Suprapubic Cystotomy). A rubber, self-retaining catheter is introduced into the bladder through the urethra to still farther facilitate drainage and to permit of through and through irrigation of the bladder.

Perineal Prostatectomy.—This is a very convenient route for removal of the prostate, especially for those of smaller size and those that are situated low down in the pelvis. This method is favorable for drainage and is followed by a lower mortality than the suprapubic operation.

The patient is placed in the lithotomy position, with the pelvis raised high upon a sandbag placed under the buttocks. A tunneled sound is introduced through the urethra into the bladder. It may be more convenient to introduce this instrument before placing the patient in the lithotomy position.

An incision is made in the middle line of the perineum, from the base of the scrotum backward to within one-half inch of the anus. This incision is carried down through the skin and fat to the deep layer of the superficial perineal fascia. The tunnel of the metal guide within the urethra is recognized with the finger in the wound and the point of the knife, guided by the finger-nail, is placed in the groove of the guide, thus piercing the membranous part of the urethra just posterior to the bulb. The urethra is incised as far back as the

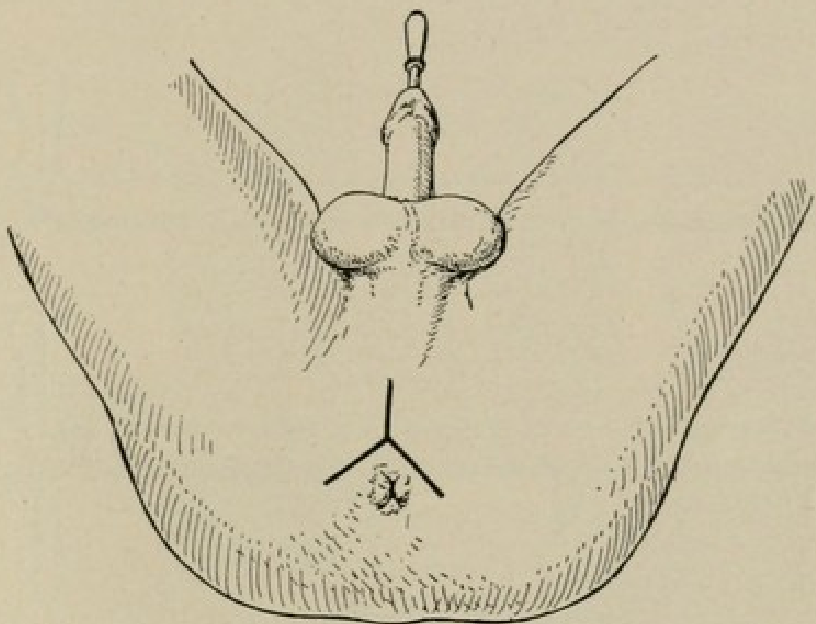

Fig. 313.—Incision for Perineal Prostatectomy.

commencement of the prostatic portion. The opening in the urethra is made large enough to permit the finger to be introduced into the bladder. The bladder may then be irrigated before proceeding with the next step of the operation—the exposure of the prostate gland.

From the posterior end of the median incision, two additional incisions, one on either side, are carried backward and outward toward the tuberosities of the ischium. These convert the incision into the form of an inverted Y. The lateral incisions are deepened. The attachment of the external sphincter ani, anteriorly, to the midpoint of the perineum is divided and the lower end of the rectum separated from its anterior attachments and displaced backward toward the coccyx. The prostate is situated above the level of the levatores ani and the edges of these muscles are seen in the incision, one on either side of the middle line. The edges of the levators may be drawn to either side with narrow, blunt retractors in order to expose the prostate more freely. The rectum is detached bluntly with the fingers and displaced backward, away from the prostate, toward the coccyx, and while this is being done it is advantageous to insert one or two fingers (with rubber glove) in the rectum and keep them there while this step of the operation is being accomplished. After the rectum has been separated and displaced backward the prostate may be brought into plain view by making traction with the tractor, which is introduced into the bladder through the opening in the urethra. The tractors of Young, Albarran, Lydston are used for this purpose.

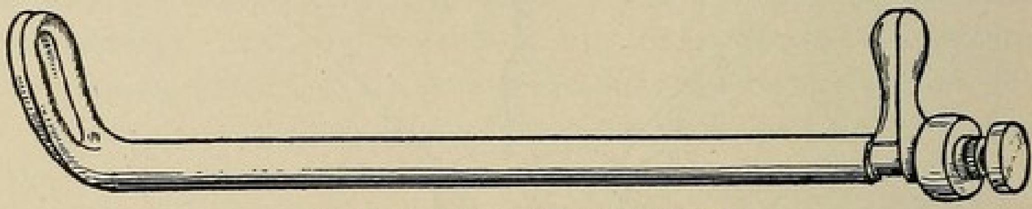

Fig. 314.—Young's Tractor Closed.

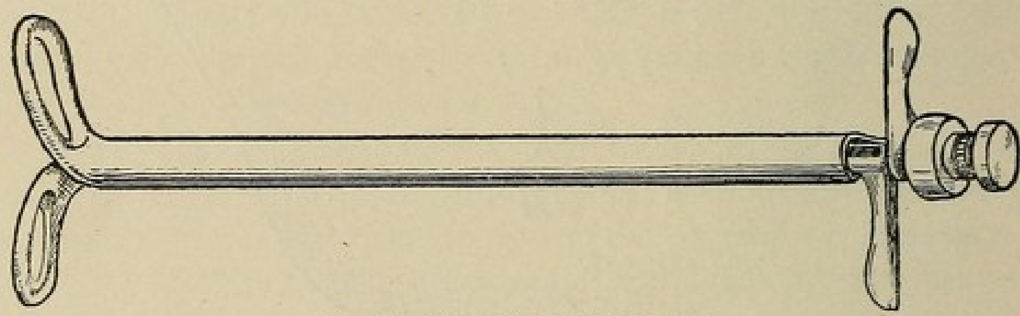

Fig. 315.—Young's Tractor Open.

The tractor, closed, is passed through the opening in the urethra, into the bladder up beyond the prostate mass, and its blades then spread by turning the arm at the handle. With this instrument the prostate mass is drawn down into the incision in the perineum and its entire posterior surface and base exposed. The rectum may be drawn back toward the coccyx, out of the way, with a broad retractor.

The fibrous sheath of the prostate is incised on either side according to the method of Young, and the prostate mass enucleated. Two incisions are made, one on either side of the middle line, extending nearly the entire length of the prostate and about 1 cm. deep. The two incisions approach each other in front, being about 1.5 cm. apart anteriorly and 1.8 cm. posteriorly. The bridge of tissue between these two incisions corresponds to the course of the ejaculatory ducts and its preservation is necessary if the ducts are to be saved from

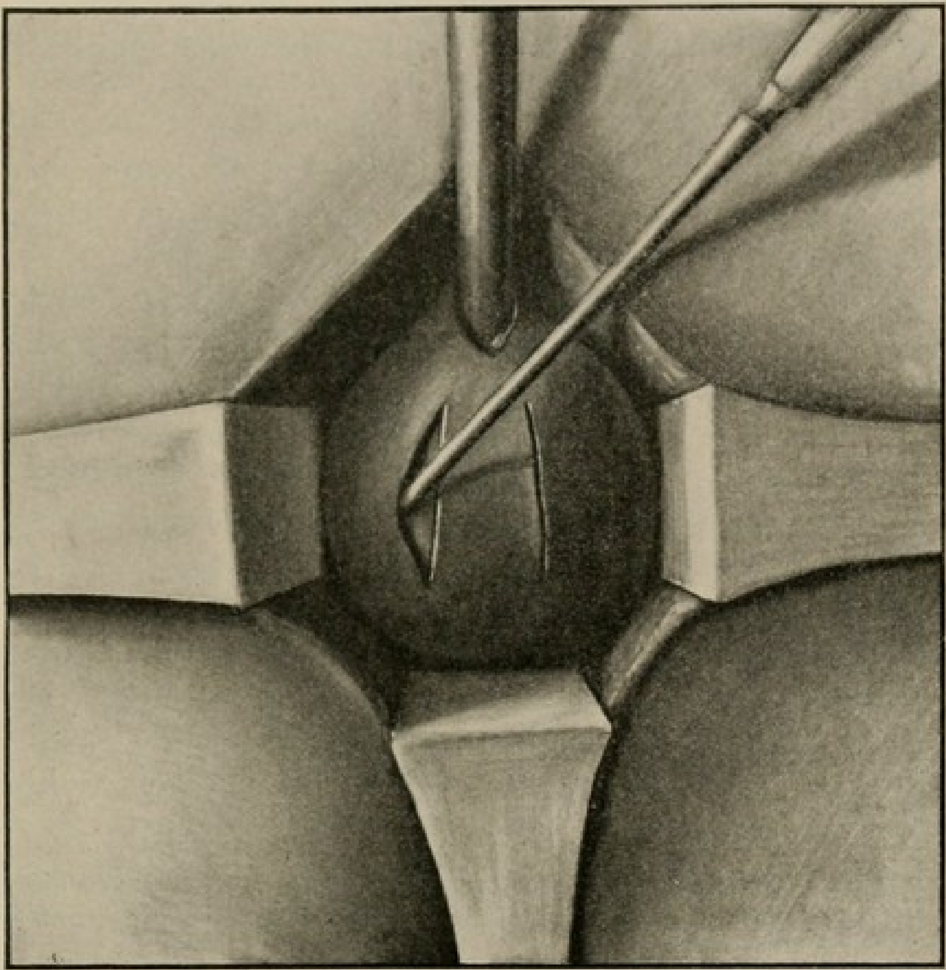

Fig. 316.—Perineal Prostatectomy (*Young*). Membranous urethra opened just anterior to prostate and tractor introduced. Incision through the sheath of prostate. Detaching the sheath from the right lobe with the blunt dissector.

injury. The incisions, being 1 cm. deep, reach into the substance of the prostate beyond the level of the ducts and close to the sides of the urethral canal.

The fibrous sheath is separated from the prostate with the blunt dissector. It is important to start in the correct line of cleavage. As this step of the operation progresses the lobe is drawn more and more out of its sheath. The urethra is then detached from the gland first on one side and then on the other, drawing down with the tractor

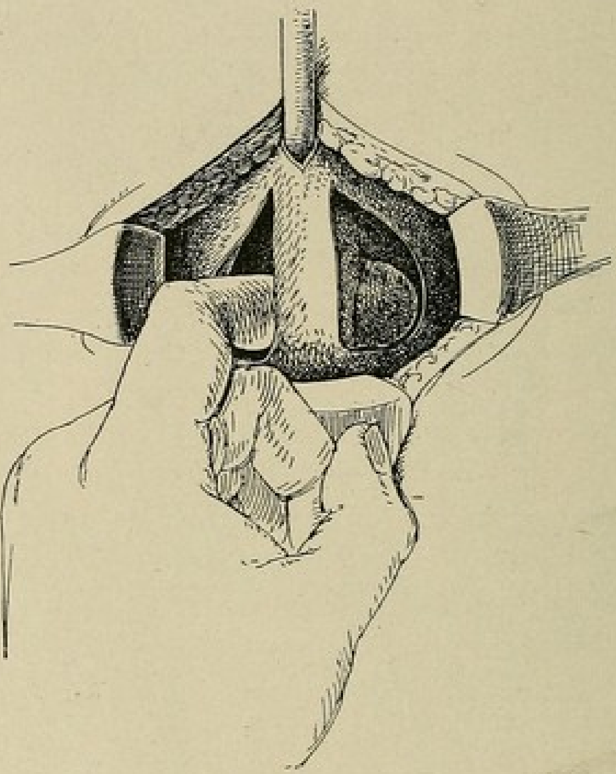

Fig. 317.—Enucleation of Middle Lobe. The finger is introduced into the empty, right pocket to force a middle lobe into the other, left, pocket through which it may be enucleated.

at the same time. In detaching the upper part of the prostate, that part which corresponds to the neck of the bladder, care must be exercised to separate the wall of the bladder without injuring it. Too much force must not be used with the tractor because, the support having been removed below by detaching the prostate all around, there is danger of tearing abruptly through the mucous membrane of the bladder. The partially enucleated mass may be seized with forceps for the purpose of making traction and thus facilitating its removal. Each half of the prostate mass is enucleated from the corresponding portion of the sheath without injuring the ejaculatory ducts and without destroying the prostatic portion of the urethra.

If, after both lobes have been enucleated, a median portion still remains, this may be drawn down with the tractor so that it will present in either one of the empty pockets from which the lateral lobes have been extirpated, assisting this maneuver by pushing with the finger in the other pocket, and while the mass is steadied in this position it may be seized and enucleated. Larger middle lobes are thus readily enucleated. A smaller enlargement in the shape of a transverse bar may be directed into one of the empty pockets and its end seized with a bullet forceps, and while traction is made the mass is carefully enucleated.

Two rubber tubes, tied together, side by side, are introduced through the opening in the deep urethra into the bladder, for the purpose of drainage. The bladder may readily be irrigated through these tubes if the necessity arises.

The wound, including the two empty prostatic pockets, is packed loosely with iodoform gauze, and the incision in the skin partly closed with several silk sutures.

The perineal tubes are removed at the end of six or seven days.

Prostatotomy (Bottini's Operation).—This operation consists in cutting the prostatic mass with a heated blade introduced into the bladder through the urethra. The operation is especially adapted to old and feeble subjects and those who suffer from kidney disease.

The necessary apparatus consists of an incisore prostatico, a battery, and a rheostat to regulate the current accurately.

One should have previously made an examination with the cystoscope for stone, etc. The patient lies upon the back with his legs hanging over the end of the table and the thighs spread apart. The bladder should contain about 6 ounces of boric-acid solution.

Usually sufficient local anæsthesia is obtained by the use of a solution of cocain which is thrown into the urethra and stripped backward into the posterior urethra with the finger, or a general anæsthetic may be employed. With the finger in the rectum the size and the shape of the prostatic tumor may be determined.

The incisore is introduced into the bladder beyond the enlarged prostate and its nose turned downward toward the base of the bladder, so that, as it is slowly withdrawn, it catches or hooks upon the prostatic mass. The extremity of the instrument may be felt with the finger in the rectum through the bladder wall above the prostatic tumor. The instrument is now held firm and steady in the whole of the left hand and the current closed and regulated by the rheostat until sufficiently strong to give a red heat, which usually requires fifteen seconds. Now, slowly turning the screw in the handle of the instrument, the heated blade is gradually withdrawn, thus burning a furrow through the prostatic mass. If the ear is held near the symphysis, a sizzling sound can be heard. If, in withdrawing the blade, we note increased resistance in the mass, the current is augmented; if too little resistance to the blade—if it cuts too easily—the current is correspondingly diminished. After the incision has been made sufficiently long the blade is shoved back with a little increase of the current.

Several such incisions or channels should be made in the prostatic mass, usually three: one in the middle line, toward the rectum with the beak of the instrument directed downward, and two lateral, one on each side of the middle line. The incision through the upper part of the prostate with the beak of the instrument directed upward toward the symphysis may well be omitted, because, in the first place, it is unnecessary and, in the second, it is dangerous on account of the ease with which the blade may cut through the neck of the bladder into the space of Retzius. Before commencing the incisions the beak of the instrument within the bladder should be felt for above the prostatic mass with the finger in the rectum in order to make certain that it has not slipped forward, over the prostatic mass, into the deep urethra.

The entire operation should occupy from five to ten minutes.

The permanent benefit that is derived from this operation depends upon the contraction which accompanies the cicatrization of the furrows that are burned in the prostatic mass.

The incisor resembles a lithotrite, having a male and a female blade, the male blade fitting into the female and consisting of platinum iridium, which may be heated to any degree by the electric current, whose strength is regulated by the rheostat.

By turning the screw at the handle the male blade is withdrawn from the groove in the female blade, and is thus made to cut or burn its way through the hypertrophied prostatic mass.

The shaft of the instrument is hollow, so that it may be supplied with a current of cold water, which flows in through one tube and out through another. The openings of these tubes both present near the handle. The cold-water current is for the purpose of keeping that part of the instrument cool which rests in the anterior part of the urethra.

The incisor as improved by Young has many advantages. The beak of Young's instrument is more sharply curved and therefore is less liable to slip forward over the prostatic mass into the deep urethra and it is provided with four interchangeable blades of different sizes and different degrees of curvature so that an appropriate blade for each case can be selected.

Immediately before using the instrument it should be tested with the current, and an observation made upon the rheostat to determine just what degree of current is necessary to bring the blade to the proper heat; usually about 45 ampères are required. The screw in the handle permits of an incision up to 4 cm. in length being made.

This operation has been modified by Chetwood, who makes a perineal incision for the purpose of introducing the incisor. This is a decided advantage. The incisor of Chetwood is a very satisfactory instrument for dividing the tissues.

PART IX.

THE UPPER EXTREMITY.

THE AXILLA.

The Axilla is a four-sided pyramidal space. Its apex is above, and corresponds to the depression upon the upper surface of the first rib, external to the attachment of the tendon of the scalenus anticus muscle, where the subclavian artery enters the axillary space to become the axillary. The base of the axilla corresponds to the fold of skin and fascia which is stretched between the edge of the pectoralis major in front and that of the latissimus dorsi behind.

The anterior wall of the axilla is made up of the pectoralis major and pectoralis minor; the posterior wall is formed by the subscapularis and the tendon of the latissimus dorsi and the teres major. The inner wall corresponds to the side of the chest, and is made up of the first, second, third, and fourth ribs and corresponding intercostal muscles and the upper serrations of the serratus magnus. The outer wall of the axilla is a narrow space, which is included between the anterior and posterior walls and corresponds to the floor of the bicipital groove. In the bicipital groove is lodged the long tendon of the biceps. The coraco-brachialis muscle, which arises from the coracoid process, descends in the outer part of the axillary space, lying close to the humerus.

To the anterior lip of the bicipital groove is attached the tendon of the pectoralis major, and to its posterior lip are attached the tendons of the latissimus dorsi and teres major.

The contents of the axilla consist of the axillary artery and vein, the large nerve-trunks which are derived from the brachial plexus, lymphatic vessels and nodes, and a mass of loose connective tissue and fat which is continuous with the connective tissue and fat of the root of the neck and the mediastinum.

The Axillary Artery.—The axillary artery is the continuation of the subclavian, and passes through the axillary space from its apex to its base, where it is prolonged downward into the arm as the brachial. The vessel passes through the upper part of the axillary space, lying close to its anterior wall. The lower, or outer, portion of the artery lies close to the humerus, beneath the edge of the coraco-brachialis, resting upon the tendon of the latissimus dorsi, and covered by the pectoralis major. The axillary vein, which is sometimes double, accompanies the artery, lying below it, and both artery and vein are in close relation with the nerve-trunks which traverse the axillary space. With the arm extended to a right angle, the course of the artery is nearly straight, and corresponds to an imaginary line which is drawn from the junction of the inner and middle thirds of the clav-

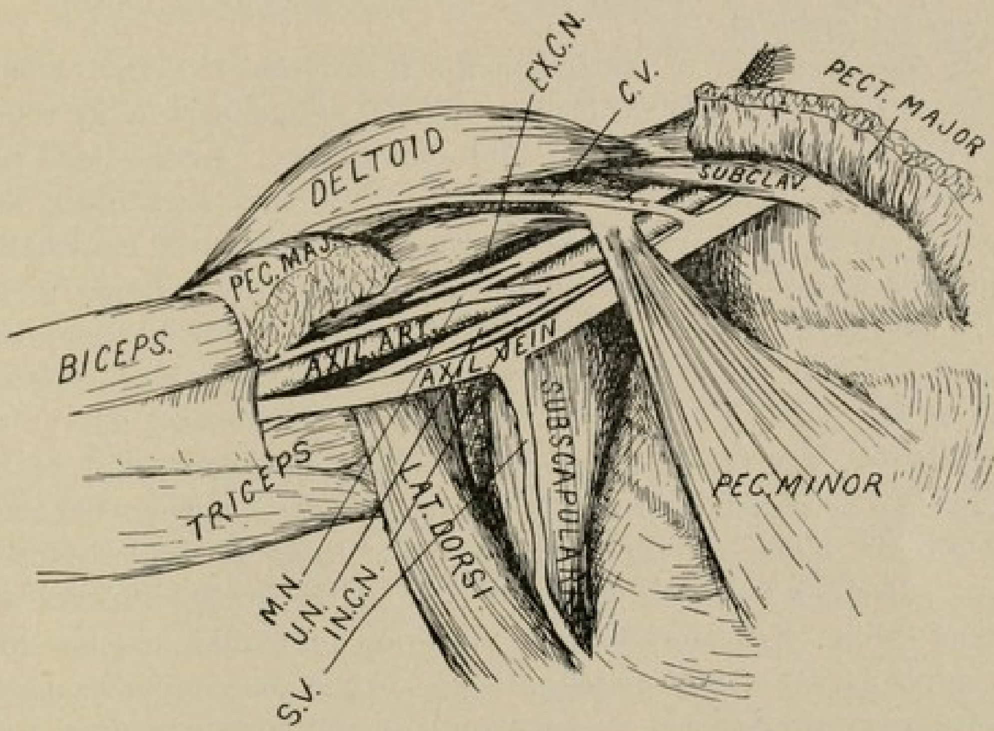

Fig. 318.—Axillary Region. Costo-coracoid membrane has been cleared away to show upper part of the axillary vessels, etc. *C.V.*, cephalic vein; *EX.C.N.*, external cutaneous nerve; *IN.C.N.*, internal cutaneous nerve; *M.N.*, median nerve; *S.V.*, subscapular vein; *U.N.*, ulnar nerve.

icle to a point upon the front of the elbow midway between the two condyles; with the arm hanging by the side, the artery describes a curve which is convex upward and outward.

After the pectoralis major has been separated from its attachment to the clavicle and reflected downward, the pectoralis minor, together with the costo-coracoid membrane, will be exposed. The costo-coracoid membrane is a rather thickened sheath of fascia which reaches from the inner border of the pectoralis minor upward, to be attached to the under surface of the clavicle and to the first rib; it is simply a reflection of the deep fascia which invests the pectoralis minor, and serves to cover in the upper, or first, part of the axillary vessels and adjoining structures.

The axillary artery is crossed about its middle by the pectoralis minor muscle, and may be conveniently considered in three parts. The upper, or first, part of the artery reaches from its commencement at the first rib to the inner border of the pectoralis minor, and is not exposed until after the costo-coracoid membrane has been cleared away; the second part of the artery is that portion which lies behind the pectoralis minor muscle, and the third is that part which reaches from the outer border of pectoralis minor to the point below where it becomes the brachial.

In the first part of its course the three trunks of the brachial plexus lie above the axillary artery. In the second part of its course one trunk lies above, one behind, and one below it. In the third part the cords of the brachial plexus communicate with each other, surrounding the axillary artery, and divide into a number of branches to supply the upper extremity. The median nerve lies external to the artery, taking one root from the external cord of the plexus and a second root from the internal cord, the latter root passing across the front of the artery. The external cutaneous nerve also lies to the outer side of the vessel, being derived from the outer cord of the plexus. To the inner side of the artery, and derived from the inner cord, are the ulnar, internal cutaneous, and lesser internal cutaneous nerves. Derived from the posterior cord of the brachial plexus and situated behind the artery are the posterior circumflex and the musculo-spiral nerves. Immediately after its origin the circumflex passes directly backward between the subscapularis and latissimus dorsi (and teres major) muscles, and is distributed to the deep surface of the deltoid.

The cephalic vein pierces the costo-coracoid membrane and passes across the first part of the axillary artery to empty into the axillary vein.

The lymphatic vessels and nodes are intimately related to the axillary vessels along their whole course within the axilla.

From the upper, or first, part of artery are given off the superior thoracic and acromial thoracic branches, which are distributed to the anterior wall of the axilla and to the axillary contents. A branch from the acromial thoracic is found in company with the cephalic vein in the groove between the deltoid and pectoralis major muscles (Mohrenheim's fossa).

At the lower border of the pectoralis minor the long thoracic is given off; this branch passes downward close to the lower border of this muscle, lying beneath the edge of the pectoralis major, and ramifies upon the side of the chest.

Still lower, and close to the posterior wall of the axilla, the artery gives off the subscapular, a large branch which descends upon the posterior wall of the axilla, along the outer border of the subscapularis muscle; it is accompanied by the large subscapular nerve, and enters and supplies the latissimus dorsi. External to this branch is given off the posterior circumflex, which passes backward between the latissimus dorsi and subscapularis muscles together with the circumflex nerve; they wind around the surgical neck of the humerus beneath the deltoid, which they supply. The axillary vessels and adjoining nerves, etc., in the upper, or inner, part of the axillary space, are located close to the anterior wall, and in the lower, or outer, part of the axilla they are found close to the humerus, resting upon the tendon of the latissimus dorsi and beneath the edge of the coraco-brachialis. Branches of the axillary artery ramify upon the anterior and posterior walls of the axillary space, and, descending upon the inner wall, side of the chest, posteriorly, is the long thoracic nerve, which supplies the serratus magnus; the middle of the axilla is, therefore, free for incisions for abscess, etc.; if it is desired to extirpate completely the axillary contents, it is well to commence by making a clean dissection of the main vessels and nerves.

THE ARM.

Upon the front of the arm there is seen a prominent spindle-shaped mass, which consists of the belly of the biceps and, joined to its inner side, the coraco-brachialis muscle. Occupying the inner side and back of the arm is a thick mass of muscle, the triceps. Upon the outer side, above, covering over the shoulder-joint, is a large mass of muscle, the deltoid. Beneath the deltoid, between it and the surgical neck of the humerus, the circumflex nerve and the circumflex arteries are found. The circumflex nerve, although well protected by the mass of deltoid muscle, on account of its relation with the neck of the humerus is often injured by blows and falls upon the shoulder, with a resulting disability of the deltoid.

Vessels of Arm. THE BRACHIAL ARTERY.—In the depression corresponding to the inner margin of the biceps and coraco-brachialis, beneath the deep fascia, lies the brachial artery. The brachial artery is the continuation of the axillary; it passes down along the inner side of the arm in the space between the anterior muscular mass, biceps, etc., and the inner muscular mass, triceps; externally and behind, the artery rests against the humerus, and below the bend of the elbow it divides into the radial and ulnar.

The linear guide to the artery with the arm abducted is a line drawn from the coracoid process to a point upon the front of the elbow, midway between the condyles; the muscular guide is the inner edge of the biceps and the coraco-brachialis muscles.

The brachial artery is covered by the integument and deep fascia, and is accompanied by two veins, venæ comites, which lie directly upon the vessel and anastomose with each other by numerous transverse branches. Above the median nerve lies to the outer side of the brachial artery, crosses the artery about its middle, and below lies to its inner side; the ulnar and internal cutaneous nerves are situated upon the inner side of the artery, the ulnar resting upon the inner head of the triceps and gradually getting farther away from the artery as it descends to reach the back of the internal condyle. Behind the artery, in the upper part of the arm, the musculo-spiral nerve is located.

The basilic vein runs parallel with the brachial artery, lying superficial to it and rather to its inner side. One may meet this vein in making the incision to expose the brachial artery. In the lower half of the arm this vein is separated from the artery by the deep fascia, but about the middle of the arm it pierces the deep fascia, and thus gets into closer relation with the artery. In the upper part of the arm the basilic joins the venæ comites to form the axillary vein. Along the outer side of the arm, superficial to the deep fascia, runs the cephalic vein; above this vein is found in the groove between the pectoralis major and the deltoid, and, after piercing the costo-coracoid membrane, passes across the first part of the axillary artery to empty into the axillary vein.

At the elbow, upon the front aspect of the arm, there is a triangular space with its apex directed downward; the inner border of the space is formed by the pronator radii teres, passing obliquely downward and outward from the internal condyle; the outer border is formed by the spinator longus, and its floor by the brachialis anticus and supinator brevis. In this space are found the tendon of the biceps, the brachial artery, and its accompanying veins, the median

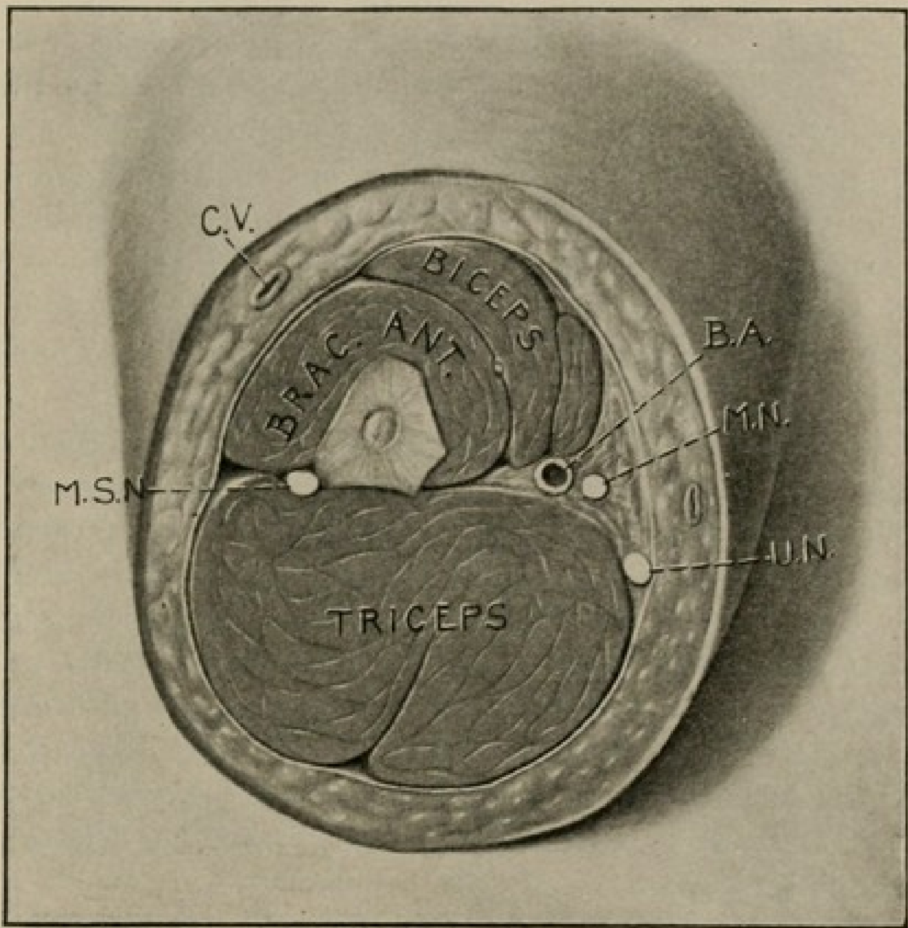

Fig. 319.—Section through Middle of Right Arm. *B.A.*, brachial artery; *C.V.*, cephalic vein; *M.N.*, median nerve; *M.S.N.*, musculo-spiral nerve; *U.N.*, ulnar nerve.

and the musculo-spiral nerves, and the bifurcation of the brachial artery into the radial and ulnar, which occurs about one inch below the bend of the elbow. In this space the median nerve is about half an inch to the inner side of the brachial artery, owing to the latter's verging outward, away from the nerve, toward the middle line.

The musculo-spiral nerve lies in the outer part of the space upon the supinator brevis, and is covered by the overlapping edge of the supinator longus. This region is covered by the skin, superficial and deep fascia. The skin of this region has a marked tendency to retract when cut, and this should be remembered in marking out the flaps for exarticulation at the elbow-joint. Lying just beneath the skin upon the deep fascia is the median cephalic vein externally, and the median basilic internally. The latter, the median basilic, is separated from the brachial artery, not only by deep fascia, but also by a fibrous expansion which is given off from the biceps tendon to the deep fascia of the forearm. The median cephalic is the vein selected by preference for intravenous infusion.

The Radial Artery.—From its origin below the bend of the elbow the radial passes somewhat outward and then downward upon the outer side of the anterior aspect of the forearm; it lies superficial, though partly covered by the overlapping edge of the supinator longus. In its course it rests upon the tendon of the biceps, the supinator brevis, the radial origin of the flexor sublimis digitorum, the pronator radii teres, the flexor longus pollicis, and the pronator quadratus. In the lower part of the forearm, just above the wrist, the artery lies beneath the integument and the deep fascia, to the outer side of the tendon of the flexor carpi radialis, between it and the tendon of the supinator longus.

In the upper part of the forearm the artery is accompanied by the radial branch of the musculo-spiral nerve, which lies to its outer side. Usually two venæ comites accompany the artery.

At the wrist the radial artery curves around the outer side of the joint, beneath the extensor tendons of the thumb and resting upon the external lateral ligament; it then passes across the posterior surface of the scaphoid and trapezium, and then forward, through the opening in the first dorsal interosseous muscle, into the palm of the hand.

In the hand the radial artery is situated deep and passes from without inward, resting upon the bases of the metacarpal bones and the anterior interosseous muscle, covered by all the structures of the hand: tendons, nerves, superficial arch, etc. Upon reaching the inner

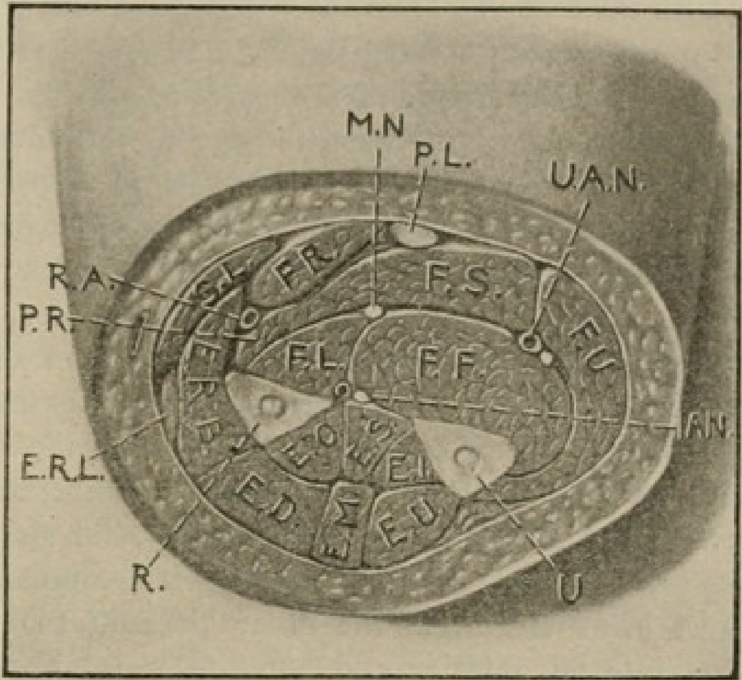

Fig. 320.—Section through Middle of Right Forearm. *E.D.*, extensor digit. com.; *E.I.*, extensor indicis; *E.M.*, extensor min. digit.; *E.O.*, extensor os. metacarpi pol.; *E.R.B.*, extensor carp. rad. brev.; *E.R.L.*, extensor carp. rad. long.; *E.S.*, extensor secundi; *E.U.*, extensor carp. ulnar; *F.F.*, flexor profund. dig.; *F.L.*, flexor long. pol.; *F.R.*, flexor carp. rad.; *F.S.*, flexor digit. sublim.; *F.U.*, flexor carp. ulnar.; *I.A.N.*, anterior interos. art. and nerve; *M.N.*, median nerve; *P.L.*, palmaris longus; *P.R.*, pronator radii; *R.A.*, radial art.; *S.L.*, supinat. long.; *U.A.N.*, ulnar art. and nerve.

side of the hand it anastomoses with the communicating branch from the ulnar, and in this way completes the deep palmar arch. The deep palmar arch is located one finger's breadth nearer the wrist-joint than the superficial palmar arch. The deep arch is accompanied by the deep branch of the ulnar nerve. From the deep arch are given off the palmar interosseous branches; these descend upon the interosseous muscles between the metacarpal bones, and at the clefts of the fingers anastomose with the branches from the superficial arch.

