the elbow at an open angle of 130 degrees, that is, approximately half-way between full extension and a right angle.

Forearm: If motion is expected to be re-established, immobilize the forearm in full supination. If a fixed arm is expected, place the elbow at mid-position between pronation and supination.

Wrist: The wrist should be dorsiflexed 40 degrees for either a fixed or mobile joint; the fingers and metacarpophalangeal joints should be left free.

Hip: Abduct the hip 10 degrees and flex it 15 degrees and rotate it externally 5 degrees, if a fixed hip-joint is expected. Thirty degrees is the most desirable degree of flexion as this will permit a comfortable sitting position as well as standing posture. However, 15 degrees usually suffices as the degree of flexion aimed at is in most cases exceeded. To retain mobility, the hip-joint should be fixed in complete abduction and extension.

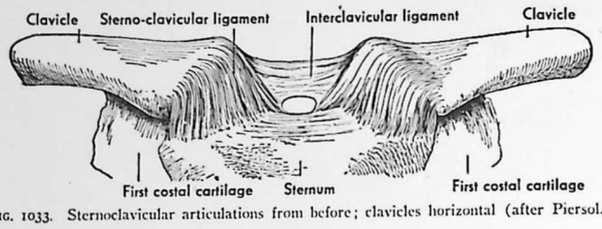


FIG. 1033. Sternoclavicular articulations from before; clavicles horizontal (after Piersol.)

Knee: Where either a mobile or fixed joint is expected, completely extend the knee but do not hyperextend it. Its inner aspect should be protected from strain as long immobilization tends to produce a genu valgum.

Ankle: Fix the ankle at 85 degrees for both a fixed and mobile joint. Support the sole properly—it should rest on a molded surface resembling the natural contour of the foot and supporting both arches.

DISLOCATIONS AND FRACTURES OF THE UPPER LIMB

DISLOCATION OF THE CLAVICLE

The maintenance of the sternoclavicular joint depends upon the integrity of its ligamentous connections and when these are ruptured, even if there is no loss of continuity in the bony tissue, the clavicle becomes dislocated (Figs. 1033-1034-1035). In old-standing cases reduction by any manipulative procedures is practically impossible and open surgical operation is the only method of obtaining satisfactory results. Care must be exerted, however, as suturing in this subcutaneous region is especially liable to suppuration.

Dislocation of the Sternal End of the Clavicle

Step 1. The approach to the joint is by a semilunar incision with its base downward. The soft tissues are incised and retracted and the ruptured ligaments are searched for.

Step 2. When the ligaments are found the clavicle is put in proper anatomic

position and the ligaments are sutured over it. It may be necessary to use any fascia or other tissue in the vicinity to strengthen the suture line; in some cases a transplanted piece of fascia is employed for reinforcement.

Step 3. The soft tissues are sutured and the external wound closed. Suitable splints and bandages are applied. The arm on the affected side is immobilized in a plaster Velpeau-like case which must be maintained for three to six weeks.

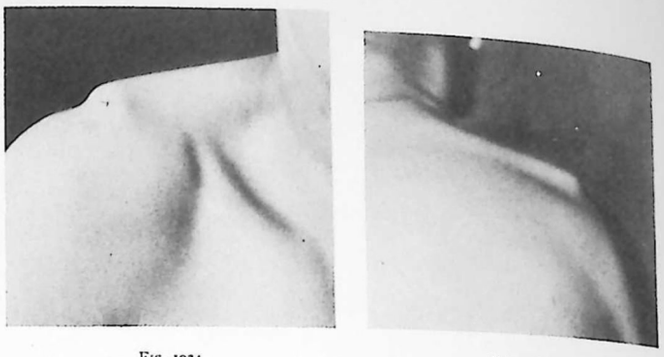


FIG. 1034 FIG. 1035

FIG. 1034. Acromioclavicular dislocation.
FIG. 1035. Acromioclavicular dislocation. Posterior view.