The Ulnar Artery.—Immediately after its origin the ulnar artery approaches the inner side of the forearm, passing deep beneath the superficial flexors, and lying upon the flexor profundus digitorum; the upper half of the artery is thus covered by the superficial flexors (pronator radii teres, flexor carpi radialis, palmaris longus, and flexor sublimis digitorum); in the lower half of its course the ulnar artery is still found resting upon the flexor profundus digitorum, but it is rather more superficial and lies between the tendon of the flexor carpi ulnaris internally and the tendons of the flexor sublimis digitorum externally. The artery is accompanied by the ulnar nerve, which lies to its inner side; in the upper part of the forearm the median nerve lies to the inner side of the artery, but a short distance below it crosses to its outer side. The artery is accompanied by venæ comites. Just below its origin the ulnar gives off the interosseous, which divides into an anterior and a posterior interosseous branch. The anterior passes down the front of the forearm, resting upon the interosseous membrane; the posterior passes through an opening in the upper part of the interosseous membrane, and runs down the back of the forearm between the superficial and deep layers of muscles.

At the wrist the ulnar artery lies superficial, passing across the anterior annular ligament, on the ulnar side of the hand, just to the radial side of the pisiform bone, with the ulnar nerve lying to its inner side; here it turns outward toward the radial side of the hand and anastomoses with a branch (superficial) from the radial, thus forming the superficial palmar arch.

In the hand the superficial palmar arch is about on a level with the palmar surface of the thumb when it is abducted and is covered by the skin and palmar fascia, resting upon the flexor tendons, etc.; it gives off digital branches, four in number, which pass downward and after anastomosing with the palmar interosseous branches, from the deep palmar arch, at the clefts of the fingers, divide into two branches to supply the contiguous sides of the fingers.

The Musculo-spiral Nerve.—The musculo-spiral nerve passes down the back of the arm. It is lodged in the musculo-spiral groove upon the posterior surface of the humerus between the inner and outer heads of the triceps muscle and covered by the long head of this muscle. In its course it crosses the posterior surface of the humerus obliquely from above downward, and from within outward, and at the elbow-joint is found in front of the external condyle beneath the supinator longus. The nerve is accompanied by the superior profunda branch of the brachial artery.

The Median Nerve.—In the upper arm the median nerve is closely related with the brachial artery. In the forearm it lies beneath the flexor sublimis muscle, resting upon the flexor profundus digitorum. Just above the annular ligament this nerve becomes more superficial, lying to the inner side of the tendon of the flexor carpi radialis.

The Ulnar Nerve.—In the upper arm the ulnar nerve lies some little distance to the inner side of the brachial artery, resting upon the inner head of the triceps, beneath the deep fascia. At the elbow the ulnar nerve lies behind the joint in the groove between the internal condyle and the olecranon process; it then swings forward, and is continued down the anterior aspect of the forearm, resting upon the flexor profundus digitorum beneath the flexor carpi ulnaris and lying close to the inner side of the ulnar artery.

THE HAND.

Beneath the integument in the palm of the hand is the palmar fascia. This is a dense, aponeurotic layer intimately joined to the integument.

Beneath the palmar fascia are the flexor tendons, superficial and deep palmar arches, nerves, etc. As the flexor tendons pass across the wrist-joint into the palm of the hand they are bound down by the anterior annular ligament. The extensor tendons, as they pass over the back of the wrist-joint into the hand, are bound down by the posterior annular ligament.

Beneath the anterior annular ligament the flexor tendons are inclosed within a synovial sheath, which extends for a short distance upward into the forearm and downward into the palm of the hand. From this common sheath there are given off two processes, one of which accompanies and envelops the tendon of the flexor longus pollicis into the thumb; the other accompanies the flexor tendons of the little finger to their destination.

The sheaths which surround the tendons of the other fingers—*i.e.*, the index, middle, and ring—do not, as a rule, reach beyond the metacarpo-phalangeal articulation, and do not communicate with this common flexor sheath. This fact is important in determining the extension of inflammatory processes which involve the tendon sheaths of the fingers up into the hand and forearm. Inflammatory processes which involve the thumb and little finger are found more apt to extend into the hand and forearm than those of the other fingers.

The hand gets its arterial supply from the radial and ulnar arteries (see description of these vessels).

The Nerve-supply of the Hand.—The nerve-supply of the hand is derived from the median and ulnar and musculo-spiral nerves. The median nerve passes into the palm of the hand beneath the annular ligament; the ulnar nerve passes into the palm of the hand across the annular ligament: *i.e.*, in company with the ulnar artery. In the hand, in close relation to the superficial arch, the median and ulnar nerves give off their digital branches, which supply the integument of the palmar aspect of the fingers with sensation, the ulnar supplying the little finger and half the ring finger, the median supplying the other fingers.

The dorsal aspect of the hand and the fifth, fourth, and part of the third fingers are supplied by the ulnar nerve; the thumb and the second and part of the third fingers are supplied by the radial nerve, which is a branch of the musculo-spiral.

All the interossei, both anterior and posterior, and the two inner lumbricales are supplied by the deep branch of the ulnar nerve which accompanies the deep palmar arch; the two outer lumbricales are supplied by the median.

A collection of pus in the palm of the hand may be situated superficially beneath the skin, between it and the palmar fascia, or deep, beneath the palmar fascia or within the proper synovial sheaths of the flexor tendons.

Incisions into the palm of the hand may be freely made without troublesome hemorrhage, if placed over the metacarpal bones and below the line of the superficial palmar arch.

Ligations. THE AXILLARY ARTERY.—The axillary artery is not often exposed for the purpose of ligation, but frequently the artery and vein and adjoining structures are laid bare during the course of operations which require a thorough cleaning out of the axilla.

A ligature may be applied to the third part of the axillary artery as it lies upon the tendon of the latissimus dorsi close to the humerus. The arm should be abducted from the side of the chest to a right angle and slightly flexed at the elbow-joint, in order that the structures may not be placed too much upon the stretch; with the arm in this position the course of the artery corresponds to a line drawn from the junction of the middle and inner thirds of the clavicle to the middle of the elbow. An incision two and one-half inches long is made through the integument down to the deep fascia; this incision is placed midway between the anterior and posterior borders of the axilla, along the edge of the coraco-brachialis muscle. This incision penetrates through the skin and fat. With a second stroke of the knife the deep fascia is incised, and one may then, with the handle of the knife, seek the white, shiny tendon of the latissimus dorsi, which is the guide to the axillary vessels in this part of their course. When this tendon is recognized, it is followed up toward its attachment to the humerus, diminishing the tension of the parts by flexing the arm somewhat at the elbow, and then the vessels and nerves are readily located, the vein, which lies below and internal to the artery, being the first structure encountered.

The artery is carefully isolated for a short distance, using blunt hooks to retract the adjacent structures, and the loose connective tissue which immediately surrounds the vessel is picked up with a toothed forceps and nicked with the point of a knife; through the small opening which is thus made in the connective-tissue sheath a director may be introduced between the vein and the artery and gradually worked around the artery, taking care to keep close to the wall of the vessel, so as not to include any of the adjoining structures—one should avoid, especially, the musculo-spiral nerve, which is located behind the artery, upon the tendon of the latissimus dorsi. A small aneurism needle is then carried around the artery, a ligature passed through its eye, and the needle withdrawn, thus leaving the vessel surrounded by the ligature, which is tied with a single square knot.

The Brachial Artery.—The linear guide to the brachial artery is a line drawn from the coracoid process to a point upon the front of the elbow, midway between the condyles, the arm being abducted to a right angle with the trunk. The muscular guide to the artery is the inner edge of the mass of muscle, composed of the biceps and coraco-brachialis.

The incision, two inches in length, is made along the inner border of the coraco-brachialis, penetrating through the skin and subcutaneous fat and exposing the deep fascia. At this stage, below the middle of the arm, the basilic vein, lying superficial to the deep fascia and to the inner side of the brachial artery, is met. In the upper part of the arm we would not encounter the basilic vein until after we had cut through the deep fascia.

The deep fascia is now incised in a direction corresponding to the skin incision, and the bundle of structures—which consists of

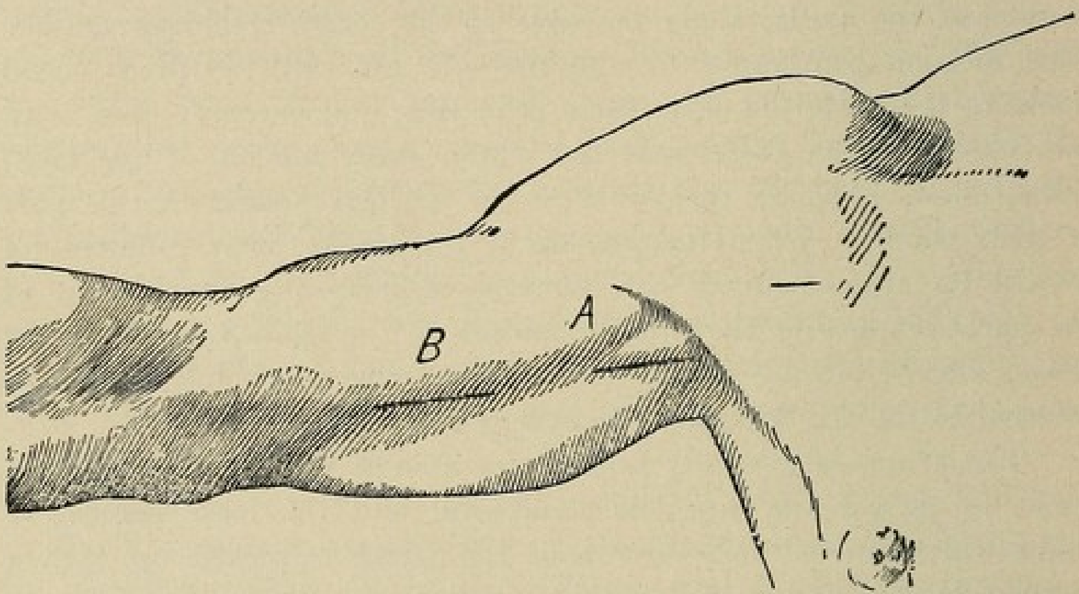

Fig. 321.—Right Arm. *A*, incision for ligation of axillary artery; *B*, incision for ligation of brachial artery.

the artery, venæ comites, and adjoining nerves and which is readily felt beneath the deep fascia—is exposed.

In the middle of the arm we find the median nerve lying upon and crossing the artery from without inward; above the middle of the arm the median nerve lies close to the outer side of the artery; below the middle it lies along its inner side. The ulnar nerve is situated upon the inner side of the artery, getting farther away from it as it descends toward the elbow-joint. The loose connective tissue that surrounds the brachial artery may be now picked up with a mouse-toothed forceps and nicked with the point of the knife; through the small opening thus made a director is introduced and gradually worked around the artery, which is thus isolated from the adjoining structures, avoiding the venæ comites, which lie directly upon it. A small aneurism needle is then passed around the artery through the path made by the director, and after a ligature is carried through its eye the needle is withdrawn, leaving the artery surrounded by the ligature, which is tied.

THE RADIAL ARTERY. *In the Middle of the Forearm.*—An incision one and one-half inches long is made between the middle and inner thirds of the forearm, reaching through the skin and fat down to the deep fascia; the deep fascia is then incised and the artery found lying partly concealed by the overlapping edge of the supinator longus, which is drawn aside with a retractor. The artery is accompanied by venæ comites, which lie close upon it, and also to its outer side by the radial nerve, which is a branch of the musculo-spiral.

Just Above the Wrist.—Here the artery is found beneath the deep fascia, lying between the tendons of the supinator longus externally and the flexor carpi radialis internally. The radial nerve quits the artery three inches above the wrist-joint, and is not met with here.

THE ULNAR ARTERY. *In the Middle of the Forearm.*—An incision one and one-half inches long is made between the middle and inner thirds of the forearm, through the skin and fat down to the deep fascia; the deep fascia is then incised, and the artery is found lying beneath the edge of the flexor carpi ulnaris, which must be drawn inward to expose the vessel. The artery rests upon the flexor profundus digitorum; to the outer side of the artery is the edge of the flexor sublimis digitorum. The artery is accompanied by venæ comites, which lie in close relation with it. The ulnar nerve is found upon the inner side of the artery.

Just Above the Wrist.—The ulnar artery lies beneath the deep fascia, with the tendon of the flexor carpi ulnaris to its inner side and the tendons of the flexor sublimis to its outer side; the ulnar nerve lies close to the inner side of the vessel in this part of its course.

AMPUTATIONS, RESECTIONS, ETC.

Surgical Anatomy of the Hand.—The hand is composed of the carpus, metacarpus, and phalanges. Each finger is made up of three phalanges, the thumb of two (see Fig. 324).

PHALANGO-PHALANGEAL JOINTS.—The fingers are formed by the phalanges, which articulate with each other, end to end. Upon the anterior aspect are found the flexor tendons; upon the posterior are the extensor tendons.

Each phalango-phalangeal joint has an anterior ligament and two lateral ligaments, the posterior ligament being formed by the spread-out extensor tendon.

Flexion and extension are permitted in these joints. Flexion occurs by the gliding of the distal phalanx around the head of the proximal, and therefore when the finger is flexed the joint is found below the angle of the knuckle at a distance which corresponds to the thickness of the end of the proximal bone.

METACARPO-PHALANGEAL JOINTS.—These joints are quite similar to the phalango-phalangeal; they are formed by the articulation of the heads of the metacarpal bones with the proximal ends of the phalanges. They are provided with an anterior ligament and two lateral ligaments; the extensor tendon spreads out in the form of a broad, fibrous sheath as it passes across the posterior aspect of the joint, and thus serves as a posterior ligament, completely covering the joint upon its posterior aspect. The anterior ligaments are firmly united with each other (except that of the thumb), so as to bind the heads of the metacarpal bones firmly together into one strong, solid row, which lends a great element of strength to the hand.

The lateral ligaments are attached to the bones, excentrically, in such a manner that, although a considerable range of adduction and abduction is allowed when the fingers are extended, this is not permitted when they are flexed; when flexion takes place, the lateral ligaments become relatively short, since the points to which they are fixed become more widely separated. When flexion takes place between the phalanx and the head of the metacarpal bone, it is accomplished by the proximal end of the phalanx gliding around the head of the metacarpal bone, and, therefore, in this position, the level of the joint will be found at a distance below the angle of the knuckle which corresponds to the thickness of the head of the metacarpal bone.

EXARTICULATION OF THE FINGER AT THE PHALANGO-PHALANGEAL JOINT.—In amputating a portion of a finger an effort should be made to use what integument may be available, with a view to preserving as much of the length of the finger as possible. No doubt, where one may choose, the best amputation is through a joint and with a long anterior flap; this brings the suture line upon the posterior aspect of the stump and out of the way of pressure.

The end of the finger which is to be amputated is seized by the operator with the left hand and strongly flexed, and a transverse incision, reaching down to the bone, is then made across its dorsal surface, about one-half inch below the point of the knuckle; this incision should not include more than one-half of the circumference of the finger. An additional incision is then made upon either side, extending from the end of the transverse incision, along the side of the finger, for a distance corresponding to the length of the proposed flap, and this should also penetrate to the bone.

With the finger still strongly flexed, the joint is now opened upon its dorsal aspect, remembering that the line of the joint lies below the point of the knuckle. After the joint has been opened the point of the knife should be passed in on each side and the lateral

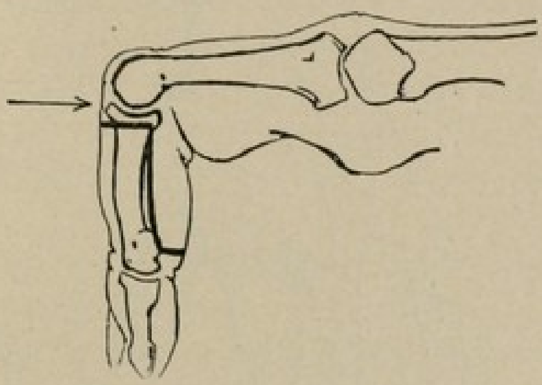

Fig. 322.—Exarticulation of the Finger at the Phalango-phalangeal Joint. The arrow indicates level of the joint when the finger is flexed. Heavy line indicates the long anterior flap.

ligaments freely divided, when the joint surfaces may be separated from each other. The blade of the knife is then introduced between the joint surfaces and behind the bone, between the bone and the anterior flap, and with a sawing motion the anterior flap is cut, with the edge of the knife directed toward the bone, down to the level of the next joint, or until a flap of sufficient length is obtained, when it is cut from within outward by turning the edge of the knife toward the skin. The digital arterial branch on either side should be tied with catgut. The corners of the flap may be rounded off, although this is probably unnecessary. The anterior flexor tendons may be united by two catgut sutures to the edge of the extensor tendons, as this increases the probability of a movable, useful finger stump. The edges of the skin are approximated with two to four catgut sutures, and the operation is complete.

Exarticulation of the Finger at the Metacarpo-phalangeal Joint.—Amputation through the metacarpo-phalangeal joint may be done with or without the removal of the head of the metacarpal bone. Removal of the head of the metacarpal bone allows the adjoining fingers to be approximated, thus diminishing, somewhat, the apparent deformity, but this is accomplished at the expense of the solidity and strength of the hand; so that, in most cases, especially in laboring people, the end of the metacarpal bone is better not removed.

The finger is seized and flexed as in the previous operation, and an incision made upon the dorsal aspect of the hand, commencing

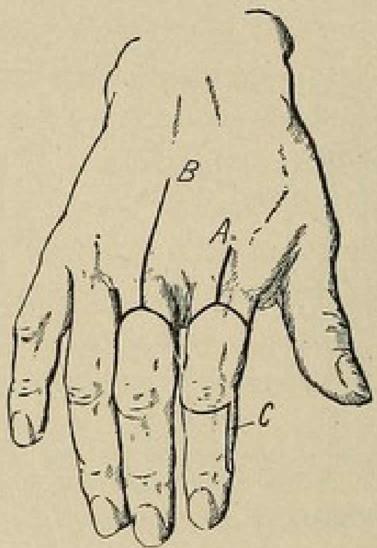

Fig. 323.—Exarticulation of the Finger. *A*, incision for exarticulation at the metacarpo-phalangeal joint; *B*, incision for amputation of finger with excision of the head of the metacarpal bone; *C* indicates long anterior flap in exarticulation through the phalango-phalangeal joint.

one-half inch above the point of the knuckle and carried down as far as the level of the web of the finger. This incision should penetrate to the bone, dividing the skin and also the aponeurotic expansion of the extensor tendon. At the lower end of this incision, upon a level with the web of the finger, a second incision is carried around the finger, cutting all the structures, including the anterior and posterior tendons, down to the bone.

A corner of the flap is now seized, the finger being drawn toward the opposite side, and the flap, including the tendinous expansion, is stripped away from the bone with the knife; this is then done, in a similar manner, with the other remaining half of the flap.

Now strongly flexing the finger, the joint, which is located a good one-half inch below the angle of the knuckle, is opened by inserting the point of the knife, and the lateral ligament on either side is then completely divided. In opening the joint and dividing the lateral ligaments the knife may be grasped by the blade, being thus held short and firm. The bone is readily dissected out of the flap, care being taken not to perforate the integument with the point of the knife.

The vessels are caught and tied, usually one on each side of the flap; the corners of the flap may be rounded off and the end of the bone covered by uniting the edges of the flap with several interrupted catgut sutures.

If, in addition, the distal end of the metacarpal bone is to be removed, the dorsal incision should be extended somewhat farther upward, toward the wrist, and through all the structures down to the bone. With the point of the knife the soft parts are then separated from the bone, and with a strong cutting forceps the bone is divided about one inch above its lower end, taking care to cut the bone straight across. The loose lower end of the bone is then seized with a toothed bone-forceps and enucleated, cutting with the edge of the knife applied close to the bone. After the vessels have been ligated, the edges of the flap are united with interrupted catgut sutures. If the head of the metacarpal bone is taken away it is not necessary to make the flap so long.

Exarticulation of the Hand at the Carpo-metacarpal Articulation.—Applicable to cases of traumatism where the thumb can be saved.

The hand which is to be amputated is seized by the operator and an incision made which crosses the palm of the hand, somewhat curved, with the convexity downward toward the fingers; it commences on the radial border of the hand near the head of the metacarpal bone of the index finger and ends on the ulnar border of the hand near the base of the fifth metacarpal bone. The incision extends through the soft parts, including the integument and palmar fascia, down to the flexor tendons. This anterior flap is reflected upward to the level of the carpo-metacarpal articulation.

Upon the back of the hand the incision extends through the skin only, and passes across the hand somewhat curved, with the concavity downward toward the fingers. If the anterior flap is scant, the posterior may be made correspondingly longer. The extremities of this posterior incision join with those of the anterior. The flexor tendons on the front of the hand and the extensors on the back of the hand are now divided transversely down to the bone with a sharp knife. The hand is again supinated and the carpo-metacarpal articulation opened, working from the ulnar side of the hand toward the thumb. Care should be taken, in exarticulating the metacarpal bone of the index finger from the trapezoid, not to injure the joint between the metacarpal bone of the thumb and the trapezium.

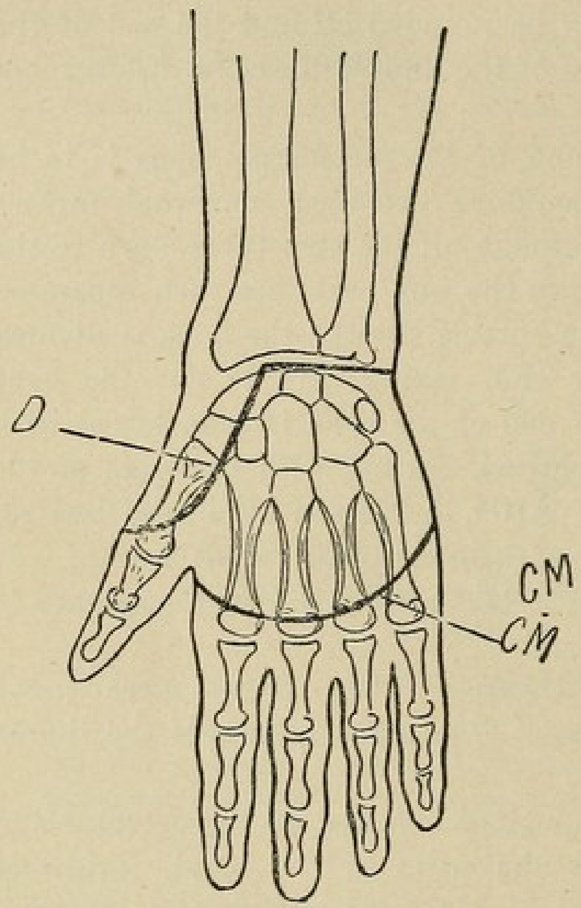

Fig. 324.—Palmar Aspect of Right Hand. *CM*, outline of the palmar flap in exarticulation of the hand through the carpo-metacarpal joint; *D*, incision for exarticulation of hand at the wrist-joint (Dubrueil), front view.

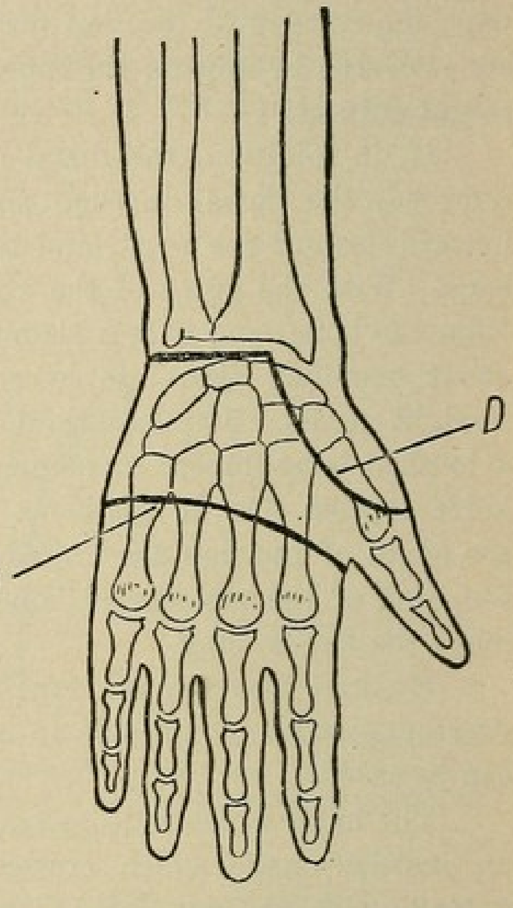

Fig. 325. — Dorsal Aspect of Right Hand. *CM*, dorsal incision for exarticulation of the hand at the carpo-metacarpal joint; *D*, incision for exarticulation at the wrist-joint (Dubrueil), back view.

The branches of the radial and ulnar arteries must be clamped and ligated before the tourniquet is removed.

The edges of the flaps are brought together with interrupted catgut sutures, the stump being thus covered by the strong palmar integument, and the suture line upon the posterior edge of the stump free from pressure, etc.

If the condition of the integument of the palm of the hand is such that the longer flap cannot be taken from this part of the hand, then one may get a sufficiently long flap from the posterior surface, or two flaps of equal length, one from the anterior and one from the posterior surface of the hand may be made.

Surgical Anatomy of the Wrist-joint.—The wrist-joint is formed of the first row of the carpal bones in order, from without inward, scaphoid, semilunar, and cuneiform, and of the lower extremities of the radius and ulna.

The three carpal bones are united to each other, and present

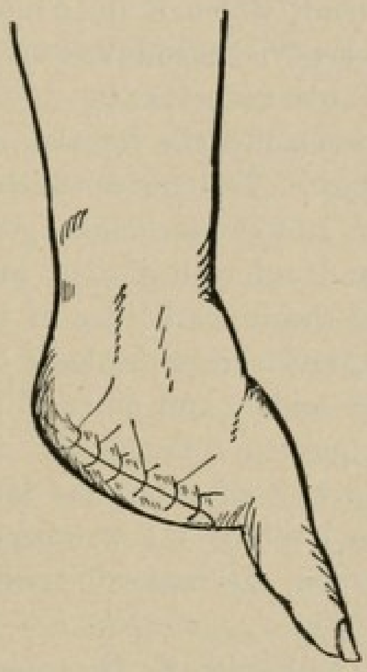

Fig. 326.—Stump Result of Exarticulation of the Hand at the Carpo-metacarpal Joint.

one continuous surface, smooth, covered with articular cartilage, and convex from side to side and from before backward. The outer extremity of this surface slopes downward to a much lower level than the inner extremity.

The articular surface presented by the lower ends of the radius and ulna is concave in order to accommodate the convex articular surface of the upper row of carpal bones. This radio-ulnar articular surface is directed obliquely downward externally, so that the outer, or radial, end is a considerable distance below the level of the inner, or ulnar, end, and is continuel into the external styloid process, to the tip of which the external lateral ligament is attached; the inner, or ulnar, side of this radio-ulnar articular surface presents the inner styloid process, prolonged from the lower end of the ulna. The tip of this process gives attachment to the internal lateral ligament of the wrist-joint.

Of the three carpal bones, the outer two, the scaphoid and semilunar, correspond to and articulate with the radial articular surface; the inner, the cuneiform, corresponds to the ulnar articular surface, an interarticular fibro-cartilage being interposed between them.

There is a broad anterior and a broad posterior ligament, and these, together with the lateral ligament on either side, practically form a capsular ligament, which is lined upon its inner aspect by a thin, serous layer, the synovial membrane of the joint.

Exarticulation of the Hand at the Wrist-joint (Dubreuil.—An assistant steadies the forearm, drawing the integument rather toward the elbow. The hand which is to be amputated is seized by the operator, and commencing upon the front of the wrist, between the middle and outer thirds, an incision is made, which is carried inward around the inner border of the wrist, below the level of the styloid process, and across the back of the wrist, terminating at a point between the middle and outer thirds and directly opposite the point where the incision commenced. This incision should extend through the skin and subcutaneous fatty tissue and should be placed well below the level of the wrist-joint; otherwise, after the integument has retracted, the cut edge will be found to be above the level of the wrist-joint.

A tongue-shaped flap, with its base corresponding to the radial third of the circumference of the wrist, is now marked out by an incision reaching from either end of the circular incision described above. This flap of integument is taken from over the metacarpal bone of the thumb, its lower extremity corresponding to the metacarpo-phalangeal articulation of the thumb (see Fig. 324). This flap, including the superficial fascia and fat, is dissected back to the level of the wrist-joint. The wrist-joint is then entered by introducing the blade of the knife into the joint on its radial side, below the styloid process, and the hand severed from the forearm, thus completing the exarticulation.

The radial and ulnar arteries are picked up and ligated, the median and ulnar nerves seized and cut short, and the ends of the bones covered over with the flap, which is fixed with interrupted catgut sutures. The first stitch should unite the apex of the tongue-shaped flap to the skin at a point corresponding to the tip of the styloid process of the ulna, and the other stitches are then placed so as to distribute the flap evenly, should it be found to be a little redundant.

An analogous operation may be done at the wrist-joint, taking the tongue-shaped flap of integument from the ulnar side of the hand.

One may also exarticulate at the wrist-joint, using two flaps, an anterior and a posterior flap, of equal length; or else one long, preferably the anterior, and one short; or the circular method may be used.

Amputation through the Forearm.—The forearm is a good place at which to practice the old musculo-tegumentary flap method. Practically, this method is now almost entirely discarded in favor of the skin flap or circular method. The arm overhangs the edge of the table. The hand, which is supinated, is supported by an assistant. A long, sharp amputating knife is introduced through the skin upon the outer side of the forearm, at the level where it is intended to divide the bones, until its point touches the outer surface of the radius; it is then pushed through the soft parts upon the front of the forearm, keeping close to the anterior surface of the bones, and emerging at a corresponding point upon the inner, or ulnar, side of the forearm. Now, with a sawing motion and with the edge of the knife directed toward the radius and ulna, the anterior flap, which includes the integument and all the muscular tissue, is cut away from the bones. If the anterior and posterior flaps are to be of equal length, each flap should correspond in length to one-half the diameter of the limb, at the point where the bones are to be divided, plus one-third extra, which is allowed for retraction. When the flap has been cut to a sufficient length, the edge of the knife is turned toward the integument and the flap cut square from within outward.

The posterior flap is formed in a similar manner. The point of the knife is again introduced upon the outer, or radial, side of the forearm in the upper angle of the incision which marks the anterior flap, and thrust through the forearm behind the bones, between them and the soft parts, emerging at the upper part of the incision upon the inner, or ulnar, side of the forearm, and then, with the edge of the knife closely applied to the bones, the posterior flap is cut equal in length to the anterior. The flaps should be square, and not tongue-shaped.

The flaps are turned back and held thus by the hands of an assistant or with sharp retractors, or by the operator. With a scalpel the interosseous membrane is cut through and the bones cleaned of any remaining soft parts, in order to make way for the saw.

The heel of the saw is placed upon one of the bones, and by drawing it backward firmly and steadily a groove is made, after which the bones can be rapidly severed, engaging the second bone after the first has been partly sawn through, and completing the section of both simultaneously. No cloth retractor is necessary, the flaps being held back by the operator's hand while he saws through the bones.

In the dead subject it will be seen that the muscles in the flap protrude beyond the edge of the integument; this is due to the unequal retraction of skin and muscle, and does not occur to the same degree in the living subject. Should the ends of the muscles or tendons protrude, they may be trimmed off with the scissors.

The radial and ulnar arteries are sought for and ligated; also the anterior and posterior interosseous. These latter are found close to the anterior and posterior surfaces, respectively, of the interosseous membrane. The median and ulnar nerves should be drawn down and cut short. The edges of the flap are joined all around with interrupted catgut sutures.

We may amputate through the forearm, using skin-flaps, anterior and posterior, of equal length, or one long and the other short; or we may reflect a circular tegumentary cuff, in all of these operations, dividing the muscles on a level with or just below the point at which the bones are to be divided.

Surgical Anatomy of the Elbow-joint.—The elbow-joint is an irregular, rather complicated joint, formed by the lower end of the humerus and the upper end of the radius and ulna.

The lower end of the humerus is broad from side to side and flattened from before backward, and presents below two partially separated, smooth, rounded, articular surfaces, the smaller, outer one being for articulation with the radius, and the broader, inner one for articulation with the ulna. The plane of this double articular surface is oblique from without downward and inward, its inner end being on a much lower level than its outer.

The surface for articulation with the radius, the external, is a portion of a sphere, and occupies the lower and anterior aspect of the humerus.

The surface with which the ulna articulates, the inner, is broad, spool-shaped, and occupies not only the anterior and inferior, but also the posterior, aspect of the bone. This portion articulates with the greater sigmoid cavity of the ulna.

Below, the joint is formed by the upper end of the radius externally and the upper end of the ulna internally. The upper end or head of the radius presents a shallow, cup-shaped surface, covered with cartilage for articulation with the radial part of the articular surface of the humerus; this surface is surrounded by a smooth, narrow margin, which rotates within the ring formed by the lesser sigmoid cavity of the upper end of the ulna and the orbicular ligament.

The head of the radius lies just below the external condyle, and may be recognized even when the joint is considerably swollen; by supinating and pronating the hand it may be felt to rotate beneath the skin. The elbow-joint is readily entered between the head of the radius and the external condyle.

The upper extremity of the ulna is irregular, and presents an articular surface, the greater sigmoid cavity, which is made up of the superior surface of the upper end of the ulna and the anterior surface of the olecranon process. The olecranon is a strong, square-shaped process of bone which projects upward from the posterior part of the upper end of the ulna. The greater sigmoid cavity is covered by articular cartilage and articulates with the trochlear surface of the lower end of the humerus. The upped end of the ulna further presents, upon its outer edge, a smooth depression, the lesser sigmoid cavity, to either end of which the orbicular ligament is attached. Within the ring formed by the orbicular ligament and the lesser sigmoid cavity the upper end of the radius rotates in pronation and supination.

Besides the parts entering directly into the formation of the elbow-joint there may be felt, internally, the internal epicondyle, very prominent and giving attachment, upon its anterior aspect, to the common tendon of origin of the flexor muscles of the forearm, and, externally, the less prominent external epicondyle, giving attachment, upon its posterior aspect, to the common tendon of the extensor muscles of the forearm. Behind may be felt the prominent olecranon process. At its junction with the ulna the olecranon process is somewhat constricted, and is here often the site of fracture. Its anterior surface enters into the formation of the elbow-joint, forming the upper part of the greater sigmoid cavity. Its posterior surface is subcutaneous and triangular in shape, with its apex below, where it is continuous with the posterior border of the shaft of the ulna. To the broad, upper border of the olecranon process is attached the triceps tendon, and around its margin the posterior and lateral ligaments of the joint. The upper border, or surface, of the olecranon process, when the arm is extended, is on a line drawn between the two epicondyles.

The elbow-joint is provided practically with a capsular ligament, which is lined, upon its inner surface, by a synovial membrane which also dips into that part of the joint between the head of the radius and the lesser sigmoid cavity of the ulna and orbicular ligament.

The ulnar nerve lies in close relation with the elbow-joint, posteriorly, in a groove between the internal epicondyle and the olecranon process.

Exarticulation of the Forearm at the Elbow-joint (Double Circular Method).—The arm overhangs the side of the table, and is steadied by an assistant, who draws the integument somewhat toward the shoulder-joint. The operator grasps the limb with the left hand, and with a long amputating knife a circular incision is made around the forearm, through the skin and fat down to the deep fascia. This incision should be placed below the level of the elbow-joint a distance corresponding to one-half the diameter of the arm at the elbow-joint, plus one-third extra, which is allowed for shrinkage of the skin. The upper surface of the head of the radius marks the level of the elbow-joint. This tegumentary flap is dissected away from the deep fascia and reflected upward like a turned-up cuff as far as the level of the elbow-joint. At this level the muscles are divided with the long knife down to the bone, and the elbow-joint then entered externally above the head of the radius, finally passing in between the ulna and the humerus, cutting the anterior and lateral ligaments. The forearm then hangs suspended by the attachment of the triceps tendon, and, this being cut close to the olecranon, the exarticulation is complete.

In this operation a common fault is that the muscles, being cut on a level with the elbow-joint, retract and leave the end of the humerus projecting into the wound. Even if the muscles are divided a considerable distance below the level of the joint and stripped away from the bone from a point below the level of the joint, it helps but little, as, upon the posterior aspect, there are no muscles, and even the tendon of the triceps, when cut close to the olecranon, lies well above the level of the joint; therefore, in most cases, it is desirable to supplement this operation by resecting the lower articular end of the humerus, which may be readily done. As regards the usefulness of the resulting stump, it matters little if we make the section just above, instead of through, the elbow-joint.

It is necessary to ligate the brachial artery and its accompanying vein separately. The median, ulnar, and musculo-spiral nerves are drawn down and cut short. The edges of the skin are united from side to side with interrupted catgut sutures, and a small drain introduced, which may be removed after forty-eight hours.

Amputation of the Arm.—Here the double circular method is preferable. The arm, hanging over the side of the table, is grasped above, near the shoulder, by an assistant, who, at the same time that he steadies the arm, draws the integument somewhat toward the shoulder. With a long amputating knife a circular incision is made, which reaches through the skin and superficial fascia down to the deep fascia. This incision should be placed below the level at which the bone is to be divided a distance equal to one-half the diameter of the arm, plus one-third, which is allowed for retraction of the skin.

The circular flap, which includes all the fatty tissue, but not the deep fascia, is now dissected back like a cuff to a point one inch below the level at which the bone is to be divided; at this point the muscles are severed down to the bone with one circular sweep of the long knife.

With a blunt elevator or the back of the scalpel the muscles, but not the periosteum, are separated from the humerus for another inch, and thus the level is reached at which the bone is to be divided. After the periosteum has been cut by drawing the knife around the bone, the heel of the saw is applied and with a firm backward movement a groove is made in which the saw may work, and then the bone is rapidly severed.

While sawing the bone it is unnecessary to use a cloth retractor, as the soft parts may be held back so as to give the saw freedom, by the hands of an assistant, or with two sharp retractors.

Having completed the amputation, it will be seen that the muscles slightly overhang the end of the bone without covering it, and that the skin-flap is sufficiently long to cover the whole stump.

The brachial artery and accompanying veins are found lying anterior and internal to the bone, and should be clamped and tied;

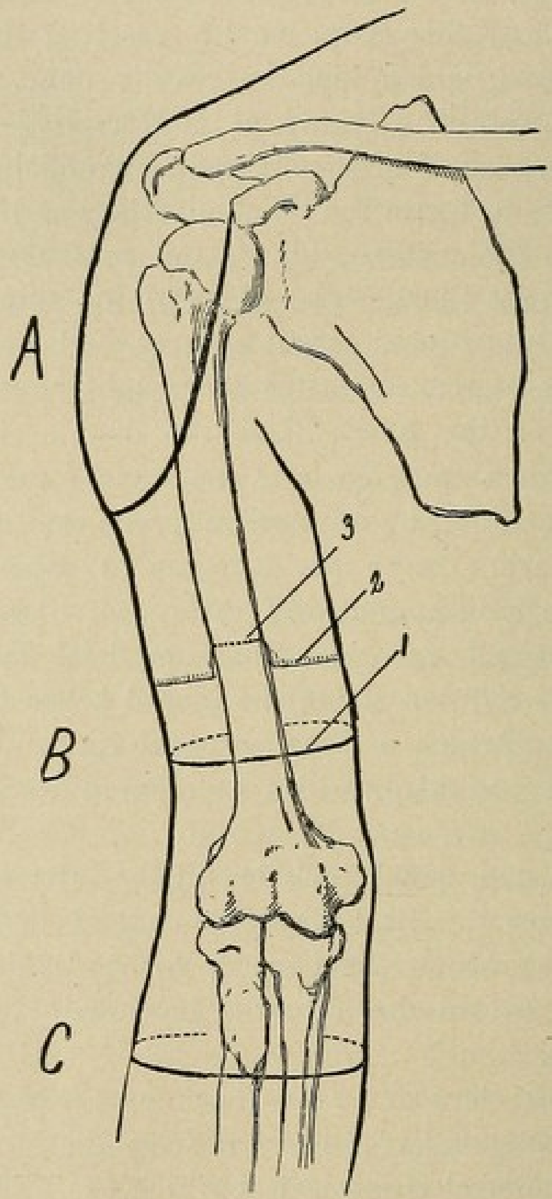

Fig. 327.—Right Arm, Anterior Aspect. *A*, outline of the lateral deltoid flap in exarticulation at the shoulder-joint; *B*, amputation through the arm; 1, incision through the skin; 2, incision through the muscle; 3, line of division through the bone; *C*, incision for exarticulation through the elbow-joint (circular method).

the median and ulnar nerves, which are in close proximity to the brachial artery, should be cut short; likewise the musculo-spiral, which is found upon the posterior surface of the humerus. The superior profunda, a branch of the brachial artery, which accompanies the musculo-spiral nerve, is also seized and ligated. The tourniquet is then removed and any remaining bleeding vessels clamped and ligated.

The edges of the skin are united from side to side, making a transverse line, by several interrupted catgut sutures; if the wound is clean, one may omit drainage, or a temporary drain may be introduced, and removed after forty-eight hours.

The arm may also be amputated with the formation of musculo-tegumentary flaps, as described for the forearm, or, instead of a cuff skin-flap, one may use lateral or antero-posterior skin-flaps of equal length, or one long and the other short.

Surgical Anatomy of the Shoulder-joint.—The shoulder-joint consists of the articulation of the upper end of the humerus and the glenoid cavity of the scapula. The articular surface of the upper end of the humerus looks inward and backward and is hemispheroidal in shape; it presents the arc of a smaller sphere from before backward, and of a larger sphere from above downward; that is, the diameter from before backward is shorter than that from above downward.

The articular surface is limited by the anatomical neck, which is narrow and well marked above, but broad and less well marked below; the anatomical neck marks the junction of the head of the bone with the shaft.

Externally may be observed the broad, large tuberosity major; internally and below the head is the smaller tuberosity, the tuberosity minor. To the tuberosity minor is attached the tendon of one muscle, the subscapularis; to the tuberosity major—*i.e.*, to its upper and posterior borders—are attached the tendons of three muscles: the supraspinatus, the infraspinatus, and the teres minor, in that order from above downward.

The anterior border of the greater tuberosity forms the external border of the bicipital groove, the external, or anterior, bicipital ridge; the lesser tuberosity and the ridge that is prolonged downward from it form the inner border of the bicipital groove, the internal, or posterior, bicipital ridge. Between the two is the bicipital groove.

To the external bicipital ridge is attached the tendon of the pectoralis major; to the internal bicipital ridge are attached the tendons of the latissimus dorsi and teres major. Lying in the groove itself, held in place by a process of fibrous tissue, is the long tendon of the biceps muscle. Close to the humerus, between the tendon of the pectoralis major in front and the tendons of the latissimus dorsi and teres major behind, are the brachial vessels and accompanying nerves, which descend in a bunch from the axilla, partially overlapped by the coraco-brachialis muscle. The bicipital groove really forms the outer wall of the axilla when the arm hangs by the side.

Below the tuberosities is the surgical neck, so called because it is a rather common site of fracture.

The glenoid cavity, a depressed area upon the head of the scapula, is much less extensive in area than the articular surface presented by the humerus; it is shallow, longer from above downward than from before backward, and is connected with the body of the scapula by the neck.

The glenoid cavity presents a slightly raised margin, to which margin is attached the glenoid ligament, which serves to deepen the cavity.

Overhanging the shoulder-joint is the acromion process, the extreme outer end of the spine of the scapula; this process articulates with the outer end of the clavicle, and forms the prominent outer part of the shoulder-girdle and a protecting ledge over the shoulder-joint.

In front and internal to the shoulder-joint the coracoid process may even be felt, and in thin subjects seen; it projects forward from the upper border of the scapula, lying below the outer end of the clavicle, to the under surface of which it is connected by strong ligaments. Passing from the coracoid to the acromion process is a strong ligamentous band, the coraco-acromial ligament. This ligament passes over the head of the humerus, across the upper part of the shoulder-joint, deepening the cavity in which the head of the humerus plays and serving to add strength to the joint.

The shoulder-joint is provided with a capsular ligament, which is attached above to the neck of the scapula around the glenoid cavity, and below to the anatomical neck of the humerus. A separate fibrous band, called the coraco-humeral ligament, extends from the coracoid process down to the neck of the humerus, where it is attached in common with the capsular ligament, of which it is really a part.

The long tendon of the biceps is attached to the upper margin of the glenoid cavity; it passes across the upper surface of the head of the humerus, through the shoulder-joint, and emerges through the anterior part of the capsule, and then passes down the arm, being lodged in the bicipital groove. In its course through the shoulder-joint the long tendon of the biceps is entirely enveloped in a tubular process of the synovial membrane, and thus, although it passes through the shoulder-joint, the tendon is at the same time excluded from it.

Like a hood or cushion, the deltoid muscle covers and serves to protect the shoulder-joint; beneath the deltoid there is a bursa, which sometimes becomes diseased.

Below the acromion and beneath the deltoid muscle the head of the humerus may be readily recognized. It may be felt to rotate underneath the soft parts upon manipulation. It is responsible for the rounded contour of the shoulder; if the head of the humerus leaves the glenoid cavity, the shoulder presents a peculiar flattened appearance, which is very striking, and the sharp outer end of the acromion process becomes especially prominent and tends to direct attention to the fact that the head of the humerus has been dislocated.

Exarticulation at the Shoulder-joint (Spence).—The shoulder should overhang the edge of the table and the arm should be abducted a little from the side of the thorax and at the same time rotated somewhat outward, so that the great tuberosity is directed outward.

The incision is about six inches long, and commences above, at the clavicle, between the acromion and coracoid processes, and passes down the front of the arm as far as the point where the deltoid is attached to the humerus. This incision is deep, penetrating through the skin, fascia, and muscle down into the bicipital groove. With the long knife a circular incision is then made around the arm, on a level with the lower end of the longitudinal incision; this incision, upon the inner aspect of the arm, should pass through the integument and superficial fascia (subcutaneous fat) only, care being taken not to sever the brachial vessels; for the rest of the circumference of the arm, however, this circular incision penetrates through all the soft parts to the bone.

The outer edge of the wound is seized, and with a scalpel the soft parts are dissected away from the outer surface of the humerus, the arm being rotated inward by the assistant, to facilitate this step of the operation.

The capsular ligament being now exposed, the joint should be opened; this is done, not by passing the blade of the knife flatwise between the head of the humerus and the acromion process, but by cutting directly down upon the upper surface of the head of the humerus, from behind forward, as though one would cut into the head of the bone. During this step of the operation the assistant may help by rotating the arm first inward and then outward. In this way the

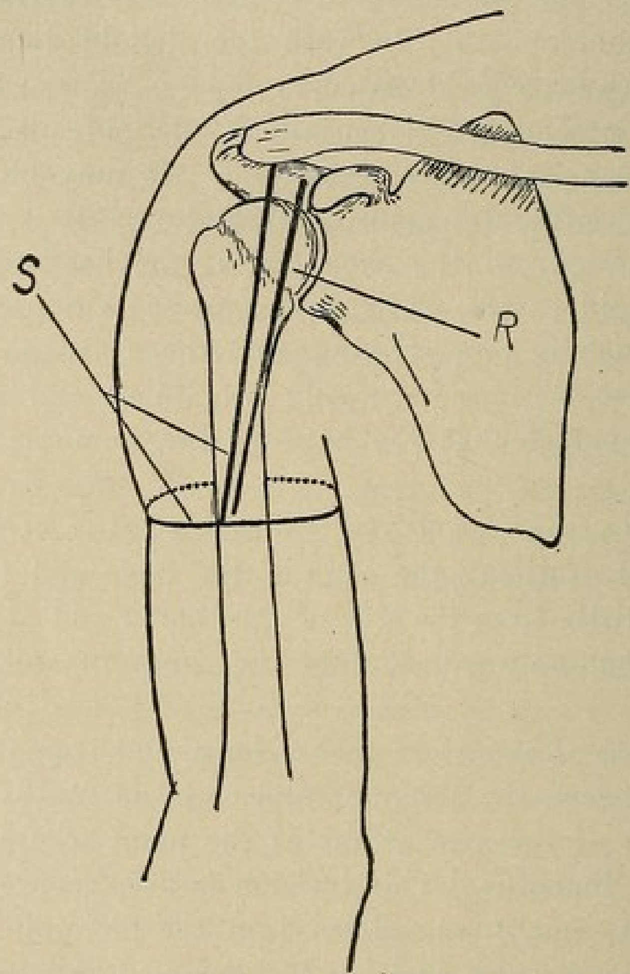

Fig. 328.—Right Shoulder, Anterior View. *R*, line of incision for resection of shoulder-joint; *S*, incision for exarticulation at the shoulder-joint (*Spence*).

joint is freely opened, the long tendon of the biceps being cut at the same time. The head of the bone is now turned out of its socket and drawn forcibly outward, away from the glenoid cavity; the long knife is introduced into the wound, behind the head of the humerus, and the soft parts, with the edge of the knife applied close to the surface of the bone, are separated from the inner aspect of the humerus to a point a little below the level of the circular incision, care being taken not to injure the brachial vessels, which run parallel with the inner surface of the humerus, and which have not, as yet, been divided.

Now, with a final stroke of the knife, the operation is completed by cutting through the soft parts upon the inner aspect of the arm down to the surface of the bone, thus severing the vessels and nerves. Just before this final cut which divides the vessels is made an assistant grasps the mass of soft parts which have been separated from the inner side of the humerus and which include the brachial vessels, and thus compresses them while they are being cut, and continues to hold them until the operator can secure the divided vessels with artery forceps, after which they are tied. Other vessels which spurt are clamped and tied as the operation progresses.

The edges of the skin may be brought together with interrupted catgut sutures, a drain emerging from the lower end of the wound and left in place for forty-eight to seventy-two hours; or the edges of the wound may be closed throughout and an opening made through the posterior part of the flap, near the glenoid cavity, and the wound thus drained. This latter plan is very satisfactory.

The above is a good method for exarticulation at the shoulder-joint, which may thus be accomplished with the loss of but little blood. Through the longitudinal incision, which is first made, the joint may be opened and freely explored and drained, or the joint may be excised; this is a great advantage, as we are often in doubt as to the necessity of exarticulation until after the joint has been opened and inspected.

Exarticulation at the Shoulder-joint with an Esmarch Bandage Applied.—The shoulder overhanging the side of the table and the arm somewhat abducted, an Esmarch bandage or rubber tube is applied tightly about the axilla, passing around the shoulder over the outer part of the clavicle. With a long knife a circular incision is then made through the integument and fat down to the deep fascia. This incision should be placed just above the insertion of the deltoid muscle. The integument, which retracts at once, is drawn toward the shoulder by an assistant, and the muscles, vessels, etc., divided by a second circular sweep of the long knife down to the bone as high up as the retracted integument permits; the bone is then sawn through at this level. The brachial artery and accompanying veins are now clamped and tied; also the superior profunda, which is found upon the back side of the humerus in company with the musculo-spiral nerve.

After these vessels have been tied the Esmarch bandage is removed and any further spurting vessels ligated.

A second incision is now made from the acromion process down upon the front of the stump of the humerus and penetrating to the bone. The soft parts are then cut away from the outer surface of

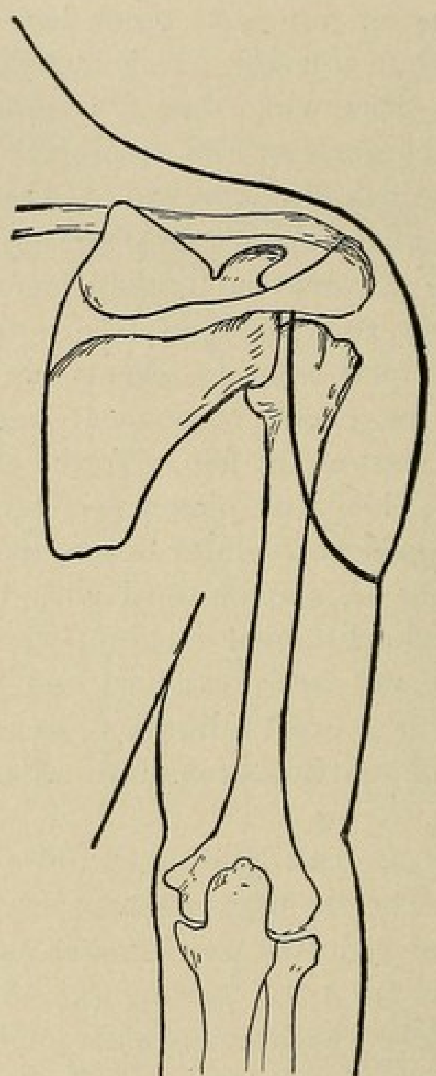

Fig. 329.—Right Shoulder, Posterior View. Outline of the lateral deltoid flap for exarticulation at the shoulder-joint.

the stump of the humerus, tying vessels as they are cut, and the joint opened by incising the capsule from behind forward, including the tendon of the biceps; the head of the bone is then turned out of its socket, and while it is drawn forcibly outward, away from the glenoid cavity, the soft parts upon its inner side are stripped away from the bone and the operation thus completed. But little blood is lost. The wound may be treated as in the preceding operation.

After the circular incision has been made through the soft parts, including the muscles, brachial vessels, etc., down to the bone, and while the tourniquet is still applied and without sawing through the bone, one may ligate the vessels and then, after removing the tourniquet, proceed to complete the operation by turning the head of the

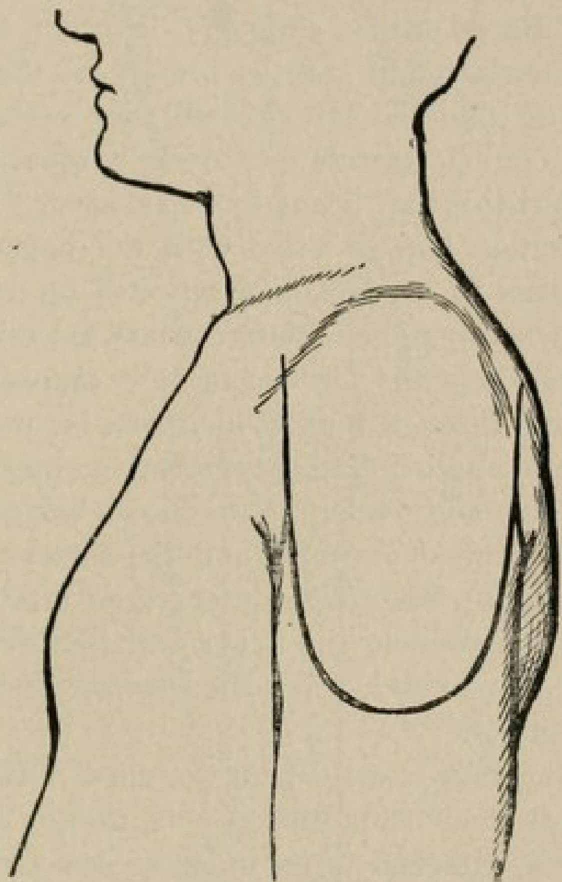

Fig. 330.—Left Shoulder, Side View. Outline of the lateral deltoid flap for exarticulation at the shoulder-joint.

bone out of its socket and stripping the soft parts away from the upper part of the bone through the longitudinal incision as described above. This would save sawing through the shaft of the humerus.

Exarticulation at the Shoulder-joint with the Formation of a Lateral Deltoid Flap.—The position of the patient is the same as in the previous operation, the shoulder overhanging the edge of the table. A large musculo-tegumentary flap, U-shaped and corresponding to the deltoid muscle, is taken from the outer aspect of the arm. The incision commences anteriorly, just external to the coracoid process, and passes down upon the front of the arm to a point a short distance above the insertion of the deltoid muscle, whence the incision is carried backward across the outer aspect of the arm and then upward as far as the spine of the scapula to a point just posterior to the acromion process; this incision reaches to the bone throughout its whole course. In dividing the muscles the knife should be directed rather obliquely, in order that the edge of the musculo-tegumentary flap may be beveled at the expense of the deeper structures so that the muscles will not protrude beyond the edges of the skin, which retracts considerably when it is cut. Care should be taken that this flap is not tongue-shaped.

This outer deltoid flap is seized with the fingers and dissected away from the surface of the bone and reflected up over the shoulder. The spurting branches of the circumflex artery are seized with forceps and tied. The capsule of the joint being now exposed, the joint may be opened by cutting through the capsule, from before backward, with the edge of the knife applied directly against the upper surface of the head of the bone, the long tendon of the biceps being cut at the same time. The arm is rotated outward, and the attachment of the subscapularis cut from the lesser trochanter; then rotating inward, the tendons which are attached to the upper and posterior border of the greater trochanter are divided, when the head of the bone drops away from the glenoid cavity.

The joint being thus widely open, the upper end of the humerus is dragged outward away from the glenoid cavity, and with a long knife the soft parts, attached to its inner aspect, are cut away from the bone, the edge of the knife being held close against the surface of the bone, in order to avoid injuring the brachial vessels, which run parallel with and close to the inner surface of the humerus. After the soft parts have been thus separated from the inner aspect of the humerus to a point about one inch below the anterior fold of the axilla, the edge of the knife is turned inward, and with a final stroke a short inner flap is cut, dividing the vessels at the same time. Just before this final cut, which divides the vessels, is made, an assistant grasps the mass of soft parts, which includes the brachial vessels, and compresses them until the operator can secure the ends of the severed artery and accompanying veins; these are then ligated and the nerves drawn down and cut short.

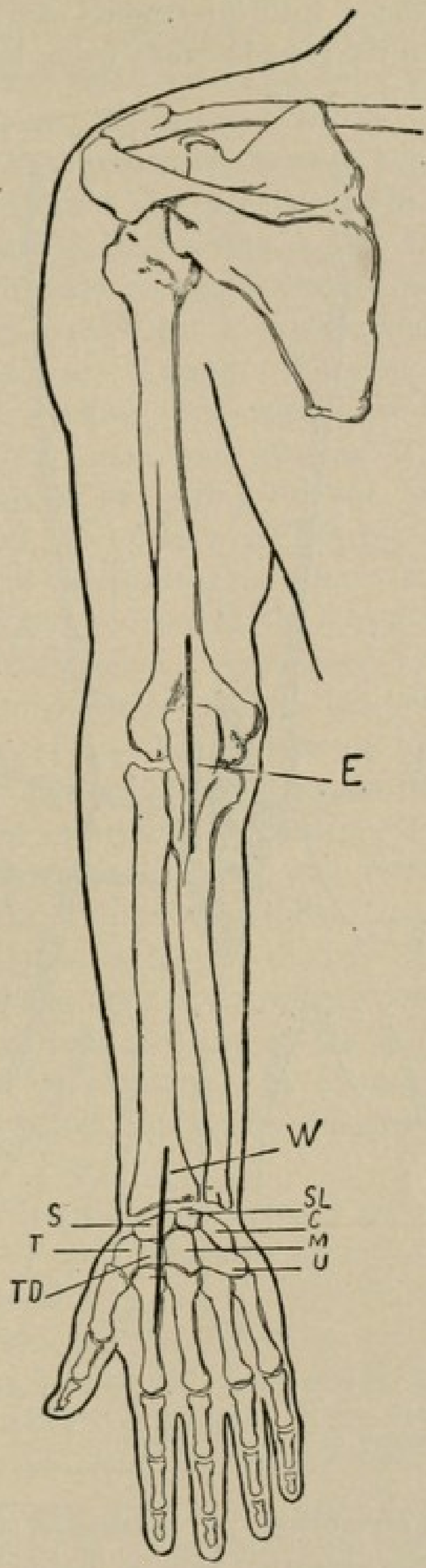

Fig. 331.—Left Arm, Posterior View. *E*, incision for resection of elbow-joint; *C*, cuneiform; *M*, os magnum; *S*, scaphoid; *SL*, semilunar; *T*, trapezium; *TD*, trapezoid; *U*, unciform; *W*, incision for resection of wrist-joint.

The wound is closed with interrupted catgut sutures, a drainage tube which reaches to the glenoid cavity being left protruding through the posterior part of the wound.

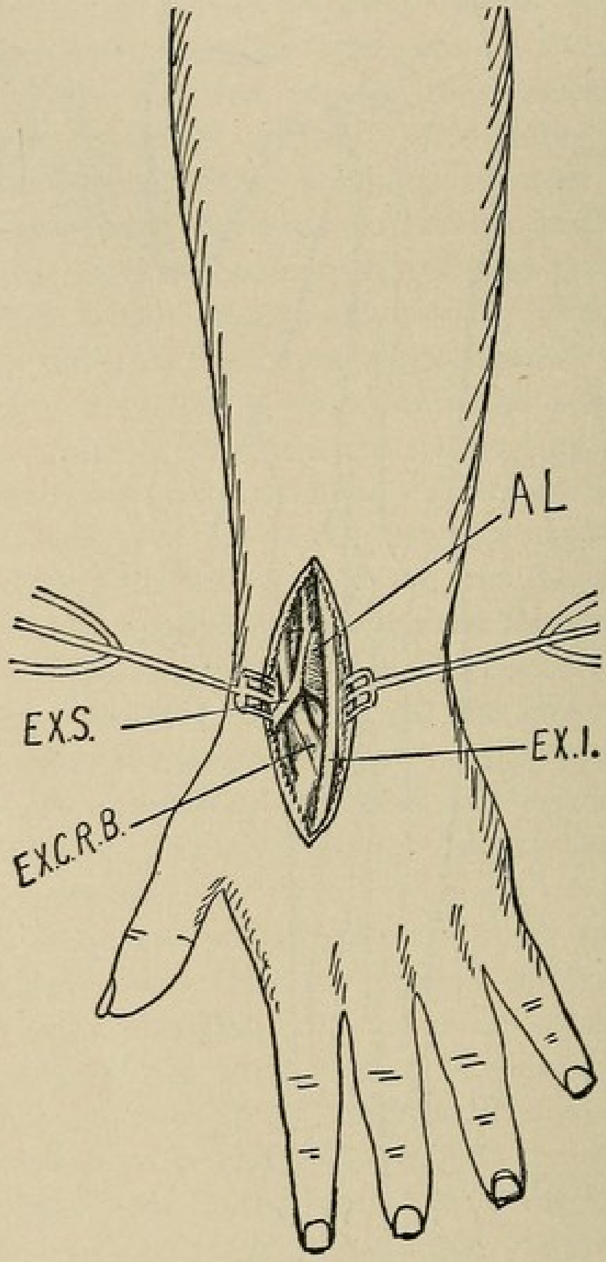

Fig. 332.—Resection of Wrist-joint. *AL*, annular ligament split to show the tendons of extensor secundi (*EX.S*) and extensor carpi radialis brevior (*EX.C.R.B.*); *EX.I.*, tendon of extensor indicis.

Resections. Wrist-joint.—A tourniquet is applied above the elbow, in order that the operation may be bloodless. A dorsal incision is made, commencing below, at the middle of the ulnar border of the metacarpal bone of the index finger, and this is continued upward, over the middle of the posterior surface of the radius, to a point one inch above the level of the wrist-joint. This incision passes through the skin and fat and runs parallel with the outer border of the extensor tendon of the index finger, the extensor indicis.

This incision is then gradually deepened step by step, and in its lower part one should avoid opening the sheath of the extensor indicis; in the upper part of the incision, nearer to the wrist-joint, the tendon of the extensor carpi radialis brevior, which is attached to the base of the third metacarpal (that of middle finger), and the tendon of the extensor secundi are exposed. We keep to the inner, ulnar, side of these tendons, drawing them toward the outer, radial, side of the wound with a blunt hook, and thus avoid cutting them. The wrist-joint is then entered by cutting through its posterior ligament, between the tendons of the extensor indicis and the extensor secundi. With blunt retractors the tendons of the extensor indicis and extensor communis are drawn toward the ulnar border of the hand, and the tendons of the extensor secundi and extensor carpi radialis brevior toward the radial border. Above the joint the incision penetrates to the surface of the radius between the bunch of tendons (extensor communis digitorum and extensor indicis), to the ulnar side, and the extensor secundi, to the radial side. The edges of the wound, including the tendons, being well retracted, an elevator is introduced and all the soft parts separated from the bones, working as close as possible to the surface of the bone. It may be necessary to partially separate the attachment of the tendon of the extensor carpi radialis brevior from the base of the third metacarpal. This is accomplished with the elevator or by chipping away a thin sliver of the bone with a chisel; the tendon should not be divided with the knife.

After the carpal bones have been freely exposed the wrist is flexed and the first row is removed, commencing with the scaphoid, then the semilunar,—which adjoins it,—and finally the cuneiform. The pisiform, which articulates with the anterior surface of the cuneiform and to which the tendon of the flexor carpi ulnaris is attached, is allowed to remain unless it is diseased.

With the wrist still flexed, thus giving better access to the carpus, the second row of carpal bones is now excised, commencing with the os magnum, which is easily recognized by its prominent rounded head. This bone is seized with a small lion-tooth forceps, isolated, and removed. Then the trapezoid lying to the outer side of the os magnum and articulating with the metacarpal bone of the index finger; after this, the unciform is seized with the forceps and removed; the trapezium, which articulates with the metacarpal bone of the thumb, is allowed to remain, if its condition permits, as its removal interferes much with the function of the thumb.

It is not always necessary to remove all the bones of the carpus; when diseased, they may often be readily enucleated with a sharp spoon; at other times the ligamentous bands which join the bones to each other and to the bases of the metacarpal bones must be cut before they can be enucleated, and in doing this one should be careful that the point of the knife does not wound the structures in the palm of the hand. There may be some difficulty in removing the scaphoid. In excising this bone, and also the trapezium, one should remember that the radial artery lies in close proximity to their posterior surfaces. Although this vessel is usually separated from the bones when the soft parts are detached with the elevator, and is therefore not endangered, yet one should look out for the point of his knife.

The removal of the unciform is rather difficult, owing to the irregularity of its hook-like process and its muscular attachments. It may be seized with a toothed bone-forceps, and, by twisting it and at the same time cutting with the edge of the knife close to the bone, it may be removed.

If the ends of the radius and ulna are to be removed, the soft parts, including the tendons, are separated from the posterior surface of the bones with the periosteum elevator; the lateral ligaments are also detached from the bones, preferably with the periosteum elevator rather than with the knife, taking care to avoid the radial artery as it winds around the outer side of the wrist. The lower ends of the bones are then forced well out of the wound and the soft parts separated from their anterior surfaces, working close to the bone or subperiosteally, and finally the ends of the bones are sawn off. One should avoid the ulnar artery and nerve, anteriorly, toward the ulnar side. The tourniquet may now be removed.

There are usually no vessels to tie, none of importance being cut. The hand is placed upon a straight anterior splint and the wound partly closed by interrupted sutures and packed with iodoform gauze.

Elbow-joint (Langenbeck).—A tourniquet is placed about the upper part of the arm. The operation should be done subperiosteally

The arm, with the elbow flexed, is thrown across the patient's chest and steadied by an assistant; the operator usually stands on same side as the diseased joint, although at times it is convenient to change to the other side. An incision, about four inches long, is made upon the posterior aspect of the joint. This incision commences about two inches above the upper border of the olecranon process and is continued downward upon the posterior triangular surface of the olecranon and ulna, passing, not through the middle of this surface, but a little to the inner side of the middle line and ending on its inner border (see Fig. 331). This incision should be made with a heavy resection knife, and throughout its whole length should penetrate through all the soft parts, including the periosteum, down to the bone. The upper part of this incision splits the tendon of the triceps lengthwise right down to its attachment to the upper border of the olecranon, and passes through the posterior ligament of the joint to the surface of the humerus. The lower part of the incision, corresponding to the posterior surface of the olecranon, passes through the periosteum to the bone.