Dislocation of Acromial End of the Clavicle

In severe old standing cases, complete anatomic reduction and reposition can best be accomplished by open surgical operation.

Step 1. Expose the joint by a semilunar incision with its base toward the neck. Retraction of soft parts.

Step 2. Locate and clean the bone ends. Drill corresponding holes in the clavicle and acromion process and fix the two bony surfaces in correct position by either kangaroo tendon sutures or silver wire which should be made to embrace the coraco-acromial ligament, clavicle and acromial process.

Step 3. Suture the soft parts over the joint and close the external wound. The arm is immobilized in a position of abduction and the applied plaster cast is kept on for a period of at least five weeks.

Comment: Commenting on Acromioclavicular Dislocation and Its Repair, Frederick Jay Cotton and Gordon M. Morrison state the following:[1]

"The understanding of this dislocation, appreciation of its seriousness, and of the various problems offered in the handling of the injury, have not been helped by the confusion between two lesions different enough to be classed entirely apart.

"The common lesion, occurring usually from falls on the shoulder,

[1] New England Jour. of Med., Vol. 210, no. 19, May 10, 1934.

common on the football field for instance, involves nothing beyond tearing of the ligaments directly connecting the clavicle and the acromion.

"Sometimes there is a crumpling fracture of the outer end of the clavicle, but not often. There is a little upward displacement of the upper end of the clavicle, usually only a half an inch or so. Unless there is much muscle spasm this displacement is reducible by shoving the arm upward; particularly with the patient on his back.

"Treatment with any sling or apparatus to hold the whole arm up beyond the ordinary carrying point, brings about prompt healing of ligaments with displacement nearly enough abolished to leave no measurable disability, as a rule.

"Rarely it may seem advisable to suture the ligaments or to reeve a fascial strip through the bones across the joint. This lesion is really hardly important.

"The other lesion, from like violence but of severer force, involves not only a tearing of the ligaments about the joint, but also of the massive coronoid and trapezoid ligaments holding the clavicle to the coracoid process of the scapula. Such a tear may be so complete as to allow a direct displacement of the outer end of the clavicle upward. In two such cases, rather neglected, I have seen such displacement of at least two to three inches. Ordinarily it is less, but very definitely more than in the lesion first described. The bone-end may be replaced but not easily, and is hard to hold. Such an injury is serious. Mere confinement after reduction is entirely inadequate treatment. Even operation at the joint is a waste of time.

"Radical operation is the only cure. Various lashings have been used, but today one would use only fascia. The only reliable treatment is an operation of obvious mechanics, but one I think not often done. The incision runs from the pectoral insertion on the humerus up to and a bit beyond the clavicle, crossing about an inch and a half inside the outer end. This incision opens directly onto the interval between the deltoid and the so-called clavicular portion of the pectoralis major. Here lies the cephalic vein. Blunt dissection separates the muscles. The vein is carried outward; occasional ties may be needed.

"High up in the space the coracoid process presents an obvious hook. From it arise the tendons of origin of the pectoralis minor and the short head of the biceps. Blunt dissection opens up room behind them thereby permitting a circling of the coracoid hook. Directly above this point the clavicle, here broadened out, is drilled through but not encircled. It is drilled from above downward, a spatula being held beneath it, to guard against any slip. The hole is enlarged to a quarter or even a third of an inch (Fig. 1036).

"The fascia, a long and very strong strip, is obtained from the fascia lata in the usual way, cleaned, rolled up to a cord, passed down through the clavicle under the coracoid from within outward (behind the tendons so it cannot slip off) brought up and forward, tied in a square knot with the free end lying in front just below the clavicle. The knot is caught with stitches of chromic gut or silk as usual. Next comes the repair of

the acromioclavicular ligaments, probably not very important. After this operation, firm sling support is needed for at least six weeks.

"As in all surgery with fascial sutures, there is presently some slack, no matter how tight the fascia is drawn, and how firmly knotted. I have done this operation on about six cases. In all that I have done or observed, thus operated on, the results have been mechanically competent and clinically good. And this applies to several cases operated some weeks after injury."