Sharp retractors are introduced into the upper part of the wound, and the attachment of the triceps tendon is chiseled away from the upper border, surface of the olecranon process on either side, taking a very thin shell of bone with it; this separation may also be accomplished with the knife, cutting close to the bone, but the subcortical separation with the chisel is preferable.

The periosteum elevator is now used to separate the soft parts, including the periosteum, from the posterior surface and sides of the olecranon process and the adjoining upper part of the ulna and lower end of the humerus, working first inward toward the inner condyle and keeping close to the bone, as this mass of soft parts includes the ulnar nerve, which is lodged in the groove between the inner condyle and the olecranon; if we work subperiosteally, or very close to the surface of the bone, the ulnar nerve is not seen and not endangered. To retract this mass of soft parts as it is detached from the bone, one should use a blunt-pronged retractor. The separation of the soft parts is continued inward and around the inner epicondyle. In separating the soft parts from the inner epicondyle one should use the chisel rather than the knife, since the tendon common to the superficial flexor muscles is attached here, and it would be disadvantageous to cut it. In a similar manner the soft parts, including the periosteum, are detached from the outer side of the olecranon, continuing outward until the external epicondyle is denuded. To the external epicondyle is attached the tendon common to the superficial extensors, and therefore one should avoid using the knife here.

The separation of the soft parts can be accomplished almost entirely with the elevator, if necessary using considerable force with the sharp edge of the elevator applied directly upon the bare surface of the bone; but it may be necessary here and there to help one's self with the chisel and occasional snips with the knife. Upon the posterior surface of the olecranon the knife may be used a little more freely, as here the periosteum is thick and fibrous, being reinforced by the triceps tendon, and is almost impossible to separate with the elevator.

After having denuded the whole of the olecranon process and the contiguous portions of the humerus, ulna, and radius out beyond the epicondyles, the elbow is flexed and the lower end of the humerus forced out of the wound, cutting away any remaining restricting bands. The soft parts about the anterior aspect of the lower end of the humerus are then quickly separated with the elevator and the articular end of the bone sawn off. The section should be made through a plane parallel with the articular surface. Then, in a like manner, the upper end of the radius and ulna are stripped of soft parts and sawn off. The diseased synovial membrane may now be completely excised with toothed forceps and blunt-pointed, curved scissors. One should avoid injuring the structures in front of the joint, brachial artery, etc., with the point of the knife. After the resection has been completed the tourniquet may be removed. As a rule, there are no vessels to tie. The incision is closed, except for a part of its length, which is left open for drainage, and the arm put up in a position of almost complete extension in a splint or plaster of Paris with a big wad of dressings.

After two weeks the arm may be gradually or at once flexed to nearly a right angle, which is the best position for ankylosis. Occasionally we get some motion.

Shoulder-joint (Subperiosteal Method of Ollier and Hueter).—The arm lies at the side, slightly abducted and rotated outward, so that the greater tuberosity looks outward. An incision is made which commences above, to the outer side of the coracoid process, and passes downward, upon the front of the arm, for a distance of five inches; this incision, throughout its whole length, is carried deep to the bone (see Fig. 328). When the edges of the wound are held apart with blunt-pronged retractors, the long tendon of the biceps, as it lies in the bicipital groove between the two tuberosities, is exposed. This tendon emerges from within the joint beneath the lower border of the capsule.

This incision above, to the outer side of the coracoid process, should extend as high as the clavicle, in order to allow easy access to the capsule and to the head of the humerus.

A director is now introduced alongside of the long biceps tendon, beneath the lower border of the capsule, and well up into the joint, and upon this the capsule is divided as far upward as the upper border of the glenoid cavity; in this way the capsule is split longitudinally throughout its entire length (the coraco-humeral ligament, which is a part of the capsule, is also divided in this cut) and the joint is thus freely opened upon its anterior aspect.

The tendon of the biceps is now lifted out of its groove and drawn outward with a blunt hook, and the periosteum incised in the upper part of the floor of the bicipital groove, between the two tuberosities; an elevator, with a sharp edge, is then introduced into the incision in the periosteum, and this, together with the attachment of the capsule, is separated from the inner side of the neck of the bone. The tendon of the subscapularis is very intimately attached to the lesser tuberosity, and in order to separate this it may be necessary to use the knife to some extent, cutting close upon the surface of the bone, or, what is preferable, one may, with the chisel, chip off a thin layer of the cortex, carrying the attached tendon with it.

In separating the capsule from its attachment around the neck of the bone it will be necessary, here and there, to use the knife, cutting with its edge applied close to the surface of the bone.

After the parts on the inner aspect of the bone have been thus separated, and while the arm is rotated inward and the long tendon of the biceps hooked over toward the inner side, the periosteum, together with the attachment of the capsule, is separated from the outer side of the bone; this is accomplished chiefly with the periosteum elevator, with occasional snips with the knife. The tendons attached to the upper and posterior borders of the greater tuberosity are intimately united with the bone, and, if they cannot be separated with the periosteum elevator, one may use the chisel, as on the inner side, removing a thin shell of the cortex along with the tendon attachments. During this part of the operation the arm is rotated more and more inward.

After the upper end of the bone has been thoroughly isolated we find it lying in a sac, formed above by the detached capsule, which is continuous below with the periosteum and tendons that have been separated from the bone.

The head of the bone is now thrown out of this sac and out of the incision, and may be sawn off with the flat saw, protecting the neighboring soft parts, or the chain or Gigli saw may be used, or it may be knocked off with a broad chisel.

After the head of the bone has been removed, the interior of the joint becomes accessible, and one may dissect away all the synovial membrane lining the joint with toothed forceps and strong, blunt-pointed scissors, curved on the flat.

The glenoid surface of the scapula, if diseased, may be thoroughly curetted with the sharp spoon, or chiseled or gouged out with the rongeur bone-forceps. Usually no vessels of importance are cut; any spurting points may be caught and tied as the operation progresses.

The cavity of the joint should be freely drained through the lower part of the incision, using a good-sized tube. An additional opening may be made posteriorly to provide still better drainage. This opening is made by pushing an artery forceps through the mass of deltoid muscle from within and then incising the skin with the knife upon this. We avoid making the opening through the deltoid with the knife in order not to wound the circumflex nerve and vessels. The opening through the muscle may be made as large as desired by spreading the blades of the forceps. In closing the incision interrupted silkworm-gut sutures, which pass through all the structures, including the edges of the split capsule, should be employed.

If it is intended to remove the head of the bone only, it is not necessary to separate the periosteum for more than a short distance upon the shaft. Usually separation of the capsule around the anatomical neck and the tendons partially from the greater and lesser tuberosities will give sufficient room to permit of the excision of the head of the bone. Only when the head of the bone is to be excised below the trochanters is it necessary to separate the periosteum and tendons for a greater distance below the antomical neck.

The operation as described above differs from Langenbeck's only as regards the incision. The incision of Langenbeck commences above at the acromion process, and is therefore more external; passing through the body of the deltoid, it divides the circumflex nerve, and is therefore likely to be followed by impairment of the function of the deltoid.

Tendon Suture.—Tendons may be found divided as a complication of a wound, or they may be accidentally cut by the surgeon during the course of an operation about a joint; one or several may be severed. The proximal portion of the tendon, that which is joined to the muscle, may be separated a considerable distance from the distal portion, owing to the contraction of the muscle, and at times considerable search may be necessary to secure it, or it may be necessary to lay the sheath of the tendon open for this purpose.

The ends should be approximated and joined by a catgut suture, one passing through the tendon proper being probably the most satisfactory. If the flexor tendons are divided, in order to coapt the ends and retain them in position with the minimum degree of tension, the joint must be placed in a position of flexion, and the reverse when the extensor tendons are severed. Asepsis is a necessary condition to healing; if the parts are infected, an effort should be made to render them sterile, and under these circumstances drainage in addition is probably advisable (see page 35).

Nerve Suture.—A nerve-trunk may be severed, either accidentally by the surgeon during the course of an operation or the condition may be encountered as a complication of an accidental wound.

The ends should be approximated and united with one or more plain catgut sutures, which may be passed through the body of the nerve proper. The union may be effected immediately after the occurrence of the accident or after the lapse of considerable time. If immediate, it is simply necessary to coapt the ends and retain them in position with one or two sutures; if after the lapse of a considerable period, it will be necessary to search for the ends of the divided nerve, and, after they are found, freshen them, before uniting them, end to end, by suture. Plain catgut is preferable for the suture material.

PART X.

THE LOWER EXTREMITY.

THE THIGH.

THE muscles and other structures of the thigh are enveloped by the skin and the superficial fascia, which is areolar in structure and includes the subcutaneous fat. These layers are loose, and movable upon the deeper parts. Beneath the fat (superficial fascia) there is a strong, tense, fibrous envelope, thicker in some parts than in others,—the proper, or deep, fascia,—which, in the region of the thigh, is called the fascia lata. This layer is attached above to Poupart's ligament, the crest of the pubis, sacrum, and rami of the pubis, and below—about the knee-joint, to all the prominent bony points; it confines the muscles and furnishes septa, which pass in between the different groups of muscles to be attached to the ridges on the femur. Beneath the skin, in the fatty layer, ramify the various subcutaneous veins and nerves, and in the region of the groin the subcutaneous arterial branches that are derived from the femoral.

The Gluteal Region.—The gluteal region corresponds to the upper back part of the thigh, and presents the prominence of the buttock. This is more developed in some persons than in others, especially in females, and is due chiefly to the cushion of fat beneath the skin.

After the skin and fat have been reflected, the deep fascia, fascia lata, is exposed. This fascia is rather thin in this region, and through it the fasciculi of the gluteus maximus muscle may be recognized. The fascia lata is attached above to the crest of the ilium; below it is continuous with the same layer of fascia upon the back of the thigh; internally it is attached to the sacrum and coccyx.

The gluteus maximus is a broad, thick muscle; it arises from the upper, posterior portion of the external surface of the ilium, from the side of the sacrum and coccyx, from the lumbo-sacral aponeurosis, and from the great sacro-sciatic ligament. In coarse bundles its fibers pass downward and outward; the upper fibers become tendons, and pass across the great trochanter and are inserted into the fascia lata upon the outer aspect of the thigh; the lower fibers are attached to the femur along the line which passes from the great trochanter downward to the linea aspera.

The muscle should be cut through at right angles to the course of its fibers and reflected, when the bursæ beneath it, one corresponding to the trochanter major and the other to the tuber ischii, may be examined and the parts which lie beneath the muscle exposed to view. Above and in front is the posterior portion of the gluteus medius, and below this, but upon the same plane, the pyriformis; these two muscles are separated from each other by a cellular interval, through which the gluteal vessels and nerves are seen to emerge from within the pelvis. Below the pyriformis, but still upon the same plane, are the two gemelli and the tendon of the obturator internus. Still lower is found the quadratus femoris, which is really the upper part of the adductor magnus muscle. These muscles are all attached to the femur at or near the great trochanter. Passing downward from the tuberosity of the ischium are the semimembranosus and the semitendinosus and biceps muscles.

The space which exists in the skeleton between the lateral border of the sacrum and coccyx and the margin of the ischium is converted into two foramina, the greater and lesser sacro-sciatic foramina, by the greater and lesser sacro-sciatic ligaments. The greater sacro-sciatic ligament is attached by its broad base to the margin of the sacrum and coccyx and by its other end to the tuberosity of the ischium; the posterior surface of the great sacro-sciatic ligament gives attachment to some fibers of the gluteus maximus muscle. The lesser sacro-sciatic ligament is attached to the margin of the sacrum and coccyx and to the spine of the ischium; the lesser is situated upon a plane anterior to the greater.

Through the greater sacro-sciatic foramen emerge the pyriformis muscle; the gluteal vessels and nerve which appear above the pyriformis, between it and the gluteus medius; the sciatic artery and great sciatic nerve, which appear below the pyriformis, and the internal pudic vessels and nerve. The internal pudic vessels and nerve, after emerging from the pelvis through the great sacro-sciatic foramen, curve around the lesser sacro-sciatic ligament, close to the ischium, and pass forward into the deep part of the perineum.

STRETCHING THE SCIATIC NERVE.—The patient lies upon the abdomen with a sandbag under the lower part of the trunk. An incision three inches long is made upon the back of the thigh, the upper end of the incision corresponding to the middle of a line drawn from the tuberosity of the ischium to a point a hand's breadth below the great trochanter; this incision passes through the skin and fat down to the deep fascia; the lower edge of the gluteus maximus is now recognized, and at this point the deep fascia, fascia lata, is incised; through the opening thus made in the deep fascia two fingers are introduced and passed under the edge of the gluteus

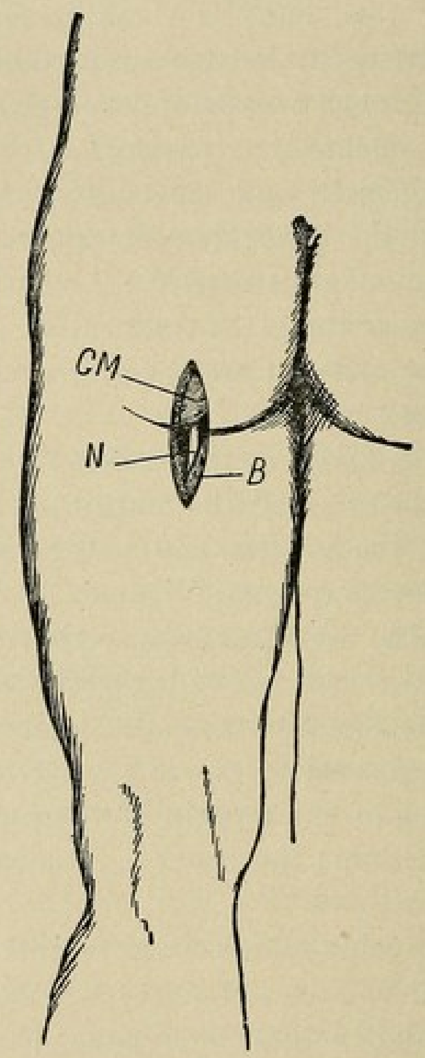

Fig. 333.—Stretching Sciatic Nerve. *B*, tendon of biceps; *GM*, lower edge of gluteus maximus; *N*, sciatic nerve.

maximus, and the sciatic nerve hooked up and drawn out of the wound. Three or four fingers being now passed under the nerve, it may be stretched to the desired degree, pulling with a gradually increasing force up to one hundred pounds; this may be repeated once or twice; in order to regulate the force one may use a scale and hook. No vessels are met with, and it will but rarely be necessary to apply any ligatures; the wound in the skin is closed without drainage.

The Anterior Femoral Region.—Upon the anterior part of the thigh just below the inner end of Poupart's ligament is the saphenous opening; this is a slit-like opening in the deep fascia, fascia lata, through which the internal saphenous vein passes to join the femoral. Its outer margin presents a prominent, curved, overhanging edge, the falciform process. The femoral vessels are situated beneath the iliac portion of the fascia lata, external and adjacent to this falciform margin, resting upon the pectineus and ilio-psoas muscles (see Femoral Region, Hernia).

This falciform process, or margin, is continuous above with Poupart's ligament, and may be traced farther inward into Gimbernat's ligament; below it curves inward and upward beneath the saphenous vein, and is here continuous with that portion of the fascia lata, pubic portion, which covers the surface of the pectineus muscle, being continued upward upon the surface of this muscle and under Poupart's ligament as far as the pectineal line, where it is attached (see Figs. 265 and 271). In the upper part of the thigh, behind the femoral vessels, this fascia that covers the pectineus muscle is continuous with that which covers the ilio-psoas muscle, the fascia iliaca.

The saphenous opening is partly closed by a wad of fascia, which is adherent around the margin of the opening and which is called the fascia cribrosa. The fascia cribrosa is pierced by the internal saphenous vein, which passes through the saphenous opening and joins the femoral vein on its inner side.

The Internal Saphenous Vein lies beneath the fatty layer of the skin; it commences upon the dorsum of the foot, and passes upward in front of the internal malleolus, along the inner side of the leg, and across the knee-joint behind the internal condyle, immediately above which it often presents a pouch-like dilatation; it is continued upward upon the inner, front aspect of the thigh, and just below Poupart's ligament passes through the saphenous opening to join the femoral. It receives many branches all along its course. That part of the vein and its tributaries which correspond to the leg and to the neighborhood of the knee-joint are apt to become very tortuous, dilated, and pouched, exhibiting the common conditions known as "varicose veins." Just before it enters the saphenous opening the vein receives many branches from the front and inner side of the thigh, all radiating toward the saphenous opening, and here also it receives the veins which correspond to the subcutaneous branches of the femoral artery. The saphenous vein is accompanied by a chain of lymphatics which terminate in nodes located about the saphenous opening, and these may become enlarged and tender when infectious processes are present below in the integument of the leg or thigh.

Those lymphatics which are situated along Poupart's ligament in the groin are usually enlarged when the external genitals are the seat of disease.

In this anterior femoral region also, lying beneath the skin, are found the superficial branches from the femoral artery. The superficial epigastric passes through the saphenous opening and upward across Poupart's ligament to ramify upon the lower abdomen. The superficial external pudic passes through the saphenous opening and inward to supply the skin, etc., of the external genitals. The superficial circumflex iliac passes upward and outward, piercing the deep fascia external to the saphenous opening and runs parallel with and below Poupart's ligament, supplying the skin and glands in this region.

These vessels are usually cut in making the incision for hernia and in extirpating diseased glands in this region.

THE FEMORAL ARTERY. *Scarpa's Triangle.*—Upon removing the integument and deep fascia from the upper anterior part of the thigh we expose a triangular space, Scarpa's triangle. This triangle corresponds to the upper third of the thigh; its base, which is above, is formed by Poupart's ligament; its outer border by the sartorius muscle, and its inner border by the adductor longus. The apex of the triangle is below where these muscles meet. The floor of the triangle is formed, from within outward, by the adductor longus, the pectineus, and the ilio-psoas.

Passing downward through this space, from the middle of its base—*i.e.,* midway between the anterior superior spine of the ilium and the spine of the pubic bone—to its apex, is the femoral artery accompanied by the femoral vein. The femoral artery is the continuation downward into the thigh of the external iliac, and emerges from the abdomen underneath Poupart's ligament at the point already described. Toward the lower part of Scarpa's triangle the femoral artery is overlapped by the inner edge of the sartorius muscle.

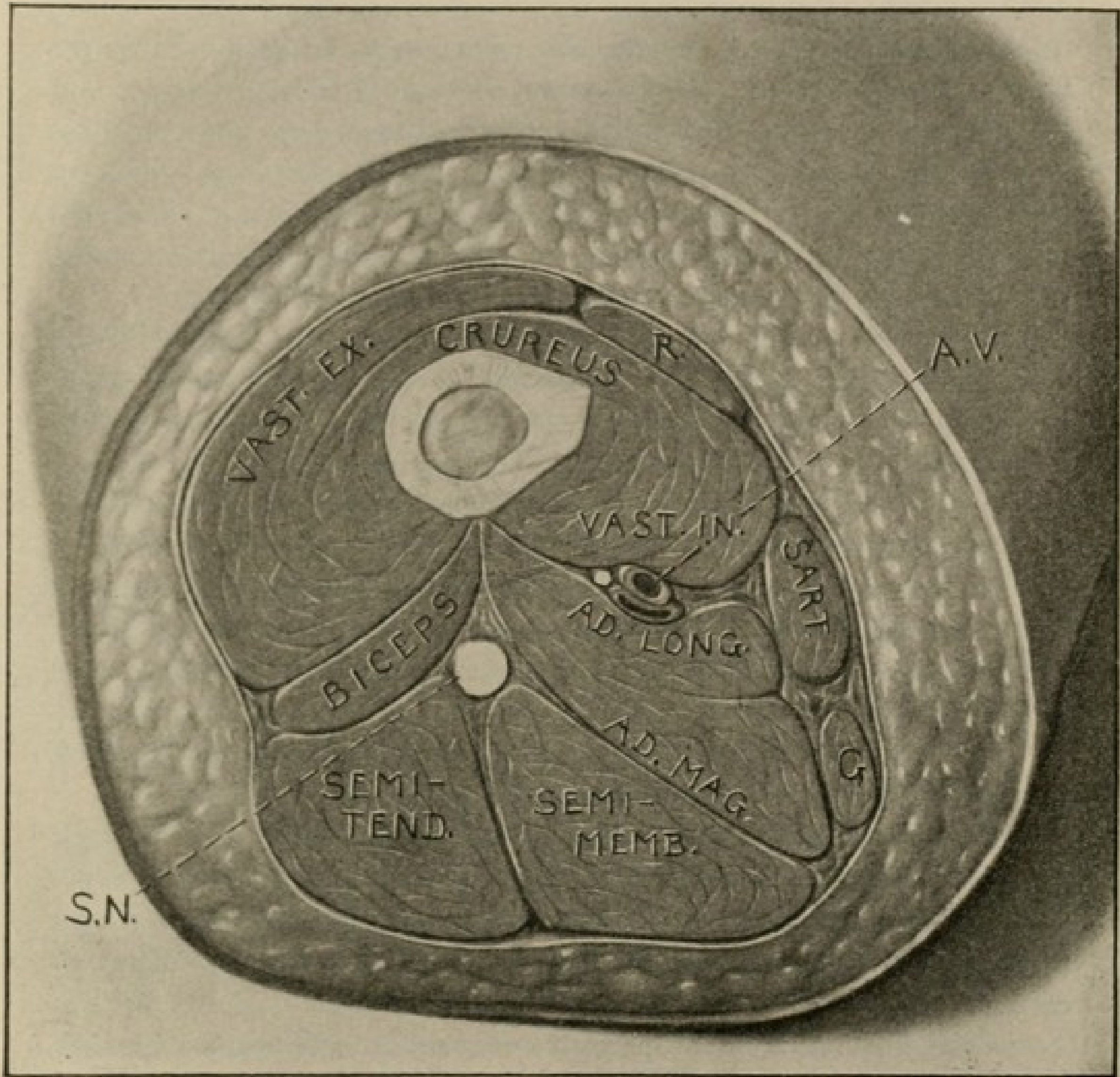

Fig. 334.—Section through the Middle of the Right Thigh. *A.V.*, femoral artery and vein; *G.*, gracilis muscle; *R.*, rectus muscle; *S.N.*, sciatic nerve.

After traversing Scarpa's triangle the femoral vessels are continued downward along the inner side of the thigh, lying beneath the sartorius muscle, quite close to the femur and inclosed within Hunter's canal.

Hunter's Canal is a musculo-fibrous space corresponding to the middle third of the thigh, lying close to the inner side of the femur; its outer wall is formed by the vastus internus, which separates the vessels from the bone; its inner wall by the adductor longus, and in the lower part of the thigh by the adductor magnus; the space between the muscles is roofed over by a fibrous sheet, which is derived from the deep fascia. Hunter's canal ends below, above the internal condyle, at the foramen in the adductor magnus muscle, through which the femoral vessels pass into the popliteal space.

About two inches below Poupart's ligament the femoral artery gives off a large branch, the profunda femoris. This vessel arises from the outer and posterior aspect of the femoral artery; at its origin it curves slightly outward and then passes behind the femoral artery and vein, and dips into the floor of Scarpa's triangle, passing through the space between the adductor longus and the pectineus; it then descends in the thigh, resting upon the adductor magnus along the inner side of the femur and giving off branches which perforate the adductor magnus to anastomose with branches upon the back of that muscle.

The femoral artery gives off other small branches in Scarpa's triangle, but they are of little surgical importance.

As the femoral artery emerges from underneath Poupart's ligament it is accompanied by the femoral vein, which lies to its inner side. During the course of the artery through Scarpa's triangle the vein gradually gets to lie behind the artery, and in Hunter's canal it is located behind and a little to its outer side.

As the femoral vessels pass out through the femoral space, beneath Poupart's ligament, they are inclosed in a connective-tissue sheath, which is continuous with the subperitoneal connective tissue of the abdomen and which is closely adherent all around the margin of the femoral space: above to Poupart's ligament, below to the fascia which covers the ilio-psoas and pectineus muscles, and internally to the margin of Gimbernat's ligament. This femoral sheath is divided into three distinct compartments by fibrous septa; the outer compartment contains the artery, the middle one the vein; the inner compartment contains a small amount of connective tissue and fat, and through it the lymphatics from the thigh pass into the abdomen. This inner compartment is continued but a short distance downward upon the inner side of the femoral vein; it corresponds to the space between the femoral vein and the outer edge of Gimbernat's ligament, and forms the crural canal, into which the gut descends in femoral hernia.

As the vessels emerge from the abdomen under Poupart's ligament they are contained within their sheath, which is, in turn, partially covered anteriorly by that portion of the fascia lata which lies external to the falciform edge of the saphenous opening; underneath Poupart's ligament the vessels within their sheath rest upon the ilio-psoas and pectineus muscles.

The ilio-psoas muscle is covered over by a layer of fascia, the iliac, which is continuous internally with the fascia that covers the pectineus muscle (the pubic portion of the fascia lata). This layer of fascia, which covers the ilio-psoas muscle, is simply the continuation downward, under Poupart's ligament into the thigh, of the fascia iliaca, which covers these muscles within the abdomen.

The Anterior Crural Nerve.—At Poupart's ligament, lying to the outer side of the femoral artery and imbedded in the substance of the ilio-psoas muscle, is the anterior crural nerve. This nerve is separated from the femoral artery by the iliac fascia, which invests the ilio-psoas muscle and is not seen in the thigh until this layer of fascia has been incised.

Below Poupart's ligament the anterior crural nerve divides into cutaneous and muscular branches. The internal or long saphenous nerve, the largest of the cutaneous branches, approaches the femoral artery as it lies in Scarpa's triangle, and accompanies it down along the inner side of the thigh, through Hunter's canal. At the lower end of the canal, where the femoral vessels pass through the adductor foramen into the popliteal space and just above the internal condyle, the nerve becomes more superficial, lying beneath the sartorius; below the knee-joint it becomes subcutaneous, and runs down the inner side of the leg in company with the internal saphenous vein, and supplies the skin of the leg.

Ligation of the Femoral Artery. *The Common Femoral.*—The common femoral is sometimes ligated as a preliminary to exarticulation of the thigh at the hip-joint. The vessel is ligated immediately below Poupart's ligament, above the origin of the profunda femoris branch, where it is quite superficial.

An incision about two inches long is made, commencing above, at the middle of Poupart's ligament; *i.e.*, at a point midway between the anterior superior iliac spine and the spine of the pubes. This

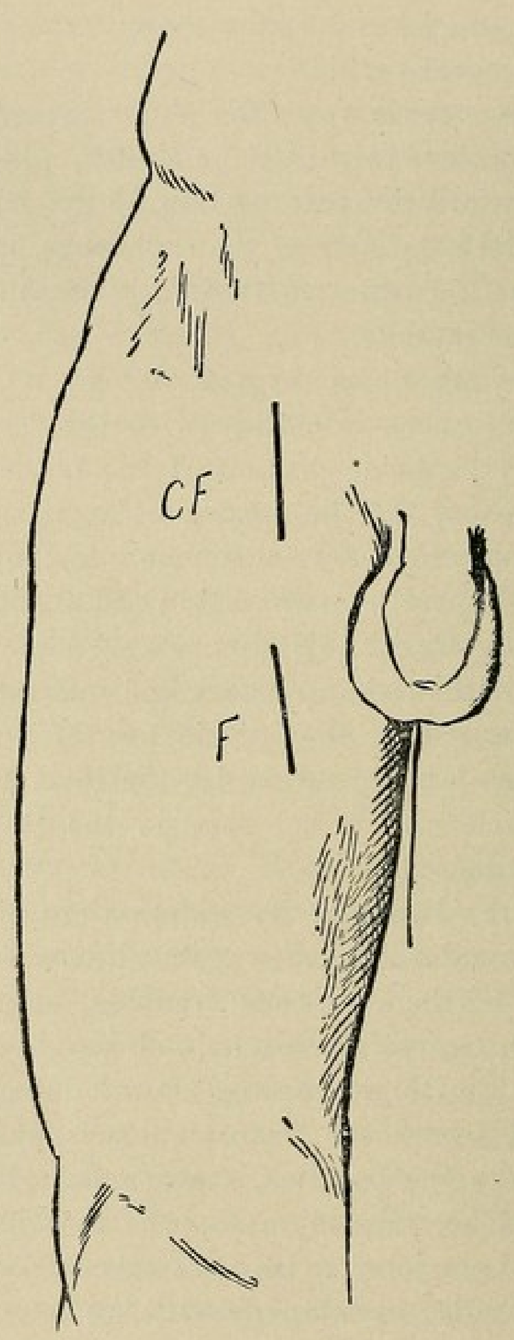

Fig. 335.—Ligation of Femoral Artery. *CF*, incision for ligation of common femoral; *F*, incision for ligation of femoral in Scarpa's triangle.

incision passes through the skin and fat down to the deep fascia, the fascia lata. The pulsation of the artery may be readily felt with the finger in the wound.

The deep fascia is incised and the artery exposed by stripping away its connective-tissue sheath. An aneurism needle, carrying a catgut ligature, is passed around the vessel from within outward,—*i.e.*, between the vein and artery,—and then withdrawn, thus leaving the artery surrounded by the ligature, which is tied. The femoral vein, which lies to the inner side of the artery, can be tied at the same time, through the same incision. The wound is closed with several interrupted sutures. This procedure makes the exarticulation at the hip-joint practically a bloodless operation.

The Femoral in Scarpa's Triangle.—The femoral artery is occasionally ligated for aneurism involving its lower portion or its continuation, the popliteal.

For this purpose the ligature is usually applied in the lower part of Scarpa's triangle, about five inches below Poupart's ligament, and therefore below the origin of its profunda femoris branch. The course of the artery is indicated by a line drawn from a point above, midway between the anterior superior spine of the ilium and the spine of the pubes, to the internal condyle below. The muscular guide to the artery, in this part of its course, is the inner border of the sartorius muscle, which slightly overlaps the vessel.

The patient is placed upon the back, with the leg rotated slightly outward. The incision is made about three inches long, corresponding to the inner border of the sartorius muscle; it commences above, about four inches below Poupart's ligament. This incision passes through the skin and subcutaneous fat and through the sheath of the sartorius, exposing the inner edge of this muscle; the muscle is readily recognized by the oblique course of its fibers. In this incision some tributaries of the long saphenous vein are cut and clamped. Having fully recognized the edge of the sartorius muscle, this is drawn outward, and the vessel may then be located by its pulsation beneath the deep fascia; this layer of deep fascia is incised along the course of the artery and the vessel thus exposed. In this situation the vein is found lying behind the artery and still slightly to its inner side; the long saphenous nerve lies a short distance to the outer side of the artery. We may see the internal cutaneous nerve passing obliquely inward across the sheath of the artery.

The loose connective tissue, which forms the sheath of the artery, is now picked up with a thumb forceps and nicked with the point of the knife, and through the opening thus made a director is introduced between the artery and the vein, working around the artery, close to its wall, from within outward. After the artery has been thus isolated a catgut ligature is carried around it, also from within outward, in an aneurism needle. Before tying the ligature one should again investigate to make certain that the artery alone is included, and then tie a single square knot. The incision is closed with several catgut sutures.

The Popliteal Space.—The femoral artery and vein, having passed through the opening in the lower part of the adductor magnus muscle, enter the popliteal space, and are known here as the popliteal artery and vein.

The popliteal space is lozenge-shaped and situated behind the knee. It is bounded above and externally by the biceps; above and internally by the semimembranosus, semitendinosus, gracilis, and sartorius, the tendons of these muscles being known as the outer and inner hamstrings, respectively. Below and externally the space is bounded by the outer head of the gastrocnemius, and below and internally by the inner head of the same muscle. The floor of the space is formed, from above downward, by the posterior surface of the lower end of the femur, the posterior ligament of the knee-joint, and the popliteus muscle.

Passing from the upper angle, through the space, to the lower angle, where it becomes the posterior tibial, is the internal popliteal nerve. In the upper part of the space, emerging from beneath the biceps muscle, is the external popliteal nerve; this nerve passes downward and outward along the inner edge of the biceps tendon.

The popliteal artery, with its accompanying vein, enters the popliteal space above, emerging from beneath the semimembranosus, near the upper angle of the space; therefore in the upper part of the space the artery lies to the inner side of the internal popliteal nerve; about the middle of the space, however, the artery passes underneath the nerve; and in the lower part of the space it is found to the outer side of the nerve.

The popliteal artery lies close to the floor of the popliteal space, separated from the posterior ligament of the knee-joint by a little connective tissue; the vein is placed superficial to the artery and rather to its outer side; the internal popliteal nerve lies superficial to the vessels, crossing them from above downward. The popliteal artery gives off several branches, but they are of but little surgical importance.

The popliteal space is covered by the skin and superficial fascia (fat) and by the deep fascia, which is stretched between the hamstring tendons. When the popliteal artery reaches the lower part of the popliteal space it divides into two branches, the anterior and posterior tibial.

It is seldom or never necessary to tie the popliteal; for popliteal aneurism the ligation of the femoral is preferred.

THE LEG.

The Anterior Tibial Artery.—Just below the lower border of the popliteus muscle the anterior tibial artery passes forward, through an opening in the interosseous membrane between the tibia and the fibula, to the front of the leg; it then passes downward, lying upon the front surface of the interosseous membrane, accompanied by two venæ comites, one on either side. In the upper third of the leg the vessel lies between the tibialis anticus on its inner side and the extensor longus pollicis on its outer side. Upon the front of the ankle the artery lies beneath the anterior annular ligament, having the tendon of the extensor longus pollicis on its inner side and the tendons of the extensor longus digitorum on its outer side. Upon the front of the ankle the tendon of the tibialis anticus lies to the inner side of the tendon of the extensor longus pollicis, and the perineus tertius lies to the outer side of the tendons of the extensor longus digitorum. After the anterior tibial artery emerges from beneath the lower border of the anterior annular ligament, it is continued downward as the dorsalis pedis, lying in the first interosseous space, and giving off a branch which passes outward across the tarsus, and, lower down, one which passes outward across the heads of the metatarsal bones. This latter branch, which is known as the metatarsal, gives off three descending branches, which pass downward upon the second, third, and fourth interosseous muscles as far as the webs of the toes, where they each divide into two lateral branches, which are distributed to the contiguous halves of the adjoining toes. These interosseous branches are for the supply of the adjoining sides of the fifth and fourth, fourth and third, and third and second toes. The dorsalis pedis itself descends upon the first interosseous muscle, this part of the artery—*i.e.*, between the first and second metatarsal bones—being called the dorsalis hallucis; it divides to supply the contiguous sides of the first (big toe) and second toes, supplying also the inner side of the big toe.

The first dorsal interosseous muscle is perforated above by a large branch of the dorsalis pedis, which passes through to the deep part of the sole of the foot, to anastomose with the external branch of the posterior tibial to form the plantar arch.

The Anterior Tibial Nerve, which is derived from the external popliteal, reaches the anterior tibial artery at the junction of the upper and middle thirds of the leg, and then accompanies it throughout the rest of its course. The nerve reaches the anterior tibial artery, as this vessel lies upon the interosseous membrane, by curving around the upper part of the fibula beneath the extensor longus digitorum. Corresponding to the middle third of the leg, the nerve lies upon the front of the artery, but in the lower part of the leg it lies to the outer side of the artery, and beneath the anterior annular ligament divides into an internal and an external branch.

LIGATION OF THE ANTERIOR TIBIAL ARTERY.—The patient lies upon the back, with the knee somewhat flexed and a sandbag placed beneath it. The linear guide to the artery corresponds to a line drawn from the inner side of the head of the fibula to a point below, midway between the internal and external malleoli.

The vessel may be tied in the middle third of the leg, as it lies upon the anterior surface of the interosseous membrane between the tibialis anticus on its inner side and the extensor proprius pollicis on its outer side.

An incision, about two fingers' breadth external to the prominent edge of the shin bone and two or three inches long, is made through the skin and fat down to the deep fascia. The deep fascia is then incised, and working down, between the tibialis anticus on the inner side and the extensor proprius pollicis on the outer side, with the handle of the scalpel, the interosseous membrane is reached. The foot is then somewhat flexed at the ankle—dorsal flexion—to relax the muscles, and retractors are introduced deep into the wound, and the artery, with its venæ comites lying upon it, is exposed. The anterior tibial nerve lies in front of the anterior tibial vessels in this part of their course. After the nerve has been separated from the artery a ligature is carried around the vessel from without inward and tied.

The Posterior Tibial Artery.—This vessel passes down the back of the leg, and below, between the internal malleolus and the tuberosity of the os calcis, it divides into the internal and external plantar. The posterior tibial is larger than the anterior, and at its origin lies deep beneath the muscles of the calf,—gastrocnemius and soleus,—

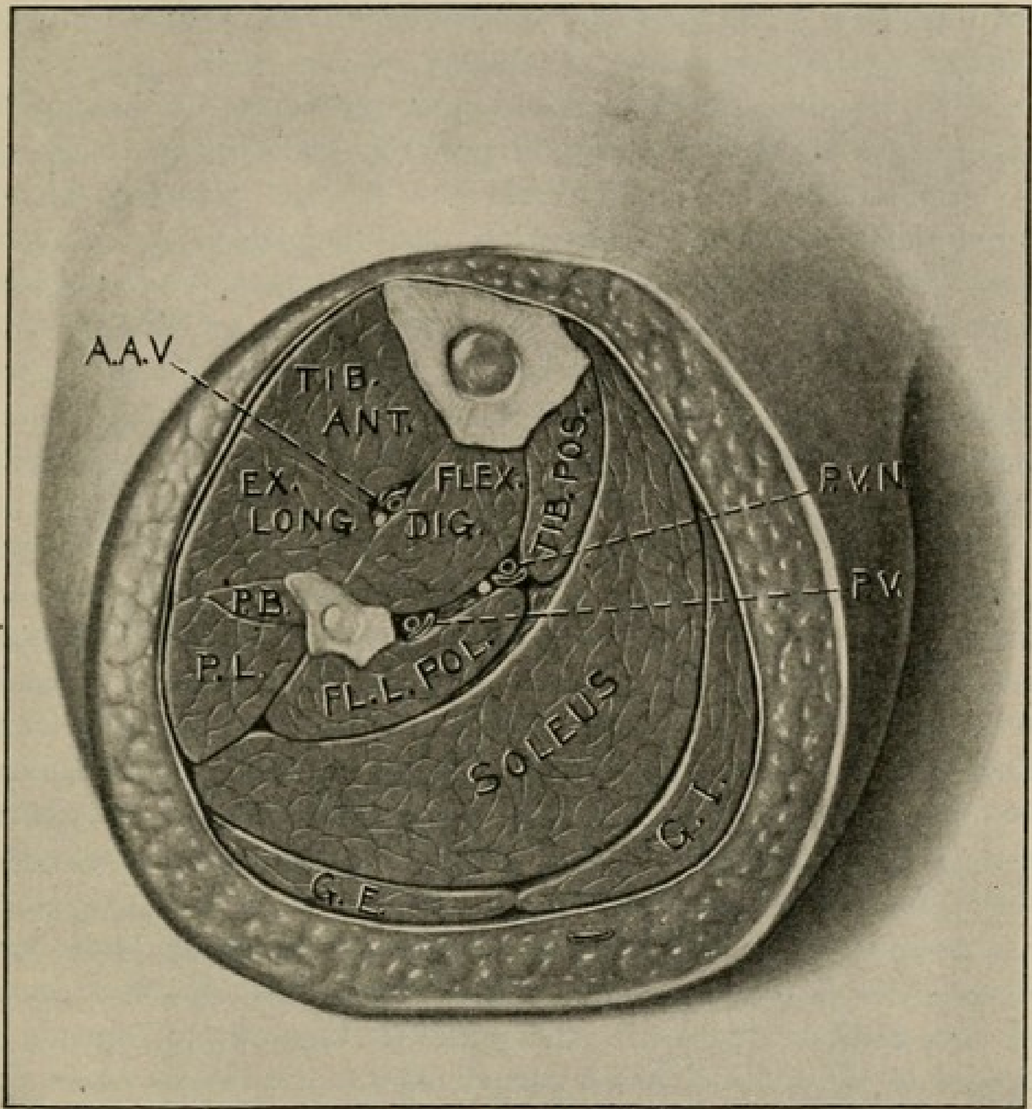

Fig. 336.—Section through the Middle of the Right Leg. *A.A.V.*, anterior tibial artery and vein; *G.E.*, gastrocnemius externus; *G.I.*, gastrocnemius internus; *P.B.*, peroneus brevis; *P.L.*, peroneus longus; *P.V.*, peroneal artery and vein; *P.V.N.*, posterior tibial artery and nerve.

resting upon the tibialis posticus; from its origin, as it descends, it gradually approaches the tibial side of the leg.

In the lower third of the leg the artery is more superficial, running parallel with the inner border of the tendo Achillis and being covered only by the deep fascia and the integument. The posterior tibial artery is accompanied by two large venæ comites, one on either side of it.

Between the os calcis and the inner malleolus, and beneath the origin of the adductor pollicis, the posterior tibial artery divides into its terminal branches, the internal and external plantar. The internal plantar, the smaller, runs along the inner side of the sole of the foot. The external plantar passes outward, beneath the flexor brevis digitorum, lying upon the flexor accessorius as far as the base of the fifth metatarsal bone; it then turns and runs inward to the interval between the bases of the first and second metatarsal bones, where it anastomoses with the large perforating branch from the dorsalis pedis, and thus forms the plantar arch.

From the plantar arch four digital branches descend in the corresponding interosseous spaces as far as the webs of the toes, where they divide for the supply of the adjacent sides of the toes. The contiguous sides of the big toe and second toe and the inner side of the big toe are supplied by the continuation of the perforating branch of the dorsalis pedis, which divides, at the cleft between the big and second toes, into two branches. One passes inward to supply the inner border of the great toe and the other bifurcates to supply the contiguous sides of the great and second toes.

As the posterior tibial artery descends in the middle of the space between the os calcis and the internal malleolus, the venæ comites lie one on each side of it; the posterior tibial nerve, already divided into the internal and external plantar, lies to its outer side; still more externally, close to the os calcis, is the tendon of the flexor longus pollicis, and to the inner side of the artery, lodged in the groove upon the posterior border of the internal malleolus, are the tendons of the tibialis posticus and flexor longus digitorum; of these two, the tibialis posticus being the more internal and the closer to the bone.

Just below its origin the posterior tibial artery gives off a large branch, the peroneal; this branch descends along the fibular side of the back of the leg, covered by the soleus and gastrocnemius and lying upon and partly covered by the flexor longus pollicis.

The Posterior Tibial Nerve accompanies the posterior tibial artery; it is the continuation of the internal popliteal, and is a large nerve. At its commencement the nerve lies to the inner side of the artery, but, a short distance from its origin the artery passing obliquely inward toward the tibial side of the leg and the course of the nerve being straight, the nerve thereby gets to lie to the outer side of the artery. The posterior tibial nerve continues down the back of the leg upon the outer side of the artery, and divides, in the space between the os calcis and the internal malleolus, into the internal and external plantar.

LIGATION OF THE POSTERIOR TIBIAL.—This vessel may be exposed and tied just above the ankle-joint and to the inner side of the tendo Achillis. An incision is made about two inches long midway between the posterior border of the inner malleolus and the inner border of the tendo Achillis. This incision reaches through the integument and fat down to the deep fascia. The deep fascia is then incised and the posterior tibial artery exposed; it is found quite superficial, together with its venæ comites, one on either side. To the outer side of the vessels, nearer the tendo Achillis, is the posterior tibial nerve. The veins are separated from the artery, and a ligature then carried around the artery in an aneurism needle, from within outward in order to avoid the nerve, and tied.

Tenotomy.—This operation is done with a narrow-bladed knife through a very small incision in the skin.

TENDO ACHILLIS.—The foot is strongly flexed so as to put the tendon upon the stretch, and a narrow tenotomy knife entered close to the inner border of the tendon and about one and one-half inches above its attachment to the os calcis; the knife is entered upon the flat and pushed through the soft parts in front of the tendon as far as its outer border; the blade of the knife is then turned so that its cutting edge is directed toward the tendon, and with several strokes the tendon is divided. The division of the tendon is really accomplished by strongly flexing the foot and thus making the tendon very tense upon the sharp edge of the knife.

There is no danger of wounding the posterior tibial vessels and nerve if the blade of the knife is introduced close to the inner border of the tendon (see Posterior Tibial Artery, etc.).

TENDONS OF THE TIBIALIS POSTICUS AND FLEXOR LONGUS DIGITORUM.—These tendons are divided as they descend in the groove upon the posterior border of the internal malleolus.

The inner edge of this groove, which marks the posterior border of the internal malleolus, should be recognized and the tenotomy knife introduced upon the flat, so that it enters in front of the tendons, between the tendons and the floor of the groove upon the posterior border of the internal malleolus. The knife is then turned so that its cutting edge is directed toward the tendons, and by forcibly flexing (dorsal flexion) the foot and everting it, thus making the tendons tense, their division is accomplished (see Posterior Tibial Artery, etc.).

OPERATIONS FOR VARICOSE VEINS.

Varicose Veins usually involve the veins upon the inner and back side of the leg and the inner-anterior aspect of the thigh, along the course of the internal saphenous. The veins become increased in length, tortuous, irregularly dilated and pouched, the walls very much thickened in some places and very thin in others. The affected veins, especially over bony surfaces, are liable to injury or may rupture spontaneously with severe hemorrhage. Ulcers may develop and the skin may be eczematous, and the veins may become inflamed and thrombosed.

The superficial veins of the leg may be considered as consisting of two groups. The branches of one or both of these groups may be affected in varicose veins of the leg. The veins of the outer and posterior sides of the leg join to form the external or short saphenous vein, and the veins upon the inner and anterior surfaces of the leg are tributary to the internal saphenous. In the leg the main trunks of the external saphenous and internal saphenous veins are accompanied by the external and internal saphenous nerves, and these should be avoided in applying ligatures to the veins.

The Internal or Long Saphenous Vein drains the inner and anterior aspects of the leg. It ascends upon the inner side of the knee, lying just posterior to the internal condyle, and continues upward in the thigh to join the femoral vein in the upper part of Scarpa's triangle. In the leg the main trunk of the vein is accompanied by the internal or long saphenous nerve.

The External or Short Saphenous Vein drains the outer and back sides of the leg. It commences by the union of a number of venous branches upon the outer side of the foot, passes upward behind the external malleolus, ascends along the outer border of the tendo Achillis, and continues up the back of the leg as far as the popliteal space, where it pierces the deep fascia to terminate in the popliteal vein. The vein is accompanied by the external saphenous nerve.

Trendelenburg Operation.—This operation consists in ligation and excision of a portion of the internal saphenous vein in the upper part of the thigh. According to Trendelenburg the varicosities are due to the fact that the valves in the internal saphenous have become incompetent and the weight of the entire column of venous blood from the vena cava is placed upon the terminal veins, which thus become stretched, elongated, tortuous and varicosed. This condition may be demonstrated by elevating the lower limb with the patient lying down so as to empty the limb as nearly completely as possible of venous blood. While the limb is held in the elevated position a bandage is applied around the lower part of the thigh, just tight enough to obstruct the venous flow. The patient is then directed to stand up, and if the saphenous vein, above the bandage, becomes distended with blood, the vein filling from above due to the blood dropping back into the vein without any resistance being offered upon the part of the valves, it shows that these are incompetent, that they offer no support to the column of blood, and that the Trendelenburg operation is indicated.

An incision about four inches long is made in the upper part of the thigh and corresponding to the course of the internal saphenous vein. The vein is exposed in the incision, its branches ligated double with plain catgut. Each branch is divided between the ligatures. The vein is ligated in the upper part of the incision and in the lower part and the intervening portion, three or four inches, resected.

Schede's Operaton.—No tourniquet is necessary. It is of advantage to commence the operation by exposing and tying the veins that go to make up the internal saphenous just above the knee-joint. For this purpose a transverse incision is made upon the inner side of the thigh, about four inches above the knee-joint. This incision is three or four inches long. It penetrates into the subcutaneous fat layer down to the deep fascia and exposes the several large subcutaneous venous branches that represent the internal saphenous vein. They may be very much dilated and sacculated. These several branches are tied double with plain catgut and divided between the ligatures. The incision is closed with several sutures and a wet bichloride towel placed over it temporarily, until the rest of the operation has been completed.

In order to expose the varicosed subcutaneous branches in the leg a circular incision is made which penetrates into the subcutaneous fat layer down to the deep fascia. This incision is made all around the leg, about on a level with the bulging part of the calf—five or six inches below the knee-joint. The incision is carried all around the leg, but not all at once. The incision is made around the leg,

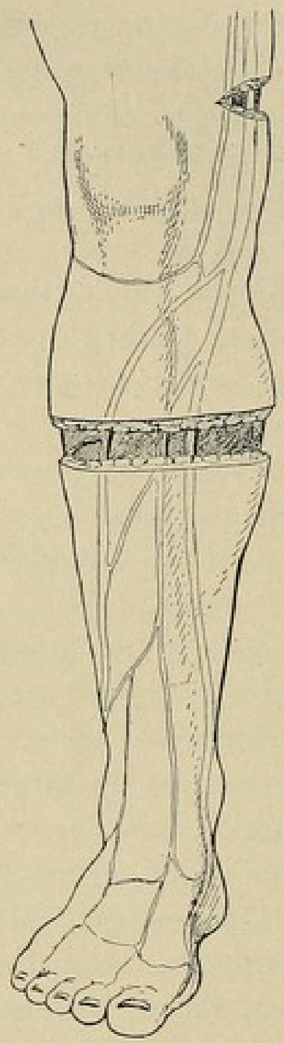

Fig. 337.—Operation for Varicose Veins, where the internal saphenous and its tributaries are affected. Incision above knee through which the internal saphenous is exposed and ligated. Circular incision around the leg to expose and ligate all the affected veins.

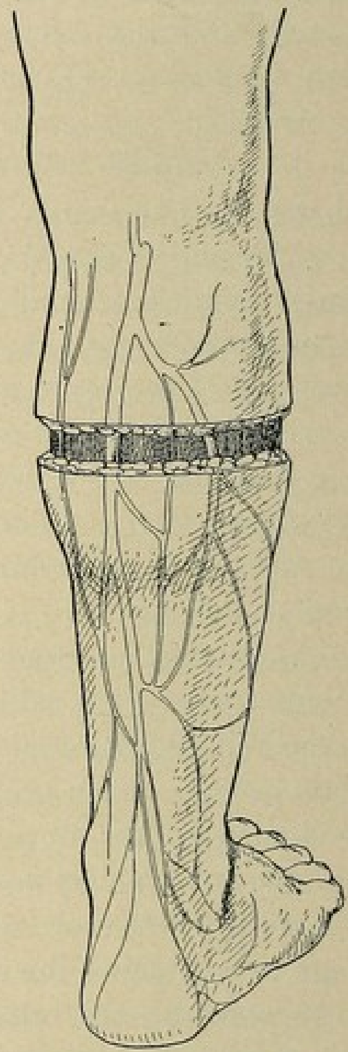

Fig. 338.—Operation for Varicose Veins. Incision exposes the external saphenous and its tributaries.

little by little, exposing and ligating the veins as they are met with. The incision is first made only part way around the leg and the vessels which are exposed in this part of the incision are tied double and cut. The incision is then carried farther around the leg and again the veins that are exposed are tied double and cut between the ligatures. Proceeding in this way much loss of blood is avoided. The larger veins may usually be seen, clamped double, and ligated before they are cut. Some of the smaller veins will not be recognized until they have been cut. They are caught with clamps and ligated. The incision penetrates down to the deep fascia throughout its entire extent, thus making certain that no veins have been overlooked. It will not be necessary, in some cases, to carry the incision entirely around the leg, only around that part which corresponds to the location of the varicose veins.

The edges of the skin are brought together with interrupted sutures of silk-worm gut.

Madelung's Operation.—This operation consists in stripping and excising the individual varicosed veins. This plan is especially adapted to those cases where the varicosities are fairly definitely limited to several larger individual veins. Above in the thigh, or in the leg, corresponding to the course of the internal saphenous or to the vein or veins that are to be excised, a longitudinal incision which exposes the enlarged varicosed vein is made. The vein is picked up, tied double, and divided between the ligatures. The lower end of the vein is drawn through the ring of a blunt dissector, which is made for the purpose, and the vein then separated with the dissector as far as it can be reached. As the venous trunk is separated and drawn out of the incision its tributaries are clamped and tied and cut as they are met with. Having proceeded as far as possible along the course of the vein through the first incision, a second is made by incising the skin over the ring of the dissector, which is presented under the skin, and the length of vein which has already been isolated is drawn out through this second incision. The vein may then be followed farther along its course, making still a third incision farther down the leg if necessary. One or several veins may be treated in this manner, according to the number of enlarged venous trunks that are present. The first incision is usually placed about the middle of the thigh, and is two to three inches long.

If the varicose veins are limited to the leg a transverse incision may be made which extends part way around the upper part of the leg so as to expose the several varicosed veins. The veins are tied double and divided, and may then be followed down the leg with the ring dissector in a manner similar to that described above.

Varicose Ulcer.—The ulcer associated with varicose veins may be treated very satisfactorily by surgical operation. After the veins leading up from the ulcer have been ligated and divided according to the plans described above, the base of the ulcer is excised and the surface covered with skin-grafts. In some cases it is advantageous to make an incision a short distance below the ulcer and ligate and divide the veins that lead from below, up to the ulcer.

AMPUTATIONS, RESECTIONS, ETC.

Surgical Anatomy of the Skeleton of the Foot.—A knowledge of the composition and articulations of the skeleton of the foot is of

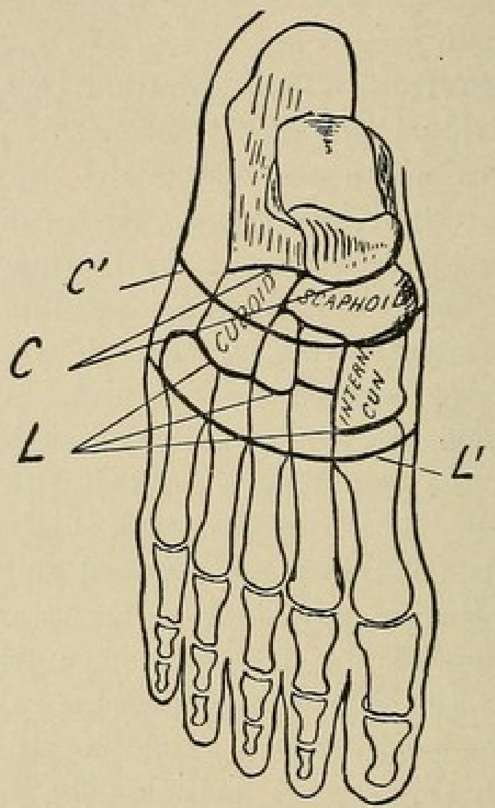

Fig. 339.—Right Foot. *C*, Chopart articulation; *C'*, incision for Chopart amputation; *L*, Lisfranc articulation; *L'*, incision for Lisfranc amputation.

much practical value in performing the various amputations upon this part.

The tarsus is made up of two rows—or, better, two groups—of irregular-shaped bones. The first row consists of the os calcis and astragalus, the os calcis occupying the outer side of the foot and forming the heel, the astragalus being on the inner side of the foot, partially resting upon the os calcis and entering into the formation of the ankle-joint. The anterior, articular surfaces of these bones are on about the same plane, and form an uninterrupted line from the outer to the inner side of the foot. The anterior, articular surface of the astragalus is convex, and is located above and to the inner side of that of the os calcis, which is rather concave.

The second group consists of the cuboid, which is on the outer side of the foot, articulating with the os calcis; the scaphoid, which is on the inner side of the foot, articulating behind with the astragalus; and the three cuneiforms. This second group presents anteriorly an irregular row of articular surfaces which is convex toward the toes, its outer end being about one inch nearer the ankle-joint than its inner end.

We next come to the metatarsal bones, five in number, which articulate as follows: The two outer, those of the little toe and the fourth, with the cuboid; the third, middle one, with the external cuneiform; the second with the middle cuneiform; and the first, that of the big toe, with the internal cuneiform. The base of the fifth metatarsal bone presents a prominent tuberosity, which projects outward and is easily felt underneath the skin; this is an important surgical guide. The second metatarsal bone is characterized by its base projecting backward, into the tarsus, beyond the bases of the adjoining metatarsal bones; so that the tarso-metatarsal articular line is interrupted at this point.

We therefore have an articular junction between the os calcis and astragalus behind and the cuboid and scaphoid in front, which we might call the Chopart joint. Through this we do the Chopart amputation. The inner end of the scaphoid presents a prominent tuberosity, which is readily felt beneath the skin just below and in front of the tip of the inner malleolus; this tubercle is the guide to the inner end of the Chopart joint, the outer end of the joint being located one thumb's breadth behind the tuberosity which marks the base of the fifth metatarsal bone.

The articular line between the tarsus behind and the metatarsus in front might be called the Lisfranc junction. This line is curved, with its convexity forward toward the toes. The outer end of the junction corresponds to the base of the metatarsal bone of the little toe, which presents a prominent tuberosity that may be readily felt and which is the guide to the joint. The inner end of the Lisfranc junction is lower than the outer, being about one inch nearer the toes, and may be located two fingers' breadth in front of the tuberosity of the scaphoid.

The line of the Lisfranc articulation is interrupted by the projection of the base of the second metatarsal bone rather less than one-fourth inch farther into the tarsus than the third metatarsal, and again by the fact that the articulation between the first metatarsal (big toe) and the internal cuneiform is about half an inch lower, nearer the toe, than that between the second metatarsal and the middle cuneiform.

Exarticulation of the Big Toe. *Oval Method.*—The toe is seized with the left hand and a dorsal incision made upon the head (lower extremity) of the metatarsal bone, commencing about one-half inch above the metatarso-phalangeal joint; this incision is carried straight down to a point about one-half inch beyond the web of the toe and then around the toe, cutting everything to the bone.

One should remember that the head of the metatarsal bone of the big toe is large and requires a considerable flap to cover it. The corners of the flap are seized first on one side and then on the other, and the flap dissected away from the bone. Flexing the toe, the joint is opened upon its dorsal aspect, the lateral ligaments being divided, while the toe is pulled first to one side and then to the other, and finally the remaining attached soft parts are separated, cutting close to the bone and from within outward. Spurting vessels are clamped and tied and the wound closed with four or five interrupted catgut sutures. A small drain may be left *in situ* for two days. Amputation of the other toes is done in a manner analogous to the above.

Exarticulation of the Big Toe, with Removal of the First Metatarsal Bone.—An incision is made which begins just above the tarso-metatarsal joint, articulation of the metatarsal with the internal cuneiform, which is located about one finger's breadth below the tuberosity of the scaphoid, and this is carried down, upon the dorsal surface of the foot, to the web of the toe, at which point it is carried, in the form of an oval, around the toe (see Fig. 355). This incision, throughout its whole extent, reaches to the bone. The edges of the incision are drawn apart with retractors, and the soft parts separated from the metatarsal bone, after which the joint above, between the metatarsal and internal cuneiform bones, is opened and the metatarsal enucleated out of its bed of soft parts, cutting with the edge of the knife close to the surface of the bone.

The tendons of the big toe are cut short above at the level of the tarso-metatarsal joint. It is unnecessary to use a tourniquet in this amputation. Spurting vessels are caught and tied, and after the bleeding has been checked the wound is closed with several interrupted catgut sutures. The incision may be placed upon the side of the foot instead of upon the dorsum; this is better for drainage, but the scar is not so well located.

Exarticulation of the Little Toe.—Amputation of the little toe and its metatarsal bone may be done in a manner similar to the preceding.

For Bunion (Hallux Valgus).—This condition consists in a prominent angulation at the metatarso-phalangeal joint of the first (big) toe due to the displacement outward, toward the middle line

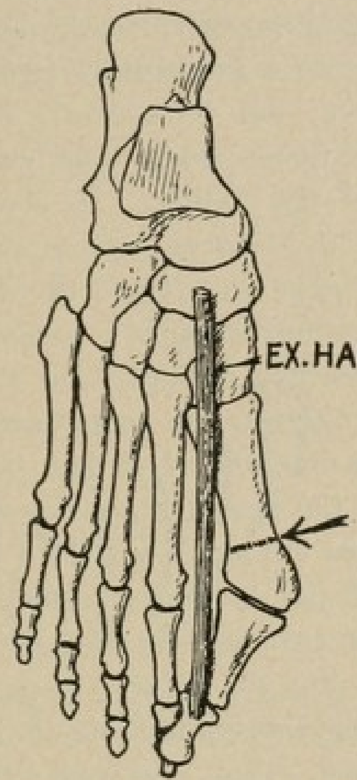

Fig. 340.—Osteotomy for Bunion. *EX.HAL.*, tendon of the extensor proprius hallucis. Arrow indicates line of division of metatarsal of big toe.

of the foot, of the big toe. The inner portion of the head of the first metatarsal bone and the corresponding portion of the articular surface of the first phalanx gradually become hypertrophied, with the result that the corresponding articular surfaces of the two bones assume a plane which is oblique to the long axes of the bones, and thus the altered position of the toe becomes permanent. A bursa is gradually developed over the prominent angle. This bursa is peculiarly subject to bruising, pressure, attacks of acute inflammation, etc., and may be the source of much pain and discomfort. Osteotomy of the distal end of the metatarsal bone, or resection of the head of the bone, may be necessary to correct the condition.

Osteotomy of the First Metatarsal Bone.—The metatarsal bone of the big toe is divided at a point just posterior to its anterior extremity (head). A longitudinal incision is made upon the inner side of the foot. The incision is about one inch long and is placed just posterior to the location of the metatarsophalangeal joint, so as to expose the anterior end of the first metatarsal bone. The incision is placed nearer the dorsal than the plantar surface of the foot (this position is better for the scar that results) and penetrates through all the soft parts down to the bone. The osteotome, chisel, is introduced in the incision down to the bone. The chisel is turned so that its edge occupies a position at right angles to the long axis of the metatarsal bone, and rests firmly upon the bone about one-half inch behind its articular end. The bone is divided at this point with several blows of the mallet. In some cases it will be more satisfactory to resect a wedge-shaped piece of the bone instead of making the simple linear osteotomy described above. The toe is then restored to its natural straight position. The incision is closed without drainage, dressings applied, and the foot placed in plaster of Paris. It may be necessary in some cases to divide the tendon of the extensor proprius hallucis if it has become relatively so short that it interferes with the proper reposition of the toe.

According to Mayo bunion is corrected by excising the bursa and resecting the head of the metatarsal bone. The raw end of the metatarsal bone is then covered over by turning a piece of the synovial lining of the bunion into the joint. A portion of the bursa is left for this purpose. In this way ankylosis of the joint is prevented.

FOR HAMMER-TOE.—This condition can be corrected as a rule by subcutaneous division of the flexor tendons of the affected toe and by forcibly extending the toe. After the tendons have been divided and the toe straightened it will usually be found that the skin on the under, flexor, side of the toe is so tense that it will be necessary to incise it. A V-shaped incision with the point of the V upward, toward the web of the toe is made. Under these circumstances we have an open wound which heals by granulation.

This condition may also be corrected by resecting the articular end of one of the phalanges of the affected joint. The articulation can be reached through an incision upon its dorsal aspect. The joint is opened and one end of either one or the other phalanx resected. It will be necessary in these cases, also, to divide the flexor tendons of the affected toe.

For Ingrowing Toe-nail. *Removal of the Offending Half of the Nail.*—This operation is done under local cocain anæsthesia. A rubber band is tied tight around the root of the toe for the purpose of confining the cocain to this part and in order to control the hemorrhage. The end of a sharp-pointed scissors is pushed under the nail and down the middle, as far as the root, and with this the nail is split. The half of the nail which is to be removed is then grasped with an artery forceps and torn away from the matrix.

Cotting Operation.—Cocain anæsthesia. A rubber band is tied around the root of the toe. The soft parts, corresponding to the affected side of the toe, are transfixed with a long, narrow-bladed knife

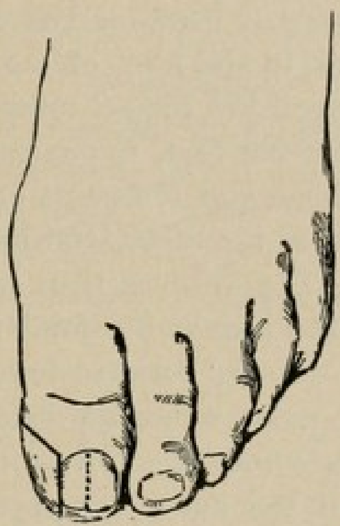

Fig. 341.—Operations for Ingrowing Toe-nail. Solid line indicates Cotting operation. Dotted line shows line of incision for removal of half of the nail.

and excised. The incision should extend backward well beyond the root of the nail. In addition, the corresponding half of the nail may be removed as described above. The bleeding digital branch upon the outer side of the toe may be clamped and tied. Although a snug bandage and elevation of the limb usually suffice to control the hemorrhage, still it is wise to ligate the bleeding point. The raw surfaces are disinfected and covered with a wad of gauze and a bandage applied.

Amputation through the Tarso-metatarsal Articulation (Lisfranc).—A tourniquet is applied just above the knee. The right foot, for example. The foot should extend over the end of the table. The guides to the Lisfranc joint are, on the outer side of the foot, the prominent base of the fifth metatarsal bone (little toe) and, on the inner side, the base of the first metatarsal (big toe) which is located a finger's breadth in front of the tuberosity of the scaphoid. The lower part of the foot is grasped in the left hand (the palm of the hand applied to the sole of the foot), with the thumb upon the outer guide and the index finger upon the inner guide, and a curved incision, with its convexity downward toward the toes, is then made; this incision extends across the dorsum of the foot, from its outer to its inner border, commencing and ending a little below the level of the joint, so that when the skin retracts it will not leave the ends of the bones protruding beyond the edge of the flap (see Fig. 339). An incision is then carried down, along the outer and inner borders of the foot, from either end of the dorsal incision, as far as the web of the toes.

The short flap which has been marked out upon the dorsum of the foot is dissected back to the level of the articulation and should include only the integument and the subcutaneous fat.

Now, forcibly flexing the foot, the extensor tendons on the dorsum are divided to the bone and the point of the knife inserted into the joint behind the base of the metatarsal bone of the little toe, and this joint thus opened. The knife is then carried inward across the foot, remembering that the line of the joint is not straight, but convex, the convexity being directed forward toward the toes.

When we reach the point where the base of the metatarsal bone of the second toe projects into the tarsus, the edge of the knife is turned backward toward the ankle for about one-fourth inch, and then, again turning it inward, the joint between the base of the second metatarsal and the middle cuneiform is opened. The edge of the knife is then turned forward toward the toes, and carried in this direction for about one-half inch, in order to reach the level of the joint between the first metatarsal (big toe) and the internal cuneiform, which is then also opened.

Flexing the foot still more forcibly, thus causing the joint to gape widely, the metatarsus, the portion of the foot which is to be amputated, is freed with the point of the scalpel upon its deep plantar aspect, and then, with the long knife, and cutting close to the bone, all the soft parts are separated upon the plantar aspect of the foot down to the webs of the toes, at which point the long plantar flap is cut from within outward and the amputation is complete.

It will be necessary to clamp and tie the dorsalis pedis upon the dorsal surface of the foot, near the inner border, and in the large plantar flap the branches of the plantar arch.

We have upon the dorsum a short, semilunar flap which is composed of skin and fat only, and upon the plantar aspect a long flap

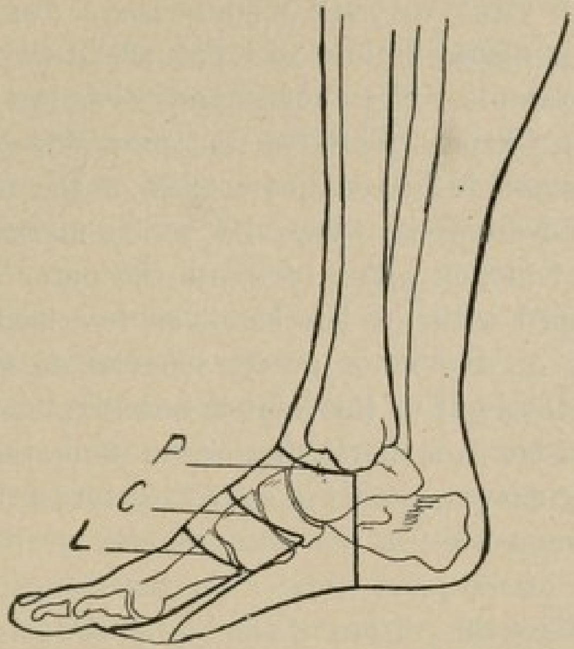

Fig. 342.—Right Foot, Inner Side. *C*, incision for Chopart; *L*, incision for Lisfranc; *P*, incision for Pirogoff.