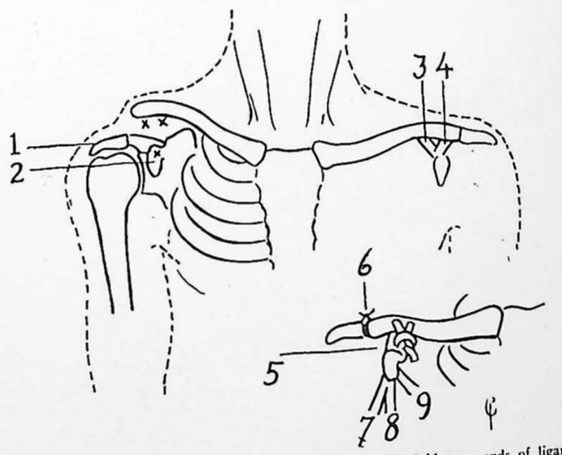


FIG. 1036. Acromioclavicular luxation: 1. acromion; 2. coracoid, torn ends of ligaments on clavicle and on coracoid process; 3. coracoid ligament with normal attachments; 4. trapezoid ligament with normal attachments; 5. the knotted fascial band through clavicle, around coracoid, back of the attachments of origin of the muscles; 6. direct suture of torn acromioclavicular ligaments; 7, 8 and 9. the short head of the biceps, the coracobrachialis, the lesser pectoral, at their origins.

FRACTURES OF THE CLAVICLE

Simple fractures of the clavicle with little or no displacements of fragments rarely call for more than support of the upper limb with a suitable sling and the use of one of the many methods which have been devised for immobilizing the clavicle as far as possible; this represents the so-called "manipulative treatment." Even in complete fractures with considerable displacement of the fragments, manipulative reduction of the fracture is generally easy; but maintenance of the fragments in close apposition, especially in restless young patients in whom this type of fracture is most generally met, without open surgery, is practically impossible (Fig. 1037). Nevertheless, union is generally obtained with only a moderate amount of callus and without much apparent deformity. An ideal anatomic union of the fractured bone ends is scarcely ever obtained. For these and other reasons some surgeons advocate open surgical reduction and

fixation of all complete clavicular fractures from the first, or at least when, following manipulative reduction, much displacement and overriding of the fragments persist.

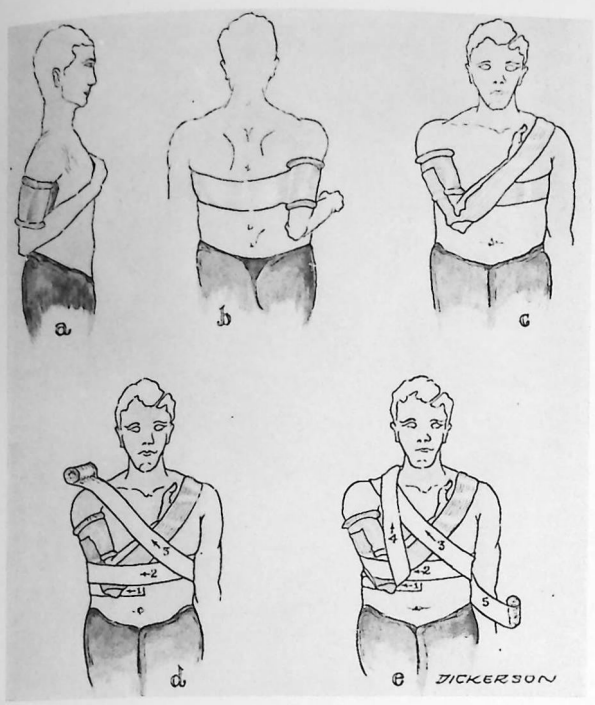


Fig. 1037. Sayre dressing: a. shoulder is held back by a padded adhesive loop about the arm, a pad is in the axilla, b. adhesive strip containing the loop is carried around the back and over the anterior chest, c. a second adhesive strip is carried from the back of the arm over the elbow point, forearm and shoulder, d. Valpeau dressing applied over the Sayre dressing. Repeat the five illustrated turns several times.