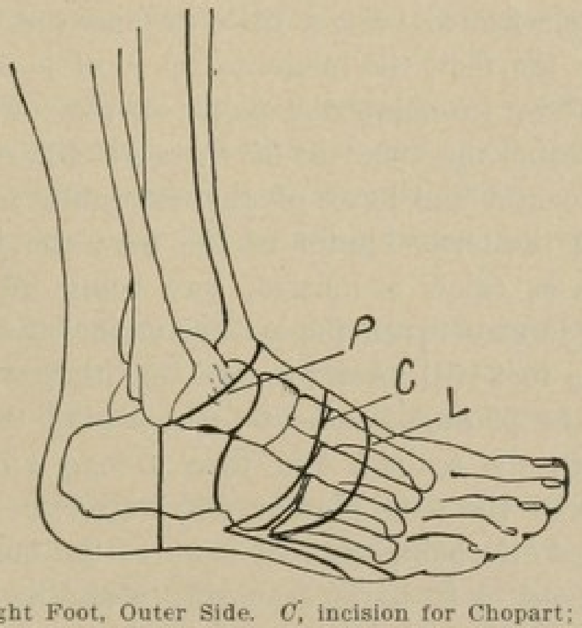

Fig. 343.—Right Foot, Outer Side. *C*, incision for Chopart; *L*, incision for Lisfranc; *P*, incision for Pirogoff.

composed of all the structures of the sole of the foot. The edges of these flaps are brought together with interrupted catgut sutures.

In amputating the left foot it is grasped in the same way by the operator, indicating the bony guides with his finger and thumb, the incision being made from the inner toward the outer border of the foot.

Amputation through the Medio-tarsal Joint (Chopart).—The tourniquet is placed around the limb above the knee-joint. The right foot, for example. The foot extends over the end of the table. The guide to the Chopart joint, on the inner side of the foot, is the tubercle of the scaphoid; on the outer side of the foot we measure a thumb's breadth behind the tuberosity which marks the base of the fifth metatarsal bone, in order to locate the outer end of the joint. The foot is grasped with the left hand, as described in the Lisfranc, the index finger on the inner guide, tubercle of scaphoid, and the thumb marking the level of the joint externally.

As in the Lisfranc, a short anterior flap is marked out by making a dorsal incision, curved, with the convexity forward toward the toes. This incision commences at the outer border of the foot rather in front of the line of the joint (nearer the toes) and ends on the inner side of the foot, likewise in front of the line of the joint (see Fig. 339). From either end of this dorsal incision a lateral incision is carried forward, along either border of the foot, toward the toes.

The short anterior flap is now seized and, including only the skin and fat, is reflected back a little beyond the line of the joint. Forcibly flexing the foot, the medio-tarsal joint is then opened, from within outward, by inserting the point of the knife into the joint immediately behind the tubercle of the scaphoid so as to enter between this bone and the head of the astragalus; then, continuing outward toward the outer border of the foot, the joint between the cuboid and the os calcis is opened, care being taken not to enter, by mistake, the joint between the astragalus and the os calcis.

Flexing the foot still more forcibly, and thus causing the opened joint to gape, the plantar ligaments, which bind the bones together, are divided with the scalpel, and then a long knife is introduced into the joint and the long plantar flap cut with a sawing motion, the edge of the knife being applied close to the bones, thus separating all the plantar soft parts from the bones as far down as the heads of the metatarsal bones, where, with a cut from within outward, the long plantar flap is completed.

It is necessary to catch the stump of the dorsalis pedis near the inner side of the foot, upon the dorsal surface, and the branches of the plantar arch in the long posterior flap. The dorsal flap is short, and consists of skin and fat; the plantar flap is long, and includes all the soft parts of the sole of the foot. The edges of the flaps are united with several interrupted catgut or silkworm-gut sutures.

In operating upon the left foot it is grasped by the surgeon in the same way, the incision marking out the dorsal flap being made from the inner toward the outer border of the foot.

Owing to the action of the tendo Achillis, the stump which results is very apt, after a time, to become extended at the ankle-joint; in order to avoid this the division of the tendo Achillis has been recommended. This, however, helps but little, and many surgeons have discarded this method of amputation entirely.

Surgical Anatomy of the Ankle-joint.—The ankle-joint is formed by the lower ends of the tibia and fibula and the astragalus. The lower ends of the tibia and fibula are bound together by the so-called interosseous ligament, thus forming an arched concavity into which the articular surface of the astragalus is received. The outer portion of the tibio-fibular arch is formed by the external malleolus (lower end of fibula), which extends a finger's breadth lower than the inner malleolus; the vault and inner buttress of the arch are formed by the lower articular surface of the tibia and the inner malleolus. The articular surface of the tibia is broader in front than behind.

The articular surface of the astragalus presents an upper, smooth surface, which slopes downward and backward and which is also wider in front than behind, and is continuous, on each side, with a lateral, smooth facet for articulation with the inner and outer malleoli.

The joint is provided with a capsular ligament, which is described as consisting of several separate portions. Behind, it is very thin and membranous, but is thicker in front and upon the sides.

The capsule is attached above, anteriorly and posteriorly, to the margin of the tibia and fibula, and on the sides to the margins of the inner and outer malleoli; below it is attached to the adjacent rough surface of the astragalus and the os calcis, some of the fibers on the inner side extending forward to the scaphoid.

The joint is provided with a synovial membrane, which is applied to the inner aspect of the capsular ligament.

Exarticulation of the Foot at the Ankle-joint (Syme).—The right foot, for example. The foot should extend over the end of the table, and is grasped by the operator with the left hand. An incision is made which commences upon the external malleolus, just above its tip, and which is carried straight downward and around the sole of the foot and thence upward as far as the tip of the internal malleolus; this incision reaches to the bone throughout its course. A second incision is made which passes across the front of the ankle-joint through the skin, joining the ends of the first incision.

Having incised the integument upon the front of the ankle, the extensor tendons, etc., are exposed; these are divided and the ankle-joint entered by cutting through the anterior ligament. In doing this one should not, by mistake, enter the joint between the head of the astragalus and the scaphoid.

After the anterior ligament has been freely divided the foot is strongly flexed, and then the lateral ligament, upon each side, is divided close to the bone. The joint now gapes, and while a constantly increasing traction is made upon the foot the tendons of the peronei are cut on the outer side and the tendons of the tibialis posticus, etc., on the inner side.

Cutting with the edge of the knife close to the bone, the os calcis is then dissected out of its bed, drawing the foot first to one side and then to the other as this dissection progresses, and occasionally searching with the finger for resisting bands, etc., that interfere with the enucleation of the bone. One should avoid buttonholing the flap, especially as the back part of the os calcis is reached and as the attachment of the tendo Achillis is being separated from the bone; the posterior tibial vessels in the inner side of the flap may also be avoided by keeping the edge of the knife close to the bone.

After the os calcis has been thus enucleated from the soft parts of the heel and the foot removed, the flap is turned up and dissected away from the lower margin of the tibia and fibula for a short distance, in order to make way for the application of the saw. A thin slice of the lower end of the tibia and the malleoli are then removed. The anterior tibial and the internal and external plantar vessels are ligated and the anterior and posterior tibial nerves drawn down and cut short, as are also the ends of any divided tendons that present themselves, and the wound then closed with interrupted catgut sutures.

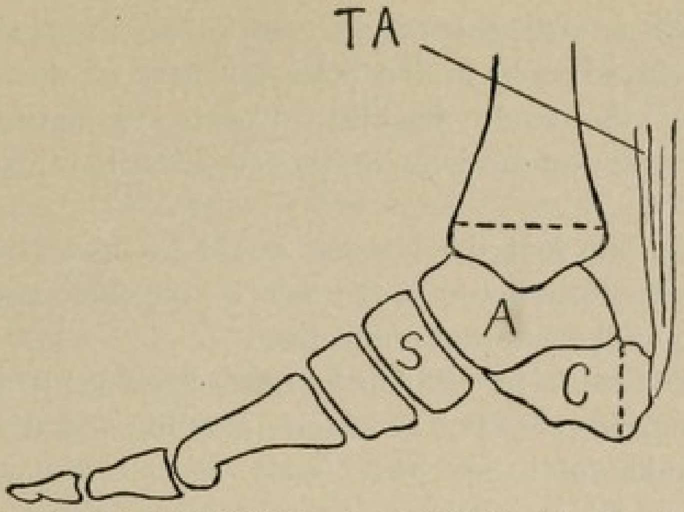

Fig. 344.—Right Foot, Inner Side. *A*, astragalus; *C*, os calcis; *S*, scaphoid; *TA*, tendo Achillis. Dotted lines show lines of section through the bones in Pirogoff's amputation.

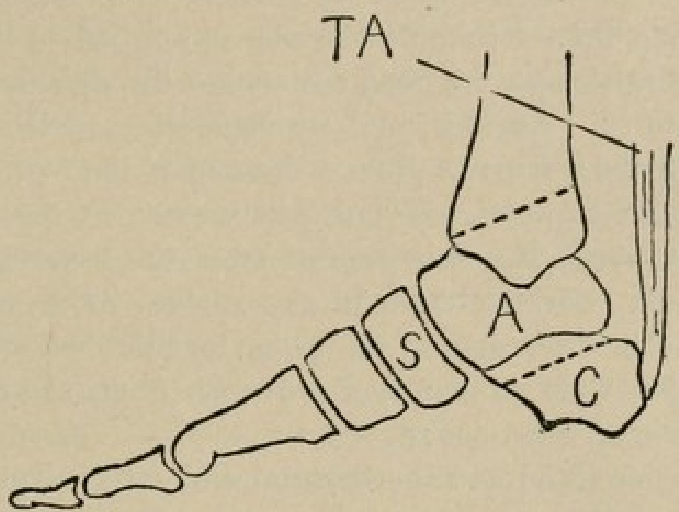

Fig. 345.—Right Foot, Inner Side. Dotted lines show section through bones. Günther's modification.

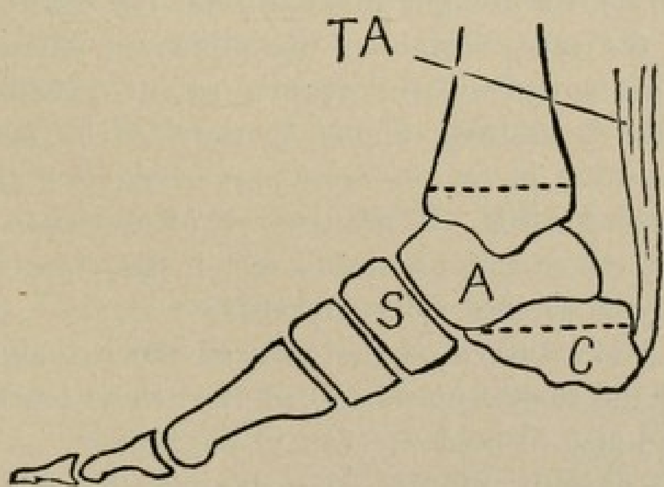

Fig. 346.—Right Foot, Inner Side. Dotted lines show section through bones. Le Fort's modification.

If a drain is used, this may emerge through a small longitudinal incision, which is made in the posterior part of the flap upon the outer side of the tendo Achillis. Koenig recommends suture of the divided anterior tendons to the edge of the lower, turned-up flap.

Upon the left foot the incision would be made from the tip of the internal malleolus around the sole of the foot, terminating just above the tip of the external malleolus.

Exarticulation of the Foot at the Ankle-joint (Pirogoff). —The incisions are the same as in the preceding operation—the Syme. After the ankle-joint has been freely opened, the soft parts are separated from the astragalus and the os calcis backward, beyond the incision that passes through the sole of the foot, as far as the posterior border of the upper articular surface of the astragalus. The soft parts being then retracted, the saw is applied to the upper surface of the os calcis and the bone cut square through upon a plane at right angles to its long axis, and corresponding to the incision that passes through the soft parts around the sole of the foot.

This hooded tegumentary flap, which contains the posterior portion of the os calcis, is now separated from the lower margin of the tibia and fibula, working close to the surface of the bones, and a thin slice of the lower end of the tibia, together with both malleoli, then sawn off. This section is made upon a plane at right angles to the long axis of these bones.

The anterior tibial and the internal and external plantar arteries are ligated and the corresponding nerves are drawn down and cut short.

When the flap is brought into position, the sawn surface of the os calcis and the sawn surface of the tibia are apposed; the edges of the wound are united with interrupted catgut sutures.

If drainage is desired, it may be provided by making a small longitudinal opening in the posterior part of the flap along the outer side of the tendo Achillis. If the traction of the tendo Achillis upon the segment of the os calcis which is left in the flap is considerable, the tendon may be divided subcutaneously.

Koenig advises suture of the ends of the cut anterior tendons to the edge of the turned-up flap to prevent these tendons retracting up the leg, and also to hold the flap in position.

The sawn surfaces of the bones are usually easily retained in apposition by the bandage and dressings, especially if the tendo

Achillis has been divided. Some surgeons prefer to fix the segment of the os calcis to the lower end of the tibia by driving a nail through the os calcis into the lower end of the tibia.

Günther's Modification of Pirogoff's Operation.—The incision across the front of the ankle is the same as in the previous operation; the lower incision, which passes through the sole of the foot, instead of passing vertically downward is directed obliquely downward and forward; upon the inner side of the foot this incision passes just behind the tubercle of the scaphoid, and a similar obliquity is also observed upon the outer side of the foot, the incision striking just behind the tuberosity of the base of the fifth metatarsal. The soft parts are dissected back, away from the bones, for a short distance, and, as in the previous operation, the ankle-joint is freely opened and the saw applied to the upper surface of the os calcis behind the astragalus and the os calcis sawn through, not straight down as in the Pirogoff, but obliquely downward and forward so as to end just behind the anterior edge of the lower surface of the os calcis.

The soft parts are then separated from the lower ends of the tibia and fibula, and, being well retracted, the lower ends of these bones are sawn off obliquely from behind forward and downward.

The sawn surface of the os calcis is now applied to the sawn surface of the tibia without any rotation, and thus division of the tendo Achillis is avoided, and, further, that part of the stump which supports the weight and is applied to the ground corresponds to the under surface of the os calcis and the integument covering it.

After the vessels have been ligated the edges of the wound are brought together with interrupted catgut sutures. It may be wise to fix the stump of the os calcis to the lower surface of the tibia with a nail, which is driven through the os calcis into the lower end of the tibia, previously making a small incision in the skin to allow the nail to be introduced. Drainage may be provided as in the preceding operations.

Le Fort's Modification of Pirogoff's Amputation.—A slightly curved dorsal incision is made across the foot, corresponding to the Chopart joint, commencing on the outer side of the foot one inch below and in front of the tip of the external malleolus and ending on the inner side of the foot at the tubercle of the scaphoid. A second incision, passing obliquely forward, is made through the sole of the foot as in Günther's operation, uniting the ends of the dorsal incision. The integument is then dissected back, and the ankle-joint, under forcible flexion, widely opened as in the Pirogoff.

The upper third of the os calcis, through a plane parallel with the long axis of the bone, is sawn off; this section through the os calcis commences at the posterior end of the bone, after first separating the soft parts and the tendo Achillis sufficiently to apply the saw, and passes forward through the bone as far as the Chopart joint (articulation between the os calcis and cuboid). The foot is then removed, leaving the remains of the os calcis, with the tendo Achillis attached, in the flap. The lower ends of the tibia and fibula, after proper separation and retraction of the soft parts, are then sawn off. The sawn surfaces are apposed and the wound closed. This is a rather difficult operation to perform.

Amputation of the Leg.—The leg may be amputated at any point up to the level of the tuberosity of the tibia. With a view to the use of an artificial limb, one should make an effort to save the knee-joint and as much of the length of the leg as possible.

In amputating the leg we may use flaps of different length, a long anterior and a short posterior, or the reverse, and the flaps may consist of the integument only or may include the muscular tissue as well. The circular method may also be used here, a flap of integument being turned back like a cuff to the point where the muscle and bone are to be divided, and if necessary, owing to the bulging of the muscles of the calf, the circular tegumentary flap may be split, on one or both sides, in order to facilitate its reflection.

It seems to me that lateral skin-flaps of equal length, cut in such fashion as to bring the suture line behind the end of the bone, is the preferable operation,—the so-called lateral hooded flap,—yet we should not commit ourselves to any particular method, but take the flaps as best we can when, thereby, more of the length of the limb can be saved.

Amputation of the Leg with Lateral Hooded Flaps.—The tourniquet is placed above the knee. The patient lies with the leg projecting over the end of the table and steadied by an assistant, who grasps it by the foot and elevates it. We must first decide upon the point at which the bones are to be divided, and then make our flaps accordingly (see Fig. 348). The incision is commenced on the front of the limb, one and one-half inches below the level at which the bones are to be divided and just to the outer side of the sharp anterior border of the tibia; from this point the incision curves downward and backward around either side of the leg, approaching the middle line on the posterior aspect of the limb, where it is carried upward, in the middle line, to a point opposite the level at which the bones are to be divided. This incision extends through the skin and subcutaneous fat down to, but not including, the deep fascia.

Each of the lateral flaps thus marked out should correspond in length to half the thickness of the limb, adding one-third to allow

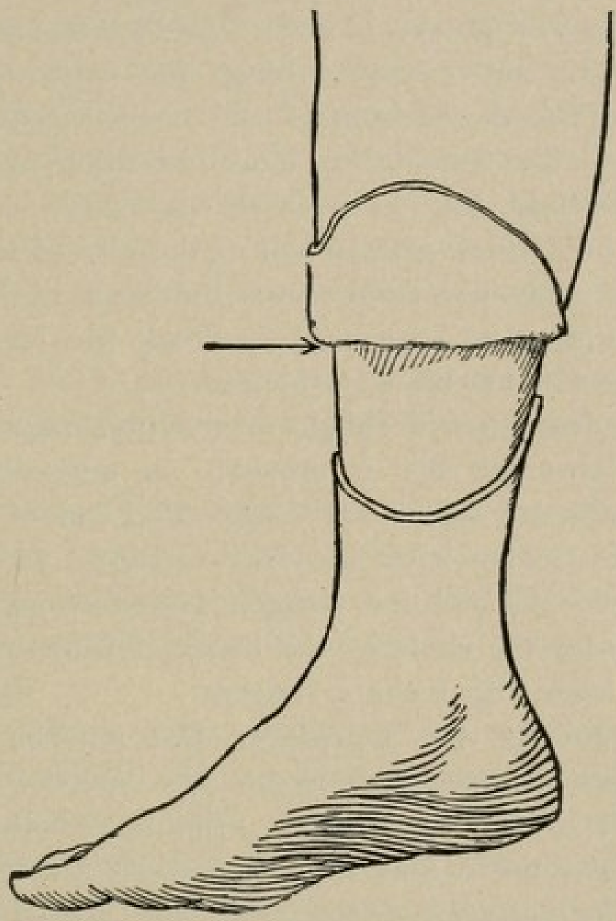

Fig. 347.—Amputation of Leg. Hooded flap of skin and fat turned back. Arrow shows level at which bones are to be divided.

for retraction. The length of the flap is measured from the level at which the bones are to be divided.

The edge of the flap is seized with the fingers, and, making strong traction, it is separated from the deep fascia, taking all the subcutaneous fat with it and cutting with long sweeps of the knife, its edge being always directed toward the deep fascia in order to avoid cutting the small vessels that ramify in the fat and supply the integument. In reflecting the flap we should work evenly around the whole circumference of the limb.

After the flaps have been turned back as far as the level at which the bones are to be sawn through, and while they are thus held by an assistant, the muscles are divided with a long knife, down to the bone, with one clean, circular sweep. The muscular tissue between the bones may be divided with a narrow, double-edged knife or with a scalpel and the periosteum then incised to make way for the saw.

The heel of the saw is firmly placed upon the edge of the tibia and, drawing back, a groove is made in which the saw works easily. When the tibia is partly sawn through the fibula may be engaged in order to complete the division of both bones simultaneously.

The use of the three-tailed cloth retractor may be dispensed with, as the assistant can better, with his hands or with sharp retractors, hold the divided muscles out of the way of the saw.

While the bones are being sawn the limb is supported below, that its weight may not prematurely break the bones before their section with the saw has been completed.

The prominent anterior angle of the tibia may be sawn off or chiseled away, although this is probably an unnecessary step, especially if the flaps are sufficiently long. The end of the fibula may be cut a little shorter with the bone-forceps. In shortening the fibula one should not use the straight bone-forceps, as they rather crush and splinter the shaft of the bone; it is better to do this by taking several bites with a sharp rongeur.

Before removing the tourniquet the anterior and posterior tibial vessels are clamped and tied. The anterior tibial is found upon the front of the interosseous membrane between the bones; the anterior tibial nerve may be pulled down and cut short at the same time. The posterior tibial vessels are located in the back of the stump, on the tibial side of the leg, beneath the gastrocnemius and soleus muscles; the large nerve which accompanies these vessels may be pulled down and cut short. The peroneal branch of the posterior tibial artery, which is found just behind the fibula, should also be tied. After the tourniquet has been removed, any remaining vessels that bleed may be caught and tied. The edges of the flaps are joined with interrupted catgut sutures, leaving a drain which emerges posteriorly. When the suture is complete, it will be seen that the suture line is located behind the end of the tibia and thus out of the way of pressure.

Surgical Anatomy of the Knee-joint.—The knee-joint is made up of the lower end of the femur and the upper end of the tibia and the patella. The lower end of the femur is expanded and rather cuboidal in form, having two prominent condyles which project backward beyond the posterior surface of the shaft of the bone.

The inner condyle, when the femur is held perpendicularly, is seen to extend lower than the outer and is also rather narrower than the outer. The inferior and posterior surfaces of the condyles are smooth, rounded, and covered with cartilage; this smooth articular surface is also continued upward upon the anterior surface of the lower end of the femur, extending rather higher externally than internally, and is limited externally by a prominent ridge.

Behind, between the projecting condyles, there is a space large enough to accommodate the thumb, known as the intercondyloid notch; to the contiguous surfaces of this notch the crucial ligaments are attached.

The inner condyle presents upon its inner surface a broad prominence, the inner tuberosity, and to this the internal lateral ligament is attached.

The outer condyle presents upon its outer surface a prominent tubercle, which is located a little behind the center, and to this is attached the external lateral ligament. Immediately below this tubercle there is a smooth groove in which the tendon of the popliteus muscle is lodged.

The lower and posterior portions of the articular surface of the condyles articulate with the articular surface of the tibia; the anterior portion articulates with the patella. The relation of these articular surfaces varies according to the position of the knee-joint.

The upper end of the tibia presents a superior surface, which is divided into two lateral concave, rather ovoidal portions, which articulate with the condyles of the femur, and an intermediate rough area which is marked by a prominence, the spinous process, the summit of which presents two prominent tubercles for the attachment of the extremities of the semilunar interarticular fibro-cartilages. This intermediate space, in front and behind the spinous process, is rough for the attachment of the semilunar cartilages and the crucial ligaments.

The anterior surface of the upper end of the tibia presents a triangular surface, its base corresponding to the anterior border of the upper surface of the tibia and its apex to the tuberosity of the tibia. The tuberosity of the tibia gives attachment to the ligamentum patellæ.

The patella presents a smooth posterior surface, covered with cartilage, which articulates with different parts of the articular surface of the condyles in different positions of the knee-joint.

The upper and lateral borders of the patella give attachment to the expanded tendon of the quadriceps; the lower part of the posterior surface, which is rough, gives attachment to the ligamentum patellæ. This ligament, which is attached below to the tubercle of the tibia, fixes the patella to this bone.

The anterior surface of the patella is smooth and is covered by a fibrous expansion from the quadriceps extensor, and is separated from the integument by a bursa which, at times, becomes inflamed—housemaid's knee.

The knee is provided with a capsular ligament which is thin or wanting in places, and is strongly reinforced by expansions derived from the deep fascia (lata) and from the quadriceps and by various accessory ligaments.

In front is the ligamentum patellæ. Behind is the ligament of Winslow, which forms the posterior part of the capsule; this ligament is strong, and extends between the femur and the tibia and is strengthened by bands from the tendon of the semimembranosus, which pass upward and outward from the inner tuberosity of the tibia to the external condyle of the femur; it forms part of the floor of the popliteal space, and the popliteal vessels lie close to it.

The origins of the gastrocnemius, plantaris, and popliteus muscles are intimately connected with the posterior ligament.

Laterally, upon the inner side of the joint, we have the internal lateral ligament, which extends from the tuberosity of the internal condyle to the upper part of the internal border of the tibia, and upon the outer side the external lateral ligament, which is attached above to the tubercle on the external condyle and below to the head of the fibula. These lateral ligaments are attached behind the center of the condyles, and are therefore put upon the stretch by any attempt at overextension of the knee-joint. The capsule is further reinforced, on the sides, by the broad expansions that are derived from the quadriceps extensor and the fascia lata; these are attached to the sides of the patella.

Within the joint are the ligamenta alaria, which are simply redundant folds of the synovial membrane that are reflected from the sides of the patella; these are prolonged downward and backward as the ligamentum mucosum, which is attached behind to the femur in the intercondyloid notch between the condyles.

The crucial ligaments, two in number, pass between the lower end of the femur and upper surface of the tibia, crossing one another, and help to fix the bones. The internal passes from the outer side of the internal condyle downward, backward, and outward, and is attached to the rough portion of the upper surface of the tibia behind the spine. The external extends from the inner side of the external condyle downward, forward, and inward and is attached to the rough space in front of the spine of the tibia.

Within the joint, interposed between the articular surfaces of the femur and tibia, are the two semilunar fibro-cartilages, the internal and the external. Placed upon the upper surface of the tibia, they serve to deepen the concavity which receives the articular surface of the femur. They are semilunar in form, and are attached by their borders to the margin of the upper surface of the tibia and to the inner contiguous surface of the capsule; by their extremities they are attached to the rough middle portion of the upper surface of the tibia between the two articular surfaces.

The synovial membrane of the knee-joint is very extensive; it lines the inner surface of the capsule and gives off a large pouch, which extends upward upon the front of the femur beneath the quadriceps extensor; as the ligamenta alaria, the synovial membrane is reflected from the sides of the patella and is continued backward as a process, the ligamentum mucosum, to the back of the femur, between the two condyles, where it is attached. The synovial membrane lines both surfaces of the semilunar cartilages and invests the crucial ligaments, and often communicates with the synovial lining of the tibio-fibular joint and with the bursæ adjacent to the knee-joint. It gives a process externally which is found between the margin of the external semilunar cartilage and tendon of the popliteus muscle, forming a bursa for this tendon. A pad of fat is wedged into the joint below the patella, being covered by the synovial membrane of the joint and prolonged into the ligamentum mucosum.

THE BURSÆ ADJACENT TO THE KNEE-JOINT.—The arrangement of the bursæ about the knee-joint is somewhat irregular.

Posteriorly. On the outer side: *First*. Between the posterior part of the capsule and the outer head of the gastrocnemius there is a bursa which sometimes communicates with the joint.

Second. Beneath the tendon of the popliteus there is a bursa which always communicates with the joint.

Third. Occasionally there is a bursa between the tendon of the popliteus and the external lateral ligament.

Inner side: *First.* Between the inner head of the gastrocnemius and the posterior part of the capsule there is a bursa which often communicates with the joint and sends a process between the gastrocnemius and the semimembranosus.

Second. Between the semimembranosus and the head of the tibia.

Third. Occasionally between the tendons of the semitendinosus and semimembranosus.

Anteriorly. *First.* Between the anterior surface of the patella and the integument.

Second. Between the ligamentum patellæ and anterior surface of the tibia (tubercle tibiæ).

Exarticulation of the Leg at the Knee-joint (Stephen Smith Hooded Flap).—The patient lies upon his back, with the leg overhanging the end of the table. One should remember that the end of the femur is large and that a considerable flap is required to cover it. The tourniquet is placed above the knee, high up.

The incision, which passes through the integument and fat down to the deep fascia, commences in front, one inch below the tubercle of the tibia; from this point it curves downward and backward across either side of the leg, and behind, near the middle line, is carried upward into the popliteal space as high as the level of the knee-joint. Two lateral flaps with rounded corners are thus marked out. One should avoid making the flap scant by getting well upon the posterior aspect of the leg before turning the incision upward into the popliteal space.

This tegumentary flap, which includes the subcutaneous fat, is now seized with the fingers and dissected away from the deep fascia with long sweeps of the knife, its edge being directed toward the deep fascia so as not to cut into the flap. Considerable traction should be applied to the flap as it is being reflected, in order to facilitate its separation from the deep fascia. The flap should be dissected up to the level of the joint all around. While the flap is retracted the knee-joint is sharply flexed and entered, cutting first through the lower part of the ligamentum patellæ; the blade of the knife is then introduced, flatwise, between the semilunar fibro-cartilages and the upper surface of the tibia, and the cartilages separated

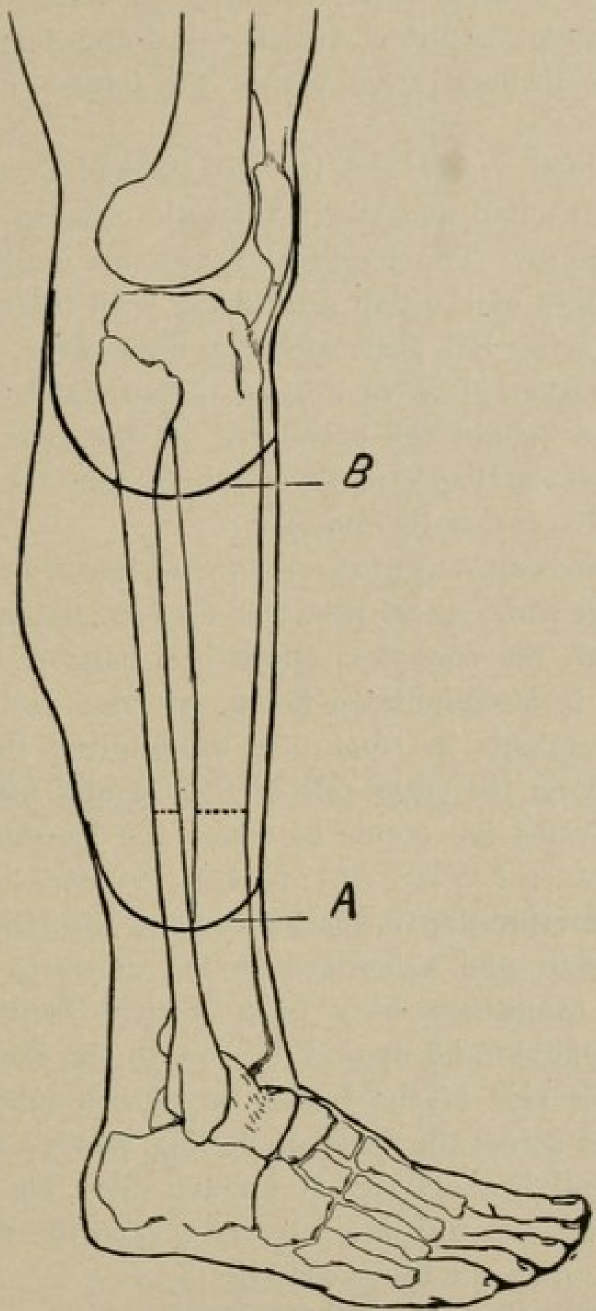

Fig. 348.—Right Leg, Outer Side. *A*, outline of hooded skin flap in amputation of the leg. Dotted line shows line of division through bones. *B*, outline of skin flap in Stephen Smith hooded flap for exarticulation at the knee-joint.

all around from the edge of the upper surface of the tibia, so that they may be left attached in the stump after the leg has been amputated.

The lateral ligaments are cut on each side, and with the limb still strongly flexed the attached ends of the fibro-cartilages and the crucial ligaments are cut away from the upper surface of the tibia, and then, with a long knife, the soft parts behind the joint, the posterior ligament, popliteal vessels, etc., and tendons and muscle, are cut square through from within the joint. The amputation is thus complete.

The popliteal artery and its vein, which lies upon (superficial to) it, are each seized and tied. They lie close to the posterior surface of the femur. The popliteal nerves are pulled down and cut short. The edges of the flap are united with interrupted catgut sutures, a space being left posteriorly for drainage.

This operation gives us a good, broad, fairly flat stump, with the suture line behind the extremity of the bone. The reason for leaving the fibro-cartilages in the stump is that they tend to make a better base to the end of the femur.

Transcondylar Amputation at the Knee-joint (Carden).—A long anterior and a short posterior flap are made, the femur being divided through the condyles. Both legs hang over the end of the table, the one to be amputated being extended and supported by an assistant, who grasps the foot. In amputating the right limb the operator stands on the outer side of the leg and with the thumb and forefinger indicates the points at which the incision commences and ends.

A long anterior flap is marked out by an incision which passes through the skin and subcutaneous fat down to the deep fascia. This incision commences at a point a little behind the middle of the internal condyle and upon a level with the knee-joint; it passes down the inner side of the leg as far as the tubercle of the tibia, swings outward across the front of the leg, passing below the tubercle of the tibia, and is then carried upward upon the outer side of the leg to a point upon the outer condyle opposite that at which the incision began upon the inner condyle.

In operating upon the left leg the operator may stand upon the inner side of the limb, making the incision from the outer condyle around to the inner. The corners of the flap should be rounded, but the flap should not be tongue-shaped.

The edge of the anterior flap is seized with the fingers, and the flap, consisting of the skin and subcutaneous fat, is dissected away from the deep fascia and reflected as far as the lower border of the patella; in thus detaching the tegumentary flap the edge of the knife should always be directed toward the deep fascia. The knee is then

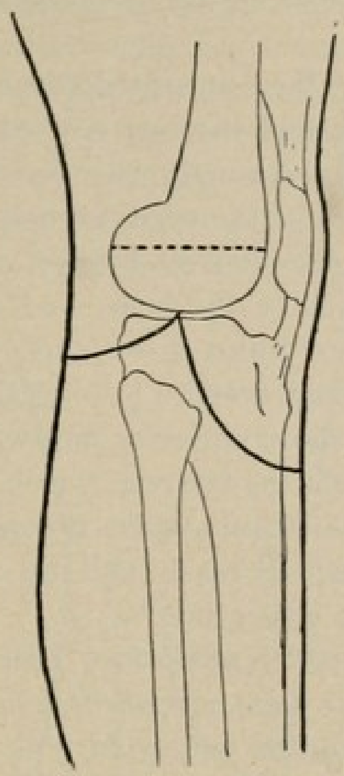

Fig. 349.—Right Leg. Carden's Amputation. Solid line indicates flaps. Dotted line shows line of division through the condyle.

flexed and the joint opened from in front with the long knife, which first divides the ligamentum patellæ and then passes straight through

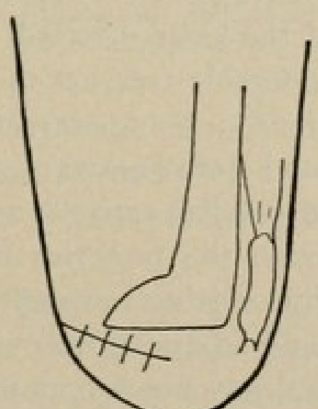

Fig. 350.—Stump After Carden's Amputation.

the joint, cutting capsule, lateral ligaments, and crucial ligaments, and emerging through the structures in the popliteal space; as the knife passes through the integument in the popliteal space the assistant should draw the soft parts upward toward the hip, and the knife may be turned somewhat downward in order that the posterior flap may not be cut too short, as the integument in this region tends to retract very much.