Open operative treatment of clavicular fractures is indicated under certain conditions (Figs. 1038-1039-1040) viz:

1. In serious compound or comminuted fractures due to a crushing or other violent injury.



Fig. 1038. Fracture of the clavicle. Muscular traction prevented the reduction of the fragments. Three unsuccessful attempts.

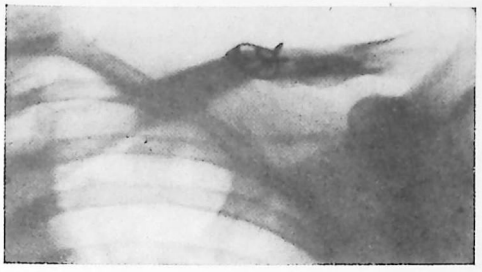


Fig. 1039. Fracture of the clavicle. Same patient, after open reduction and immobilization.



Fig. 1040. Fracture of the clavicle. Same patient. Final result.

2. In recent irreducible fractures.

3. When a fracture has healed with considerable deformity due to overlapping of the fragments and shortening of the clavicle.

4. When there is non-union or only fibrous union of the fragments continuing for a considerable time after the fracture.

5. When there is serious functional impotence of the arm or hand owing to the fracture fragments or callus involving the brachial plexus or the subclavian or other blood vessels in the immediate vicinity of the clavicle.

6. In bilateral clavicular fractures. An open surgical operation may, therefore, be indicated either immediately following or at a considerable time after the actual injury.

The technic most generally adopted is as follows:

Step 1. An incision, at least 1½ inches long, is made parallel to the line of the acromioclavicular joint. The incision is made either immediately over the bone or curved with its base upward so that a wide flap of the soft parts can be turned up before the bone is exposed. The latter has the advantage that the clavicle can be covered with intact skin which is particularly desirable to avoid a disfiguring scar in the case of women. If the particular case demands it a second incision can be made along the posterior border of the clavicle.

Step 2. The site of fracture is exposed, the bone ends freed and all callus removed. According to the degree of separation of the fragments the surgeon will have to decide upon the method of osteosynthesis to be employed, namely, drilling and suturing the two ends, wiring, plating or bone graft. If a drill is used care must be taken not to injure the underlying subclavian vessels. If a metal plate is used it must, of course, first be molded to the shape of the bone and then screwed into place. These metal plates are liable to give rise to irritation and lead to infection. The tibial or rib bone graft method seems to be best when there is considerable separation of the fragments and in the case of old ununited fractures.

Step 3. In the case of a bone graft, the periosteum is stripped from the fractured bone ends for a few centimeters; the bone ends are freely freshened and a lateral or an intramedullary graft is secured by kangaroo tendon sutures passed through holes made in the graft and the bone ends. The stripped periosteum and soft parts are then sutured over the graft and the external wound closed. A retention dressing must be placed just as if no operative reduction had been made.

Step 4. As soon as union of the graft has been verified by x-ray investigation, the shoulder and, if necessary, the arm and wrist are reencased in a plaster of Paris dressing for several weeks until solid union takes place between them and the graft. If the osteosynthesis has been performed by means of wiring or plating, these foreign bodies, when causing irritation, should be removed at this time.

It should be emphasized that in any method of osteosynthesis the most important postoperative procedure is the means of securing coaptation of the fragments so that recurrence will not take place.

Much of what has been said above will also apply in cases of open surgical operation on other bones when there is faulty union or non-union of the bone

fragments, and it will not be necessary to repeat the subject matter when dealing with these conditions.

FRACTURES OF THE SCAPULA

Fractures of the scapula are rare except in severe accidents and they are then usually associated with other injuries. Closed fractures, whether of the body, of the neck or glenoid process of the scapula, are almost always treated by manipulative methods by which good results are usually obtained (Fig. 1041).

Open surgical operation is indicated in the case of non-union or when reposition of the fragments by manipulative measures is unsuccessful; also in the case of compound fractures. The incision is made over the site of fracture and the



Fig. 1041. Fracture of neck of scapula (rare).

fragments are held in anatomic position by wiring or heavy absorbable sutures; small spicules of bone are removed. The same precautions during and after operation are taken as have been described for fractures of the clavicle.

DISLOCATION OF THE SHOULDER JOINT

This may result from falling on the shoulder or hand. In the usual case (subcoracoid) the head of the humerus follows a downward and forward direction and comes to rest below and outside the coracoid process.

It should be remembered in diagnosing this condition that the contour of the shoulder is flat and the acromion process very noticeable. The axis of the arm is oblique, being directed upward and inward and displacing the elbow from the side. The fingers of the surgeon inserted under the acromion process will find that the head of the humerus is absent from its normal location and instead a bony lump is felt immediately under the coracoid which with gentle rotation of the arm will prove to be a head. The arm is helpless, no motion being possible

at the shoulder joint. This condition is sometimes not diagnosed as after the first shock the pain is not great and some movement (scapular) may be possible. X-ray and palpation should confirm the diagnosis (Figs. 1042-1043-1044-1045-1046).

The subscapularis muscle obstructs reduction by being stretched over the head, holding it down on the ventral aspect of the scapula; thus, relaxation of this muscle is necessary before reduction can take place. It is recommended that an anesthetic be given. Reduction is done in four steps.

Step 1. Bring the elbow into contact with the side of the thorax (Fig. 1047).

Step 2. Relax the subscapularis by rotating the arm with great care, externally. Force should be applied very gradually. Bend the elbow and exert strong traction on the arm while rotating it (Fig. 1048).

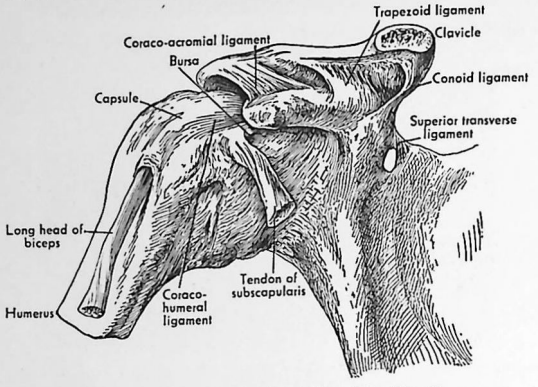


Fig. 1042. Right shoulder joint from in front (after Piersol).

Step 3. Lever the head of the humerus down until it is directly opposite the lower part of the joint by bringing the elbow forward, inward and upward, at the same time continuing the external rotation at the shoulder and traction in the long axis of the humerus (Fig. 1049).

Step 4. Rotate the arm in, bringing it across the chest to the opposite axilla until the head of the humerus slips into the joint (Fig. 1050). This method is recommended by Kocher and requires no force at any time. However, it may not succeed if the shoulder has been dislocated for several days. In that event reduction may be brought about by exerting traction on the arm at right angles to the trunk (Fig. 1051).

Have an assistant exert countertraction by pulling on a folded sheet which has been placed around the upper part of the chest under the axilla; a second assistant exerts strong traction on the abducted arm while the surgeon moves the limb from side to side trying to get the head back in position.

Some maintain that the method of directly pulling on the arm while the surgeon's foot is in the patient's axilla is contraindicated on account of the danger of injuring important nerves and blood vessels and possibly fracturing ribs. This statement should, however, be qualified because experienced surgeons have for decades resorted to this, the Doyen method of treating shoulder dislocations with excellent results. Judgment and systematic procedure are followed by good results here. I have made use of this method on numerous occasions with



Fig. 1043. Subcoracoid dislocation of the left humerus. Observe difference in appearance of shoulders.

gratifying results. In speaking of the Doyen method Paul B. Magnusen states: "A considerable amount of force can be used without damage, the heel being used not only for countertraction but to press the head backward and upward toward the glenoid. In my experience this has been the more uniformly successful method." Figures 1052-1053, and 1054 depict the procedure. The legends on the illustration describe the steps.