The soft parts are then separated about the circumference of the condyles and retracted, and the saw applied, the section being made, not above, but directly through, the condyles proper. The sharp edge of the sawn surface of the condyles may be rounded off somewhat with a file or with a rongeur bone-forceps. The popliteal artery and vein are found posterior to the bone, and should be tied separately and the popliteal nerves drawn down and cut short.

The stump is covered over by joining the edges of the long anterior skin-flap and the short posterior flap with interrupted catgut sutures. It is wise to drain the synovial pouch, which is located in front of the lower end of the femur, under the quadriceps extensor, by introducing two tubes, which reach well up into the pouch, emerging through the incision on either side.

Amputation at the Knee-joint (Gritti-Stokes).—The position of the patient is the same as described in Carden's amputation. A long anterior flap is marked out by an incision commencing upon the internal condyle just behind its middle, and passing down the side and then across the front of the leg just below the tubercle of the tibia, and thence upward to a point on the outer condyle a little behind its center. The flap thus outlined is like the Carden, but somewhat shorter. The edge of this anterior flap is seized with the fingers and, including all the subcutaneous fat, is separated from the deep fascia, cutting with the edge of the knife directed toward the deep fascia and constantly making considerable traction upon the flap. At the lower border of the patella, the flap being retracted and the leg flexed, the knee-joint is opened from before backward, cutting with the long knife through the ligamentum patellæ, capsule, and lateral and crucial ligaments, and finally through the posterior ligaments and the parts in the popliteal space. While cutting through the integument in the popliteal space the skin should be drawn well upward toward the hip-joint so that the posterior flap may not be cut too short. There should be a short posterior flap, one-half to one inch long.

The soft parts are separated from the lower end of the femur, working with the edge of the knife close to the bone, to a point beyond the upper limits of the articular surface; here a circular cut is made around the bone, and with the saw the end of the femur is removed parallel with the plane of its inferior articular surface. After the articular end of the femur has been removed, the patella, being surrounded by a towel to give a good, firm grip, is seized with the left hand and the whole of its articular surface sawn off. The sawn surface of the patella is then apposed to that of the lower end of the femur, to which it is fixed by two chromicized catgut sutures, which are passed through drill holes in the posterior edge of the femur and the lower border of the patella. The patella may also be fixed to the femur by a nail driven through it into the femur. The popliteal

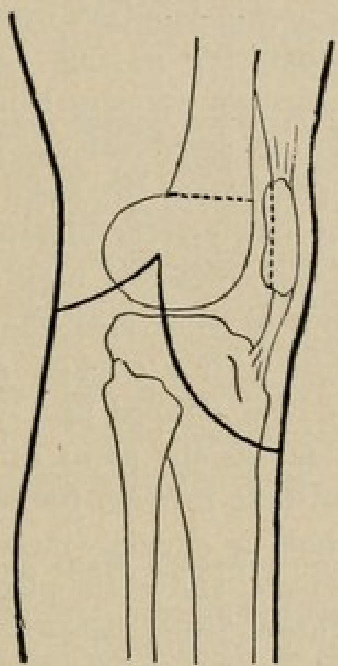

Fig. 351.—Gritti-Stokes Amputation. Solid lines indicate flaps. Dotted lines show section through femur and patella.

vessels require ligation. A tube may be introduced on each side to drain the large synovial space under the quadriceps extensor tendon. The edges of the wound are sutured with interrupted stitches of catgut.

Amputation of the Thigh.—As a rule, this is accomplished by a modified circular in two—or, better, three—steps, the skin being divided upon one level, the muscles upon another, and the bone upon a third. A tourniquet is placed about the limb, high up, near the hip-joint.

The thigh should hang over the end of the table. For either the right or the left thigh it is probably more convenient for the operator to stand upon its outer side. An assistant steadies the thigh by grasping it above and drawing the integument a little toward the hip. A second assistant may support the limb below.

The point at which the bone is to be divided is first located, and then, with a sweep of the long amputating knife, a circular incision is made around the limb through the skin and fat down to the deep fascia, thus marking the lower limits of the skin-flap. This circular incision in the skin should be placed below the point at which the bone is to be divided a distance equal to half the diameter of the limb at that point (where the bone is to be divided), adding one-third more to allow for retraction.

The edge of the skin-flap is seized with the fingers and the flap reflected like a cuff, separating it from the underlying deep fascia with long sweeps of the scalpel, its edge being always directed toward the deep fascia in order to avoid cutting into the flap. While the flap is being dissected away from the deep fascia, upon the posterior aspect of the thigh, the limb may be elevated by the assistant.

After the flap has been dissected back to within one inch of the point at which the bone is to be divided, the long knife is again taken and the muscles are cut, with a circular sweep, down to the bone. The muscular tissue is then scraped back away from the bone with a blunt instrument as far as the point at which the bone is to be divided. While the assistant retracts the skin and muscles with his hands or sharp retractors, a circular incision is made through the periosteum around the bone, and then, planting the heel of the saw upon the bone, it is drawn firmly backward, thus making a groove for itself, and the bone is then quickly severed; the assistant supports the limb lightly below in order that the bone may not be broken before it is sawn completely through. The limb should not be so held by the assistant as to jam the saw.

The femoral and profunda femoris arteries and veins, which are located close to the inner side of the femur, are tied separately, and the tourniquet then removed, after which any remaining bleeding points may be clamped and tied.

While seeking these bleeding points only a limited part of the surface of the stump need be exposed at one time, the rest being covered and compressed with a hot gauze pad. The chief bleeding points are sought between the muscles. The sciatic nerve, which is found between the muscles on the back of the thigh, is pulled down and cut short.

The edges of the flap are brought together from side to side, making a transverse line, with interrupted catgut sutures. It is usually wise to leave a drain for several days. If the subject is very muscular and the limb very thick, it may be necessary to incise the flap on one side in order to facilitate its reflection.

This is probably the preferable method of amputating the thigh. Instead of the above described method, one may use a long anterior and a correspondingly shorter posterior tegumentary flap, or flaps which include all the muscle down to the bone as well as the skin may be used.

Surgical Anatomy of the Hip-joint.—The hip-joint is composed of the upper end of the femur and the acetabular cavity of the os innominatum.

The upper end of the femur presents a rounded head which represents about two-thirds of a sphere; it is smooth, covered with cartilage, and is marked in the apex of its posterior, inferior quadrant by a depression in which is attached the ligamentum teres. The head of the femur is directed upward, inward, and forward.

The head of the femur is joined to the shaft by the neck, which passes from the head downward and outward to the shaft; the neck is somewhat flattened from before backward, and is broader at its junction with the shaft than with the head, and is narrowest midway between these points.

The upper end of the shaft presents upon its outer aspect the great trochanter, a prominent, square-shaped mass of bone. The external surface of the great trochanter is continuous with the external surface of the shaft, and is marked by a rough line that passes obliquely from above downward and forward; to this line is attached the gluteus medius muscle; the smooth surface below and behind this line is covered by the gluteus maximus, a bursa being interposed.

The inner surface of the trochanter is applied to the shaft of the bone, except for its upper, posterior part, which is free and hollowed out to form the digital fossa; here the tendon of the obturator externus is attached, and this attachment must be separated before one can dislocate the head of the femur backward in doing a resection of the hip-joint.

The prominent upper border of the great trochanter is free, and gives attachment to the tendons of the obturator internus and gemelli in front and to the tendon of the pyriformis behind. The anterior border of the trochanter major gives attachment to the gluteus minimus; its posterior border is thick and rounded and limits the digital fossa behind.

On the inner side of the shaft, at its junction with the neck, is the trochanter minor; it is smaller than the trochanter major, prominent, and pyramidal; to it and to the shaft of the bone immediately below it is attached the ilio-psoas muscle.

Upon the front of the bone, commencing above and externally at the great trochanter and curving obliquely downward and inward and passing around the inner side of the shaft, just below the lesser tuberosity, is the so-called spiral line. This line, on the back of the bone, runs into the linea aspera, forming one of the arms of this prominent ridge. This spiral line is well marked, and upon the front of the bone gives attachment to the capsular ligament.

Upon the posterior aspect of the bone, a prominent, rounded line is presented, which runs from the posterior border of the great trochanter downward and inward to the lesser trochanter; this is known as the posterior intertrochanteric line.

The acetabulum is a large cup-shaped depression corresponding to the junction of the three portions (pubes, ilium, ischium) of which the os innominatum is formed. This cavity extends downward and inward as far as the edge of the obturator foramen, and its floor looks downward, outward, and forward; it is surrounded by a sharp, prominent ridge whose summit gives attachment to the ring-like cotyloid fibro-cartilage which serves to deepen the cavity, constricting its orifice and gripping the head of the femur, thus assisting in retaining it within the socket of the joint. In order to dislocate the head of the bone, in resecting the hip-joint, it is necessary to nick this cotyloid ligament.

The lower portion of the margin or rim of the acetabulum, that part which is adjacent to the obturator foramen, is interrupted by a wide, deep notch, the cotyloid notch. In the recent state this notch is bridged over by a ligamentous band, the transverse ligament; that part of the ring-like cotyloid fibro-cartilage which corresponds to the notch is applied to the upper surface of the transverse ligament. The transverse ligament converts the cotyloid notch into a foramen, through which vessels, nerves, etc., pass into the hip-joint.

The floor of the acetabulum is partly articular and partly non-articular; the articular part is the smooth, horseshoe-shaped surface which occupies the periphery of the cavity; the non-articular portion is the rough, depressed area which occupies the middle of the cavity and is prolonged down along the floor to the site of cotyloid notch; this non-articular, depressed surface lodges a mass of fat and its margins give attachment to the ligamentum teres.

The hip-joint is provided with a capsular ligament, which is attached above around the margin of the acetabulum and transverse ligament (which completes the circumference of the acetabulum below); below it is attached to the femur; in front, to the spiral line as far as the lesser trochanter; behind it is attached to the surface of the neck proper, one-half to two-thirds inch above, away from, the posterior intertrochanteric line. The capsule is materially strengthened by the circular fibers that are woven into it (ligament of Webber).

The capsule is reinforced by three auxiliary bands of fibers. The most important is the ilio-femoral band, which is thickest, widest, and longest; it is attached above to the ilium just below and behind the anterior inferior spinous process and below spreads out and is attached along the spiral line, from the greater to the lesser trochanter; it is known as the "Y" ligament of Bigelow.

The ischio-femoral band is attached to the ischium behind and below the acetabulum (to the upper part of the groove for the tendon of the obturator externus), and to the femur it is attached at the upper part of the trochanter major and spreads out and encircles the capsule.

The pectineo- or pubo- femoral band is thin, and attached to the pectineal eminence on the os innominatum and to the neck of the femur behind the ilio-femoral band, being incorporated with the lowermost fibers of the ilio-femoral band.

The transverse ligament is a fibrous band that bridges across the notch in the lower part of the rim of the acetabulum, thus converting the cotyloid notch into a foramen.

The cotyloid ligament is a complete fibro-cartilaginous ring which is attached to the edge of the bony rim and the transverse ligament, encircling the acetabulum and deepening the cavity and constricting its orifice.

The ligamentum teres is an interarticular fibrous band which passes between the head of the femur and the bottom of the acetabulum. It is attached in the bottom of the acetabulum to the margins of the rough space and to the transverse ligament; its narrow end is attached to a dimple which marks the apex of the posterior inferior quadrant of the head of the femur. It is usually a strong band.

The rough depression in the bottom of the acetabular cavity is filled in with a cushion of fat in which the vessels that pass along the ligamentum teres to supply the head of the bone are lodged.

The synovial membrane of the hip-joint lines the inner surface of the capsule, covers the mass of fat in the floor of the acetabular cavity, and is thence reflected upon the ligamentum teres as far as the head of the femur as a tubular prolongation, and thus practically shuts the teres ligament out of the cavity of the joint.

A large bursa lies beneath the ilio-psoas muscle upon the front of the capsule; this often communicates with the joint. Smaller bursæ are located between the various tendons and adjoining bony parts, etc.

The hip-joint is covered in front by the ilio-psoas and the pectineus muscles; on the outer side by the glutei; behind by the gluteus maximus, pyriformis, obturator internus and gemelli, and quadratus femoris; internally and below by the obturator externus.

Exarticulation of the Thigh at the Hip-joint (Wyeth).—The patient lies upon the back with the thigh extended over the end of the table. In order to prevent slipping of the tourniquet, which is placed about the thigh for the purpose of compressing the femoral vessels and thus controlling the hemorrhage, two long pins are introduced through the soft parts, the ligature being applied above these. The pins are about ten inches long and are introduced as follows:—

One, transfixing the soft parts on the outer side of the thigh, is introduced one inch below the anterior superior spine of the ilium, and, passing backward through the soft parts for a distance of about three inches, emerges about one inch below the crest of the ilium; this pin transfixes the upper part of the tensor vaginæ femoris muscle.

A second pin is introduced through the soft parts on the inner side of the thigh, one inch below the pubic bone; it passes through the adductor muscles, and emerges posteriorly one inch below the tuberosity of the ischium; in introducing this inner pin one must avoid injuring the femoral vein. The femoral artery passes into the thigh underneath Poupart's ligament at a point which corresponds to the middle of a line drawn from the anterior superior iliac spine to the pubic spine. The femoral vein lies just to the inner side of the artery. Corks are applied to the sharp points of the pins after they have been introduced, to prevent one from prickng one's self.

The tourniquet is placed around the thigh above the pins, which prevent its slipping down. A pad may be placed beneath the tourni-

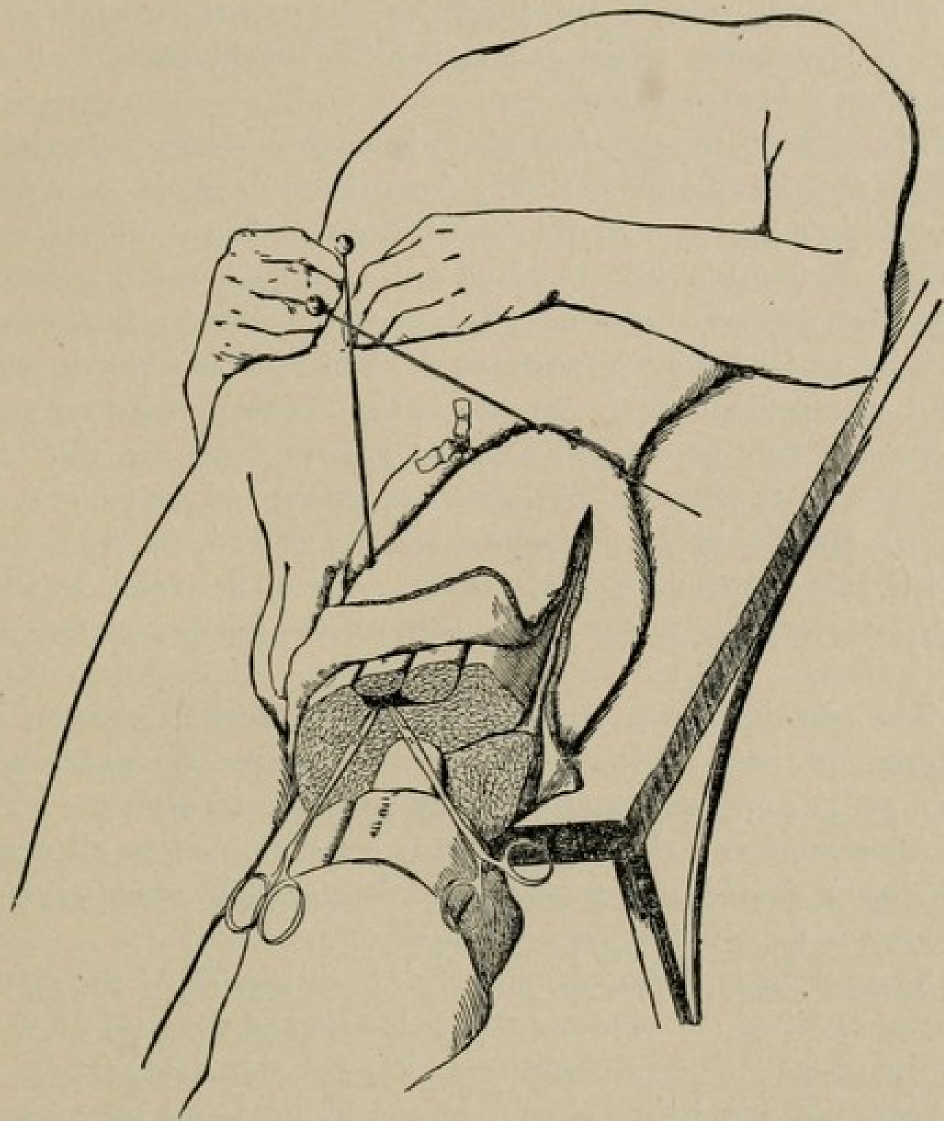

Fig. 352.—Exarticulation at Hip-joint. Wyeth pins in place to prevent ligature from slipping. Upon the outer side of thigh the incision reaches to the bone. A circular skin flap has been turned back and the muscles and blood-vessels divided down to the bone. Clamps applied to femoral artery and vein.

quet, upon the front of the thigh, corresponding to the location of the femoral vessels, to still further secure their compression.

The operator stands on the outer side of the limb, which is supported by an assistant. With a long knife a circular incision is made through the skin and fat down to the deep fascia; this incision should encircle the thigh a hand's breadth (five inches) below the perineum.

With a stout scalpel a second incision is made along the outer side of the thigh. Commencing above the great trochanter, this incision is carried downward, upon the surface of the trochanter and along the outer side of the thigh, as far as the circular incision, where it terminates. This second incision should reach to the bone throughout its entire extent.

The edges of the skin-flap which is marked out by the circular incision is seized and dissected away from the deep fascia for a distance of about three inches. At this point, the skin-flap being retracted, a circular cut is made with the long knife, through the muscles, down to the bone, dividing the vessels, the femoral and the profunda femoris, which lie in front and internal to the bone. These vessels are now sought, clamped, and tied. In order to get better access to the vessels the muscles may be scraped downward away from the shaft of the bone for a short distance. We should make sure of the femoral artery and vein and the profunda femoris and its vein; these latter lie in a deeper plane than the femoral vessels. Any other vessels which may be visible, searching in the spaces between the bundles of muscle, are also ligated.

The tourniquet may now be removed, gradually loosening it and catching additional vessels as they bleed, and then the pins are withdrawn or the tourniquet and pins may be left until after the bone has been enucleated and the amputation is complete, but in all cases the main vessels should always be secured immediately after the circular cut through the muscles has been made.

The next step in the operation is the separation of the soft parts from the shaft of the bone and the dislocation of the head of the bone from its socket. The soft parts are retracted and stripped away from the bone, working with the edge of the knife close to the bone and rotating the limb first inward and then outward to facilitate this part of the operation. After the shaft of the bone has been denuded of its soft parts up as far as the capsule of the joint, the joint is opened by incising the capsule and the cotyloid fibro-cartilage, and the head of the bone is then thrown out of its socket, cutting or tearing the ligamentum teres, and any remaining soft parts, and thus completing the exarticulation.

After ligating any bleeding points that show themselves and having cut the nerves short, the edges of the skin are united with interrupted catgut or silkworm-gut sutures, taking, besides, a few deep catgut sutures through the muscles. A large drainage tube is introduced; this reaches into the deepest part of the wound, into the acetabular cavity, and emerges through the lower end of the incision.

Exarticulation at the Hip-joint, with Preliminary Ligation of the Common Femoral.—Amputation at the hip-joint may be accomplished with the loss of very little blood if, as a preliminary step, the common femoral artery and vein have been ligated high up within two inches of Poupart's ligament; *i.e.*, above the origin of the profunda femoris branch. After the common femoral artery and vein have been tied a circular incision is made around the thigh, five inches below the perineum, and in addition to this a longitudinal incision, which commences above the trochantar major and is carried down the outer side of the thigh just the same as in the preceding operation. The integument is then reflected, in the shape of a tegumentary cuff, for a distance of about three inches, at which level the muscles are divided layer by layer, ligating any vessels that bleed as they are met with. In cutting through the muscles on the back of the thigh we meet several large branches, but these are readily secured with clamps as they spurt and are then ligated. Having cut through the muscles down to the bone, the soft parts are separated from this in the usual manner, and the head of the bone turned out of the acetabulum and the amputation thus completed. We may use this method where tumor, etc., prevent the use of the Wyeth pins.

Resections. Ankle-joint (Langenbeck-Hueter).—This operation is done subperiosteally, and is especially applicable to cases of traumatism. The foot rests with its inner side upon a thin sandbag, the knee being slightly flexed.

An incision about three inches long is made along the posterior border of the fibula just in front of the sheath of the peronei tendons; this is carried downward as far as the tip of the malleolus, where it is turned upward for a short distance along the front border of this malleolus. This incision reaches through the soft parts and periosteum to the bone. The tissues which cover the bone are raised subperiosteally with an elevator, laying bare all of the lower end of the fibula and taking care not to injure the peronei tendons, which are lodged in the groove upon the posterior border of the external malleolus. There is considerable difficulty in separating the periosteum from the surface of the malleolus below, and in order to accomplish this it may be necessary to resort to the knife, cutting with its edge close upon the surface of the bone or else one may chisel away a thin shell of the cortex of the bone.

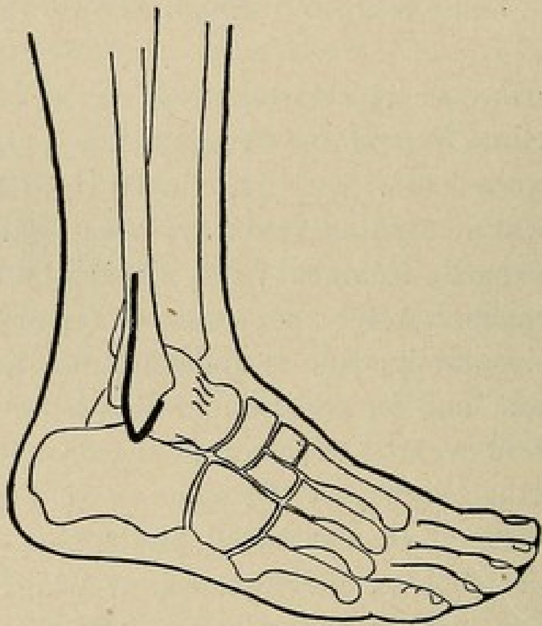

Fig. 353.—Right Foot, Outer Side. External incision for resection of ankle (*Langenbeck-Hueter*).

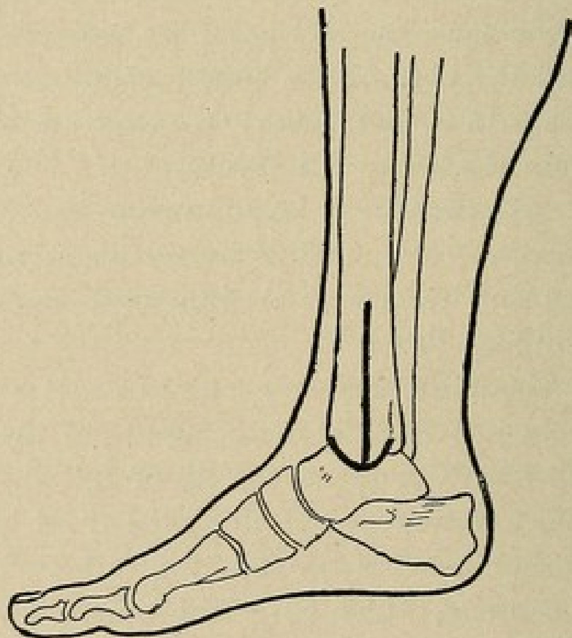

Fig. 354.—Right Foot, Inner Side. Anchor-shaped incision upon inner side of ankle for resection (*Langenbeck-Hueter*).

In isolating the lower end of the fibula on its inner aspect, corresponding to the attachment of the interosseous ligament which binds the lower ends of the tibia and fibula together, care should be taken to stick close to the surface of the bone, so as to leave the periosteum connected with the interosseous ligament.

Now, corresponding to the upper part of the wound, the fibula is encircled with a chain or wire saw and divided, or it may be cut through with a chisel. The upper end of the detached fragment is then seized with the bone-forceps and wrenched free from the remaining ligaments (external lateral) which still hold it. This gives access to the interior of the joint, and through this opening the upper articular surface of the astragalus may be removed with the chisel or sharp spoon and the joint irrigated and drained.

One may stop with this partial operation, or else proceed to do a complete resection. In this latter case the foot is turned so that it rests upon its outer side, and an anchor-shaped incision then made which consists of a cut two and one-half or three inches long, down the middle of the inner subcutaneous surface of the tibia as far as the tip of the malleolus, and from this point additional incisions, which are carried upward along the anterior and posterior borders of the malleolus for a distance of about one inch. These incisions all reach through the periosteum to the bone. In many cases the single longitudinal incision will suffice. Through this incision the periosteum and soft parts are separated from the lower end of the tibia in one mass, working first upon the anterior surface and then upon the posterior surface of the bone, and avoiding injury to the tendons; upon the outer surface of the lower end of the tibia, corresponding to the attachment of the tibio-fibular interosseous ligament, one should work as close as possible to the surface of the bone.

During this part of the operation the edges of the wound are held well apart with blunt retractors. The soft parts should be separated from the lower end of the bone as much as possible with the sharp-edged periosteum elevator, but, if necessary, one may resort to the use of the knife, keeping close to the surface of the bone, or may chisel away a thin layer of the cortex of the bone. Finally, the internal lateral (deltoid) ligaments are cut close to the edge of the malleolus,—it is better to separate these also with the elevator or the chisel,—and the ankle-joint is now open upon its inner side. The lower end of the tibia may be cut through with the chain or wire saw or chisel upon the same level as the fibula was divided; it is then seized with a bone-forceps and detached from any remaining bands that hold it.

The upper articular surface of the astragalus, if desirable, may now be sawn off from behind forward with a thin, flat saw, taking care of the tendons on the back and front of the joint, or, better, it may be cut away with the chisel. This section should be made through such a plane that, when the sawn surface of the astragalus is apposed to the sawn surface of the tibia, the foot will be at right angles to the leg. There is a tendency to make the section through the astragalus upon a plane which would place the foot in a position of extension (plantar flexion), and this is to be avoided.

When this operation is performed for traumatism, the result is good. Much of the bone is reproduced and the parts regain almost their former contour; any excess of bone that is produced from the detached periosteum is usually absorbed. Portions of the tibia, even as much as 8 to 10 cm., have been removed and reproduced. An ankylosed ankle is the preferable result after this operation; the joints between the bones of the tarsus eventually give considerable spring to the foot. When the operation is performed for tuberculosis, frequently no bone is reproduced, healing fails, and we have, as a result, a wabbly joint, with sinuses.

It may not be necessary in all cases to do a complete resection, since all of the parts—for example, the articular surface of the astragalus—may not be diseased, etc. Care should be exercised in applying the dressings to place the foot at a right angle with the leg and turned somewhat outward. It is probably wise in all cases to drain, at least for a few days. The edges of the wound are approximated with interrupted catgut sutures.

With Extirpation of the Entire Astragalus.—The long middle incision on the inner side of the ankle is prolonged downward about one inch farther than described in the foregoing operation, so as to reach to the sustentaculum tali, and at its lower end an antero-posterior incision is added which is about two inches long and which penetrates to the bone (see Fig. 358). The soft parts are separated forcibly with the elevator and the whole of the astragalus thus brought into view. The joint between the head of the astragalus and the scaphoid is opened (tuberosity of the scaphoid is the guide), and also the joint between the astragalus and the os calcis (sustentaculum tali); after this the astragalus is seized with a bone-forceps, and, twisting and at the same time cutting close to the bone, it is removed. In resecting the ankle-joint for tuberculosis, if the astragalus is diseased, it is well to remove this bone entire.

ANKLE-JOINT (KOENIG).—This is a satisfactory operation, especially for tuberculous joints. The lower part of the leg rests upon a sandbag, the foot being elevated and turned outward. An incision is made upon the inner side of the ankle, commencing an inch or an inch and one-half above the level of the joint, and passing down along the anterior border of the tibia and inner malleolus parallel with and just internal to the extensor tendons which lie upon the front of the joint.

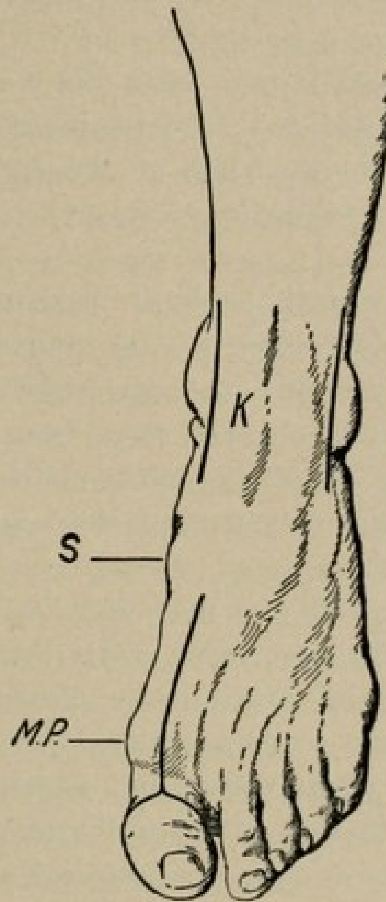

Fig. 355.—*K*, incisions for resection of ankle (*Koenig*); *M.P.*, articulation between metacarpal bone of the big toe and first phalanx; *S*, location of tubercle of scaphoid. Incision for amputation of big toe with removal of the first metatarsal.

This incision penetrates through the integument and periosteum to the tibia, and is continued downward across the ankle-joint, into which it opens, and then curves forward upon the neck of the astragalus as far as the tubercle of the scaphoid.

A similar incision is made upon the outer side of the joint, commencing above at the same level as the internal incision and passing downward along the anterior edge of the outer malleolus, across the ankle-joint, into which it opens, and ending at a point opposite the lower end of the inner incision. This incision runs parallel with the outer margin of the extensor group of tendons.

Between these two incisions there is a bridge of tissues consisting of integument, anterior tibial vessels and nerve, extensor tendons, anterior ligament, and synovial membrane. This mass of soft parts is freely separated from the front of the tibia above and from the astragalus below, as much as possible subperiosteally with the elevator, and when necessary with occasional snips with the scissors or knife.

Access to the ankle-joint is now fairly free, and one may commence the excision of the diseased synovial membrane with mouse-toothed forceps and scissors; the ends of the tibia and fibula and the articular surface of the astragalus may also be reached with the sharp spoon.

If it is desirable to resect the ends of the bones and it becomes necessary to gain still better access to the interior of the joint, a thin shell of the cortex, carrying the periosteum and the attachments of the ligaments, may be chiseled away from the surface of the inner and also from the surface of the outer malleolus, leaving them bare and free. Drawing the soft parts widely asunder with blunt hooks, a broad chisel may be applied, through the inner incision, to the lower end of the tibia, and this may then be divided; the fragment which is thus detached is seized with bone-forceps and removed, cutting the remaining attachments close to the bone and taking care not to injure the tendons which lie close to the back of the bone nor the posterior tibial vessels and nerve. The lower, bare end of the fibula may be treated in a similar manner, avoiding the peroneal tendons in the groove upon its posterior surface. In laying bare the malleoli one should try to separate the lateral ligaments with the chisel subperiosteally in preference to cutting them.

The articular surface of the astragalus may be removed with the broad chisel or with a narrow, thin-bladed saw, the section being made through a plane which will allow the foot to be placed at a right angle with the leg.

In most cases of tuberculous joints, when the astragalus is involved, it is probably better to remove this bone entire; this will also permit treatment of the joints between the astragalus and os calcis and the astragalus and scaphoid if these are involved, and this is frequently the case. The astragalus is readily removed through the inner incision, first opening the joint between the head of the astragalus and the scaphoid, and then the joint between the head of the astragalus and the sustentaculum tali of the os calcis. The astragalus is seized with a lion-tooth forceps, and, cutting its attachments close to the bone, it is twisted free.

Whether the entire astragalus is removed or not in cases of tuberculosis the whole synovial membrane lining of the ankle-joint should be removed with toothed forceps and scissors; that part of the membrane which lines the posterior portion of the capsule is difficult to reach, but its removal may be facilitated by drawing the foot strongly downward away from the tibia and at the same time strongly reflecting the anterior flap or bridge of soft parts.

Usually there are no vessels to tie. Drainage tubes may be introduced on each side and the wound packed with iodoform gauze. The edges of the wounds are brought together with interrupted catgut sutures, being left partly open to allow for the drainage tubes and gauze. The foot is dressed at a right angle to the leg.

ANKLE-JOINT (LAUENSTEIN).—A very satisfactory method, especially for tuberculous joints. The knee is slightly flexed, and the foot rests with its inner surface upon a thin sandbag. The incision is placed upon the outer side of the joint, passing through the skin and subcutaneous fat and exposing the external surface of the outer malleolus and the lower end of the fibula for a distance of about three inches. The surface of the fibula thus exposed is subcutaneous, and is included between the tendon of the peroneus tertius in front and the tendon of the peroneus brevis behind; from the tip of the outer malleolus the incision curves forward and inward across the dorsum of the foot, terminating just external to the tendon of the peroneus tertius, which should not be cut.

The joint is now opened in front of the external malleolus by cutting the anterior fasciculus of the external lateral ligament, and then the integument, together with the extensor tendons and other soft parts, including the anterior portion of the capsular ligament, are separated from the front of the tibia with the periosteum elevator, these soft parts being meanwhile drawn forcibly forward, away from the front surface of the tibia, with a blunt hook.

The posterior margin of the incision is next seized and retracted and the sheath of the peroneal tendons opened; these tendons, together with the integument, are drawn well back out of the way with a blunt hook and the remaining fasciculi of the external lateral ligament (middle and posterior) then divided.

The foot, being somewhat extended in order to relieve the tension of the peronei tendons, may now, with moderate force, be completely dislocated by rotating it inward upon its long axis in a hinge-like fashion around the internal malleolus.

All parts of the joint are now accessible; the synovial membrane may be dissected away with a thumb forceps and scissors, and the upper articular surface of the astragalus, if desired, may be chiseled away or resected with a thin, flat saw, or, by extending the incision somewhat, the entire bone may be removed. If the tibia and fibula are diseased, the soft parts about the lower ends of these bones may

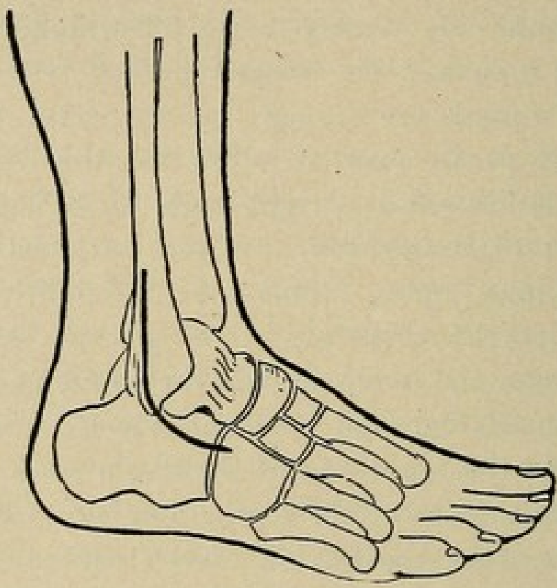

Fig. 356.—Resection of Ankle-joint. Lauenstein's incision.

be detached, preferably subperiosteally, with the elevator, and the diseased portion of the bones then resected with the saw. If the articular surface only of the astragalus, and not the whole bone, is to be removed, one should take care to make the section through the bone in such a plane that, when the foot is replaced, the cut surfaces of the astragalus and tibia will permit of the foot being placed at a right angle with the leg. There is a marked tendency, in resecting the articular surface of the astragalus, to carry the section through a plane which would result in the foot's being joined to the leg at an obtuse angle, in a position of extension, and this is to be avoided.

Ankle-joint, Osteoplastic (Mikulicz-Wladimirow).—The patient lies upon the abdomen. A transverse incision is made across the sole of the foot. This incision commences on the outer border of the foot a finger's breadth behind the tuberosity which marks the base of the fifth metatarsal bone (little toe), and ends on the inner side of the foot at the tubercle of the scaphoid. From either end of this incision, upon either side of the foot, an additional incision is carried obliquely upward and backward across the lower end of each malleolus to their posterior borders, and then still another incision is made transversely, just above the heel, uniting the ends of the two lateral incisions and dividing the tendo Achillis and the posterior tibial vessels. All these incisions penetrate to the bone. The foot is now forcibly flexed (dorsal flexion) and the ankle-joint is opened

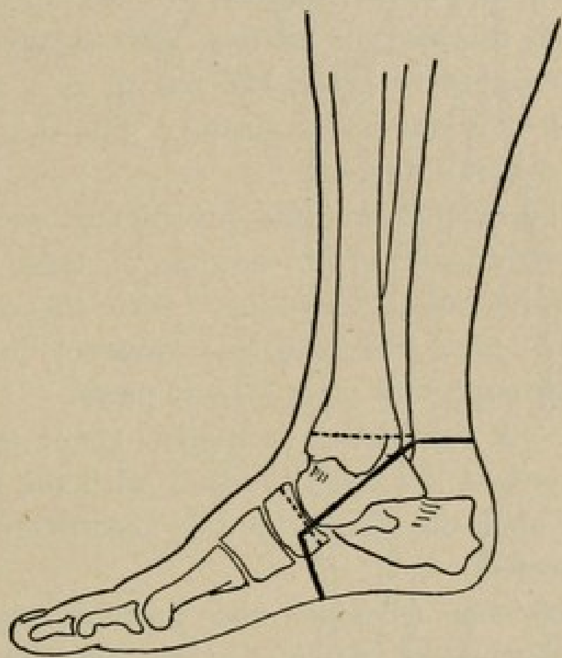

Fig. 357.—Right Foot, Inner Side. Line of incision for Mikulicz-Wladimirow osteoplastic resection of the ankle-joint. Dotted lines indicate section through the bones.

from behind and the lateral ligaments are cut. The astragalus and the os calcis are then dissected out of the mass of soft parts in which they are located, working with the edge of the knife close to the surface of the bones; during this step of the operation the bones are forcibly drawn, first to one side and then to the other, in order to facilitate their enucleation, and, working forward, the joint between the astragalus and the os calcis behind and the scaphoid and cuboid in front is finally opened. The remaining ligaments and bands are then severed and the bones removed.

The soft parts around the lower end of the tibia and fibula are now separated, cutting with the edge of the knife close to the surface of the bones, and a thin slice of the lower end of the tibia, including both malleoli, is sawn off.

A thin slice, including the articular surfaces, is likewise sawn off from the scaphoid and cuboid, so that when the foot is extended (plantar flexion) the sawn surfaces of the cuboid and scaphoid may be apposed to the sawn surfaces of the tibia and fibula, the long axis of the leg being thus prolonged into the foot, as a direct line, the patient walking upon the heads of the metatarsal bones and the phalanges.

The posterior tibial vessels which lie behind the ankle-joint, to the inner side of the tendo Achillis, are cut, and must be ligated. The bones may be retained in contact with sutures of chromicized catgut carried through drill holes, but this is, as a rule, unnecessary, especially if the foot is put up in plaster. The skin wound is closed with interrupted catgut sutures.

One should be careful that the integument on the front of the ankle, which is redundant after excision of these bones, does not interfere through its bulk, "bunching," with the correct apposition of the bones. One may overcome this tendency by passing several quilting sutures through this mass of soft parts.

Knee-joint.—A tourniquet is applied about the upper part of the thigh. The patient lies upon the back with the leg extended, the operator standing upon the side of the table corresponding to the joint which is to be resected.

The usual incision (Textor) and probably the best for most cases is convex downward, passing across the front of the joint, below the patella, and extending from the middle of one condyle to a similar point upon the other. This incision should reach deep to the bone, and below the patella divides the ligamentum patellæ.

The knee-joint having been thus opened, the limb is strongly flexed at the hip and knee, with the sole of the foot resting upon the table, and it is thus supported by an assistant. The lateral ligaments and the lateral portions of the capsule are now divided, cutting them close to the surface of the femur.

The knee being still more markedly flexed, the crucial ligaments are divided close to their attachment to the upper surface of the tibia, cutting with the edge of the knife directed downward, as if one would cut into the articular surface of the upper end of the tibia; if the ligaments are divided with the edge of the knife directed backward, one may accidentally cut the popliteal vessels.

The anterior flap, which includes the patella, should be dissected back and retracted sufficiently to allow free access into the synovial pouch, which is located above the patella, between the quadriceps tendon and the front of the femur.

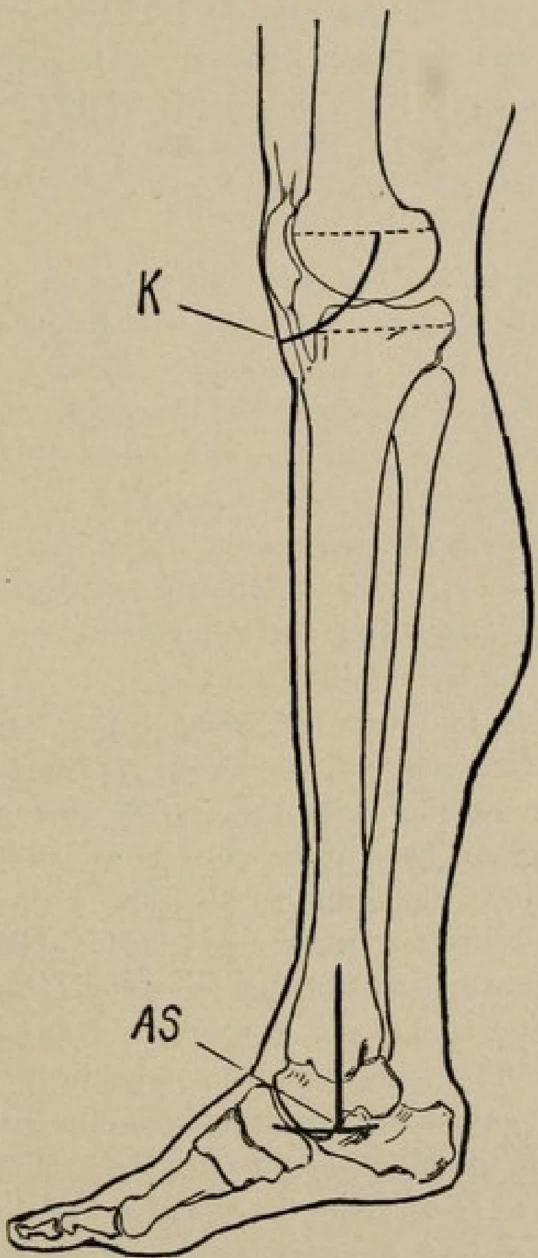

Fig. 358.—Right Leg, Inner Side. *AS*, incision upon the inner aspect of the ankle for resection of the astragalus; *K*, Textor incision for resection of the knee-joint. Dotted lines indicate planes of section through the bones.

With mouse-tooth forceps and blunt-pointed scissors, curved on the flat, the synovial membrane which lines the joint may now be entirely resected. If the bones are healthy, one may stop at this stage of the operation and close the wound, after irrigating thoroughly and providing for suitable drainage (arthrectomy).

In resecting that part of the synovial membrane which lines the posterior part of the capsule one should avoid cutting deeply, on account of the liability to injure the popliteal vessels, which lie adjacent to this part of the capsule. There is rather less danger of doing this if the posterior ligament is put upon the stretch by drawing the tibia away from the femur while this part of the synovial sac is being excised. This portion of the synovial membrane is also more accessible after the ends of the bones have been resected.

If the disease in the bones is limited to one or more foci, these may be thoroughly scooped out with a sharp spoon, thus avoiding the resection of the ends of the bones. Especially in children one should avoid, wherever possible, the resection of the ends of the bones, since interference with the epiphyseal line may retard very much the subsequent growth of the limb.

The patella is usually extirpated if the ends of the femur and tibia are resected, even if it is apparently not diseased. It is grasped with double sharp hooks and excised, cutting with the edge of the knife close to the surface of the bone.

If one decides to resect the ends of the bones, the lower end of the femur is first removed, separating the soft parts back as far as necessary, and working with the scalpel close to the bone. The end of the femur, stripped of its soft parts, is forced upward, out of the wound, above the level of the tibia (hip flexed) and with a sharp, broad saw the section is made through the end of the bone from before backward, commencing by placing the heel of the saw upon the bone and making a groove by drawing the instrument firmly backward. The femur should be steadied with both hands of an assistant who supports himself by resting his elbows upon the table. The end of the bone should be forced sufficiently far upward out of the wound so as to make the use of a towel to protect the soft parts during its section unnecessary. The piece of bone resected must be of the same thickness anteriorly, posteriorly, and upon either side; otherwise, when the operation is completed, the limb will be found to be in a position of knock-knee or bow-leg, or there will be too much or too little extension.

The section should pass through a plane which is parallel with the articular surface of the bone, and not at right angles with the long axis of the bone, and therefore in making the section one should disregard the long axis of the bone, and rather keep his eye on the plane of the articular surface.

The end of the tibia is now likewise stripped of its soft parts and projected upward out of the wound well beyond the sawn surface of

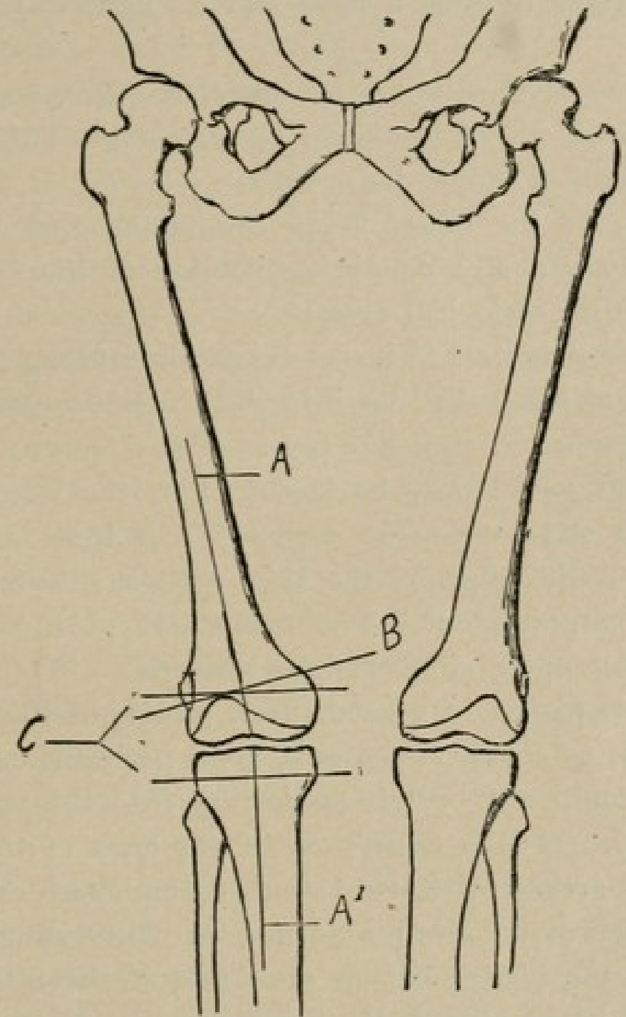

Fig. 359.—Resection of Knee-joint. *A*, *A*[1], long axes of the femur and tibia; *B*, line drawn at right angles to the long axis of the femur. *C*, lines through the lower end of the femur and upper end of the tibia parallel with the plane of the articular surfaces. Through these planes the section should be made in resecting the knee-joint.

the femur, and a section of the bone removed, as in the case of the femur, parallel with the plane of its articular surface.

At times it is necessary to excise two or three inches of the bones (femur and tibia together), but one should remove as little as the conditions present will permit, especially in children. The sharp spoon may be used to extirpate foci which extend into the substance of the bone beyond the surface exposed by the section, and, if the cortex is healthy, one may remove much of the medullary portion of a bone rather than sacrifice more of the length of the limb by removing a thicker segment of bone.

The limb should now be extended and the position of the joint noted; when the ends of the bones are brought together there should be the normal slight bowing inward and a slight degree of flexion (five degrees).

If the position of the limb is not satisfactory, one may remove a further section from one of the bones to correct it; but the necessity for this second section should be avoided.

The position of the bones being satisfactory, all loose, ragged tissue is cut away and any remaining portion of the synovial membrane that has been overlooked excised.

In most cases it is well to insert tubes for drainage, one on each side. These should reach well up into the recess beneath the quadriceps muscles, between it and the front of the femur; in addition, strips of iodoform gauze may be packed into the wound, the ends emerging through the incision on each side; if tubes are used, they should be fixed to the edge of the skin with a silkworm-gut stitch to prevent their slipping out. The front part of the skin incision is closed with interrupted silkworm-gut stitches.

If the limb is placed in a good, firm, plaster-of-Paris splint, the ends of the bones, as a rule, remain in good position. A sharp edge of either bone should not be left projecting into the popliteal space (popliteal vessels). If it is desired to fix the ends of the bones they may be joined together with two stout chromicized catgut sutures which pass through drill holes placed near the anterior margin of the sawn surfaces of the bones, one on each side of the middle line, or, after the skin has been sutured, the bones may be joined by two nails, one driven through the front of the upper end of the tibia and reaching obliquely upward into the sawn surface of the femur, and the other passing through the front surface of the femur and reaching down into the upper end of the tibia. Small incisions may be made in the skin to allow the introduction of the nails.

These accessory measures, for the purpose of holding the bones in apposition, are, as a rule, unnecessary if the ends of the bones have been sawn square, and fit well, and a good plaster splint is applied. In adjusting the plaster splint one should see that the foot is slightly everted, so that the patient will not "toe in."

Before suturing the wound the tourniquet may be removed and any spurting vessels secured; usually there are few or none, and any slight oozing may be controlled by the pressure of the dressing.

Instead of the incision described above, the knee-joint may be opened by an incision, with the convexity directed upward, passing across the limb above the upper border of the patella. This is the reverse of the incision described above, and gives very free access to the synovial pouch under the quadriceps tendon.

Volkmann makes a transverse incision across the front of the knee, through the skin down to the surface of the patella, the knee being slightly flexed and resting upon a sandbag; corresponding to this incision through the skin, the patella is sawn through transversely, To this may be added two lateral incisions, one on each side of the jòint running up and down. We then have an H-shape incision. This incision is especially adapted to those cases where the disease is limited to the synovial membrane alone; so that after its excision the segments of the patella may be sutured with chromicized catgut. This incision is often desirable in children.

HIP-JOINT (LANGENBECK).—This operation is done as much as possible subperiosteally. The patient lies upon the well side of the body, with the hip and knee slightly flexed. A longitudinal incision is made over the outer side of the hip four to five inches long; it commences two or three inches above the upper border of the great trochanter, upon a line corresponding to the long axis of the femur, and from this point is continued straight down upon the outer surface of the trochanter and ends upon the upper part of the shaft of the femur; the incision throughout its whole length penetrates to the bone; that portion of the incision which lies above the trochanter passes through the fibers of the glutei muscles down to the surface of the ilium, which it reaches just above the margin of the acetabulum, exposing the capsule of the joint.

Sharp retractors are inserted deep in the incision and the soft parts drawn forcibly asunder. The capsule is incised from the rim of the acetabulum downward toward the great trochanter, the cotyloid ligament, also, being nicked, or may be separated from the bony rim of the acetabulum for a short distance on either side of the incision in the capsule.

With the periosteum elevator, or, when necessary, with the knife or chisel, the tendons, together with the periosteum and the capsule, are separated from the greater trochanter and the neck of the femur;

this should be accomplished as much as possible subperiosteally with the sharp-edged periosteum elevator; but, where the attachment of the parts to the bones is very intimate, it may be necessary to resort to the knife, cutting with its edge close to the surface of the bone, or the chisel may be used, chipping off a thin shell of the cortex, which carries the attached tendons with it. An assistant rotates the limb inward or outward as may be necessary to facilitate this part of the operation.

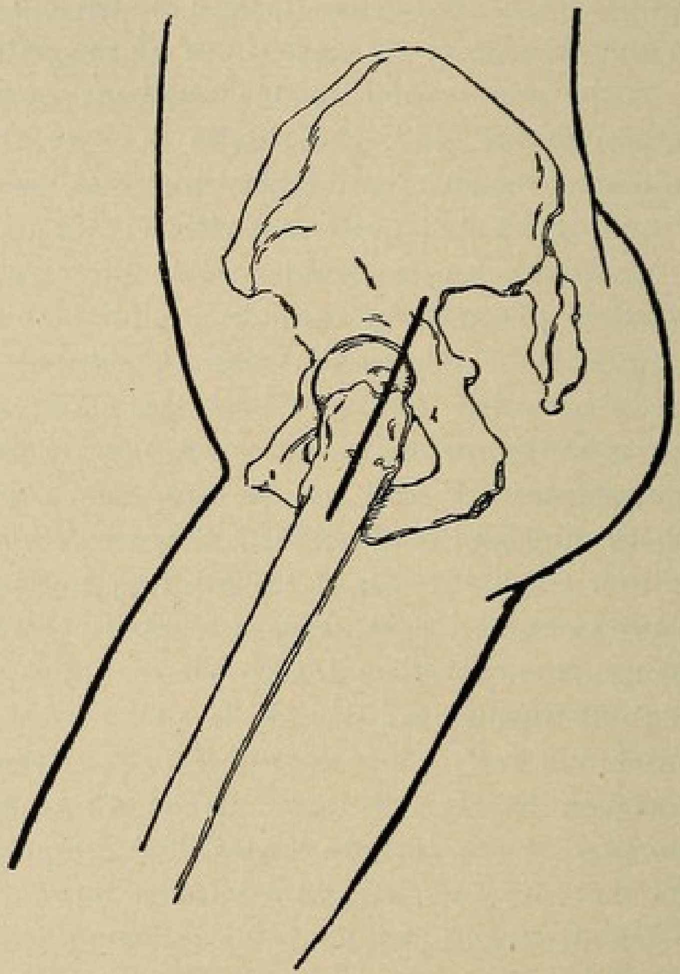

Fig. 360.—Resection of Hip. Langenbeck's incision.

In this way the upper end of the femur is denuded. Pains should be taken to separate the tendon of the obturator externus, which is attached, in the digital fossa, upon the inner aspect of the great trochanter, and also the tendons that are attached to the upper border of the great trochanter.

In order to cut the ligamentum teres the thigh is flexed, rotated inward, and adducted, in this way partly luxating the head of the bone; a long, narrow knife is then introduced into the joint above and behind, and sweeping downward and forward across the head of the bone, the ligament is usually cut. In operating on diseased joints it is, as a rule, not necessary to cut the ligamentum teres, as it is, in most cases, already destroyed, or, at any rate, readily ruptures upon forcibly manipulating the joint (adduction and rotation inward). The head of the femur is then completely luxated backward by

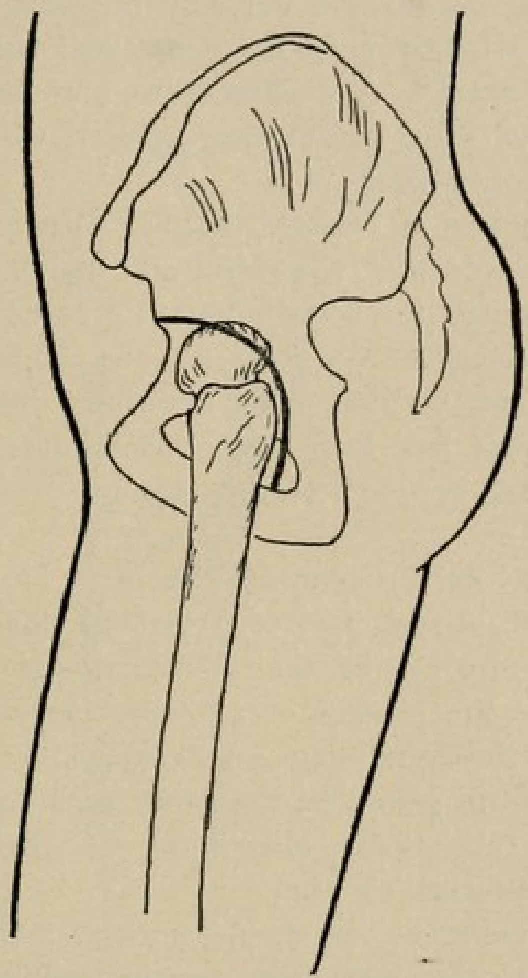

Fig. 361.—Resection of the Hip. Anthony White's incision. Commences anteriorly midway between the anterior superior spine of the ilium and the upper border of the trochanter major and curves backward above the trochanter major and then downward behind the trochanter for a distance of about two inches.

manipulation (flexion, adduction, and rotation inward) and forced out of the wound, when the head and neck may be readily removed with a Gigli or chain saw, with a flat saw, or with a chisel.

Some surgeons make it a practice to remove the trochanter as well as the head and neck of the femur, making the line of section through the shaft of the bone just below the great trochanter. In order to do this it is necessary to separate the periosteum, etc., correspondingly lower down upon the shaft of the femur. If the trochanter is healthy, it is unnecessary to remove it; yet, if at all suspicious, it is better to make the section through the bone below the great trochanter, removing the great trochanter as well as the head and neck, because the result is just as good, and many surgeons claim better, than when it is left.

Now, rotating inward and outward, but chiefly by extension of the limb, pulling strongly upon the femur and holding the edges of the wound widely apart to give us room, we may proceed to excise the synovial membrane, using long, sharp scissors, curved upon the flat, and mouse-tooth forceps.

If the acetabulum is diseased, it may be curetted with a sharp spoon or even resected with the chisel and mallet. A sinus may be found leading through the acetabulum to a focus within the pelvis, in which case drainage of the joint may be combined with counter-drainage through an incision made anteriorly just below Poupart's ligament. There is but little hemorrhage during the operation; bleeding vessels may be seized as they are cut during the progress of the operation.

The soft parts are brought together with interrupted silkworm-gut sutures, which should pass deep through the integument, muscles, and periosteum, closing the wound, except for a space below sufficient to allow the passage of a thick tube, which should reach upward as far as the acetabulum for drainage, or the wound may be packed with iodoform gauze, or the gauze packing may be combined with the use of a tube. Before closing the wound it should be washed out with hot bichloride solution.

During the operation one should work as much as possible with the periosteum elevator and chisel, cutting as few tendons as possible with the knife. We should strive to keep the capsule and the periosteum or shell of cortex that is separated from the bone, along with their attached tendons, hanging together in one continuous layer; so that, when we are ready to resect, the denuded upper end of the femur lies in a sort of sac which is made of the above-named structures, and which all hang together, continuous with one another, and it is out of this hood or sac that we deliver the upper end of the bone for resection. In closing the wound the upper edges of the hood should be included in the sutures, except the part that is left open for drainage.

Plating for Fracture (Lane).—In fractures both simple and compound, where the fragments cannot be reduced or retained in satisfactory position, they may be securely held with metal plates,—Lane's bone plates. These are provided in various shapes and sizes for the different bones. The plates are applied directly to the surface of the fragments. In compound fractures the wound already present may be sufficiently enlarged to reach the fragments. In simple

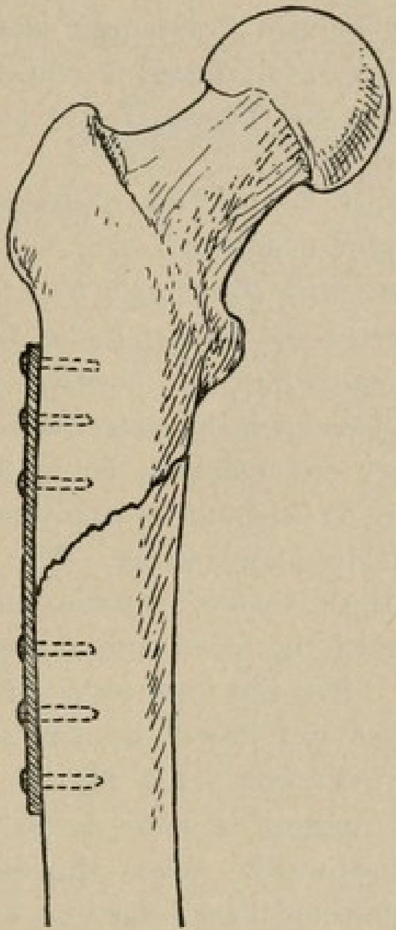

Fig. 362.—Plating for Fracture (*Lane*). Shows plate applied to femur and secured by screws to upper and lower fragments.

fractures it will be necessary to expose the fragments through an incision in the soft parts, the incision being placed so as to produce the least possible damage to important structures. It may be necessary to freshen the ends of the fragments with the chisel, or curette, etc. By means of rotation, extension, etc., the fragments are brought into accurate apposition. This may be facilitated by employing the special bone forceps, levers, etc., devised by Lane. The plate is applied without detaching the periosteum. Corresponding to the screw-holes in the plate, holes are drilled in the bone, first upon the distal fragment and the screws, then driven in with the screw-driver. The fragments are again brought into the proper position and the screw-holes drilled in the proximal fragment and the screws driven in. The drill-holes go through to the medullary canal and should correspond to the size of the screws, neither too large nor too small. The wound must be dry, free from oozing. The soft parts are sutured with several layers of catgut sutures, in clean cases without drainage, and the limb put up in a plaster-of-Paris cast.

If the conditions require drainage a small rubber-tissue drain may be introduced and the limb placed in a moulded wire splint which will permit easy access to the wound for the purpose of removing the drain after a few days.

The operation must be performed under the strictest aseptic precautions and with gloved hands.

For Fracture of the Patella.—The failure to obtain bony union in cases of fracture of the patella is due to the interposition of fringes of torn periosteum, etc., between the fragments, to the thick layer of clotted blood which coats the edges of the fragments, and to the fact that we are unable to bring the fragments into immediate approximation on account of the distension of the capsule of the knee-joint with blood and serum. The fragments of the bone ride upon the top of the distended capsule, and it is not possible to draw them together until the blood and serum have been evacuated from the knee-joint. After the knee-joint has been opened and the blood and serum cleared out it will be observed that the fragments can be approximated with very little effort.

A slightly curved incision is made across the front of the knee, the convexity being downward. When the very short flap which is thus marked out is dissected back, the line of fracture through the patella is exposed to view and the knee-joint is opened between the fragments. It will be observed that the dense fibrous capsule of the joint is torn to a greater or less extent upon either side of the patella and on a line corresponding to the line of fracture.

Any ragged edges of periosteum which overhang the edges of the bony fragments and which might get in between them are trimmed away with the scissors. Each fragment is, in turn, lifted up into the incision with a sharp hook and scraped free of blood-clot with the sharp spoon. The blood is cleared out of the joint with dry gauze wipes. The joint should not be irrigated.

The edges of the torn capsule are united with a sufficient number of sutures of kangaroo tendon; usually two or three sutures upon each side will suffice. The suture, which is placed immediately adjacent to the patella, is inserted very close to the side of the bone. When the sutures are tied it will be seen that the fragments of the patella are brought into very close apposition. Several sutures of chromic catgut may be inserted to bring the edges of the periosteum

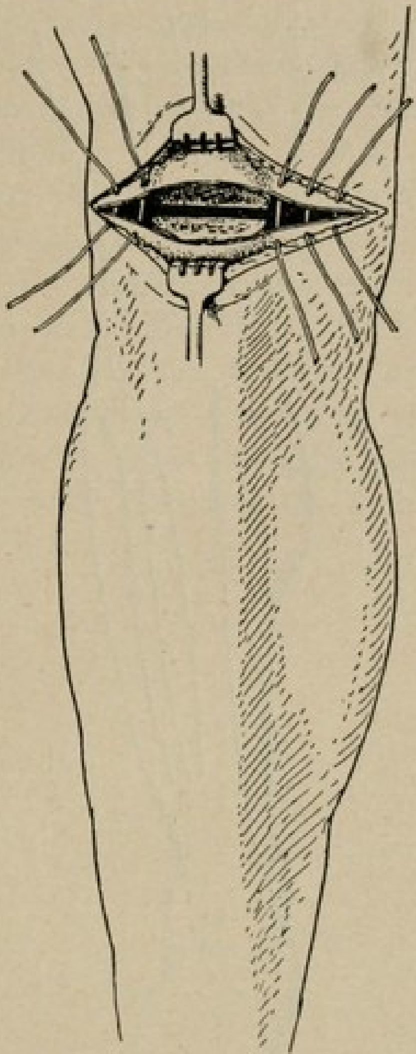

Fig. 363.—Operation for Fracture of the Patella. The edges of the torn capsule are brought together with a sufficient number of sutures, thus bringing the edges of the fragments into close apposition.

together along the line of the fracture. No sutures are introduced through the bony fragments themselves. All bleeding must be controlled so that the wound is perfectly dry. The incision in the skin is closed without drainage, and the limb placed in a plaster-of-Paris cast.

The strictest asepsis must be observed in this operation. Rubber gloves are worn by the operator and his assistant. The number of assistants should be limited to one. The parts are handled as little as possible and all oozing controlled before the incision is closed.

Osteotomy of the Femur for Genu Valgum—Knock-knee (Macewen).—The knee is somewhat flexed, its outer side resting upon a sandbag. A short longitudinal incision is made upon the inner

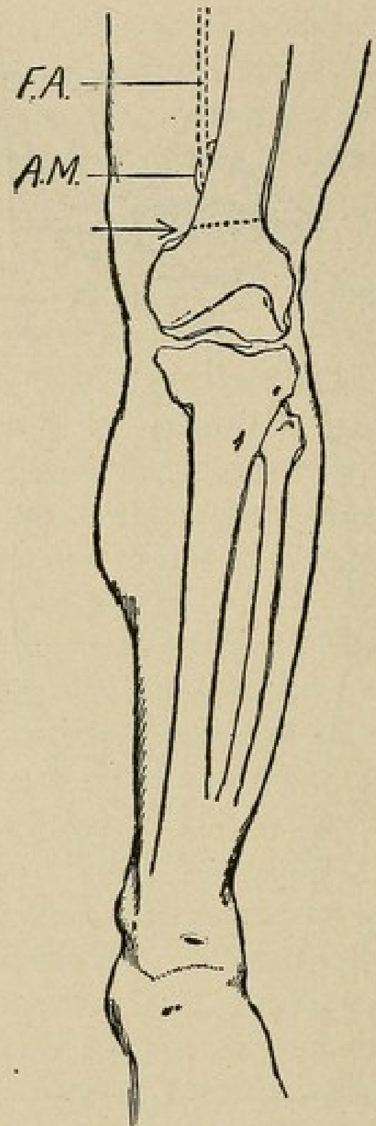

Fig. 364.—Osteotomy (*Macewen*). *A.M.*, opening in the adductor magnus through which the femoral artery (*F.A.*) passes into the popliteal space. Arrow indicates point at which the chisel is applied and the dotted line the plane of section for bow-legs and knock-knee.

side of the thigh just above the knee-joint. It is placed one finger's breadth in front of the tendon of the adductor magnus, its lower end upon a line which is drawn around the lower part of the thigh one finger's breadth above the upper border of the external condyle; or we may locate the lower end of the incision two fingers' breadth above the inner condyle and one finger's breadth in front of the tendon of the adductor magnus. The incision is prolonged upward for a distance of 4 cm. and reaches to the bone through the integument, vastus internus muscle, and periosteum.

The periosteum is separated from the surface of the bone over an area sufficient to allow the application of a broad chisel, with which the bone is divided, in a direction outward and slightly upward. The line of fracture does not pass through, but just above, the joint. The deformity is then corrected, and the limb, including the foot, placed in a plaster splint.

It is not necessary to chisel through the entire thickness of the shaft of the femur, but only far enough to allow one to gradually bend the bone into position—it should not be forcibly fractured or bent into position with a sudden jerk. The line of fracture is placed above the epiphyseal line, and therefore this operation may be done upon children and young people without interfering with the natural subsequent growth of the femur. This operation may also be done through an incision upon the outer aspect of the limb upon the same level.

INDEX.

(The names of arteries, veins, nerves, muscles, etc., are placed in the Index under the headings "Artery," "Vein," etc.)