A sling should support the arm for about 3 weeks, electrical treatments given the muscles and shoulder and movements begun. Full abduction of the shoulder should not be attempted before the expiration of three or four weeks.

Old shoulder joint dislocation may call for an open surgical operation on account of symptoms resulting from pressure on nerves or blood vessels and for functional as well as cosmetic improvement. The general intention of such opera-

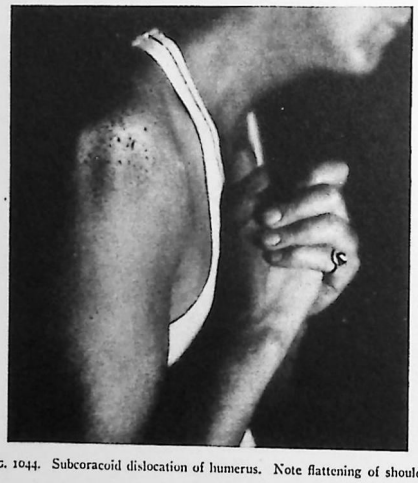


Fig. 1044. Subcoracoid dislocation of humerus. Note flattening of shoulder.



Fig. 1045. Subcoracoid dislocation of the humerus.

tions is to restore the head of the humerus to a normal and permanent location. A number of different technics have been described.

Step 1. Make an anterior incision over the head of the humerus.

Step 2. The conditions constricting or restricting the movements of the head of the humerus in the glenoid cavity should be investigated, and from what he

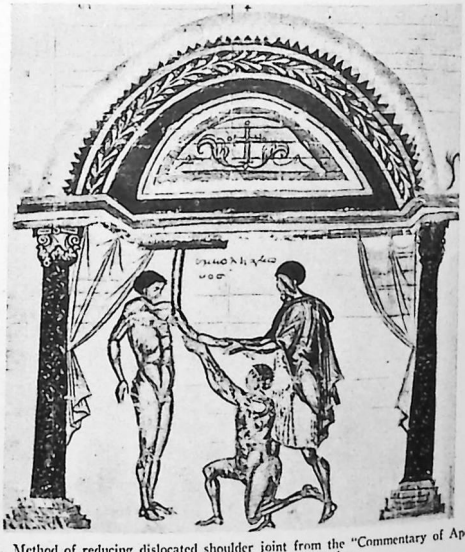


Fig. 1046. Method of reducing dislocated shoulder joint from the "Commentary of Apollonios of Kitium" from his work on dislocation.

finds the surgeon must decide upon what method to follow in order to restore conditions to normal.

Habitual and Recurring Dislocation of the Shoulder

While not common, this occurs frequently enough to interest the surgeon. The types of surgical interference for correcting this condition include operations upon the capsule, operations upon muscles and check ligaments, arthrodesis of the shoulder joint and bone transplants, the last method being probably the most satisfactory. The steps are as follows:

Step 1. The deltoid muscle is partly cut through at about 1 cm. below its clavicular insertion.

Step 2. The tip of the coracoid process is sawn off so as to lower the coracobrachialis and pectoralis minor muscles.



Fig. 1047



Fig. 1048

Fig. 1047. Dislocation of the shoulder; Kocher's method of reduction, Step 1: bring the elbow into contact with the side of the thorax.

Fig. 1048. Dislocation of the shoulder; Kocher's method of reduction, Step 2: the forearm is carried outward into the transverse axis of the thorax.



Fig. 1049



Fig. 1050

Fig. 1049. Dislocation of the shoulder; Kocher's method of reduction, Step 3: elevation of the elbow.

Fig. 1050. Dislocation of the humerus; Kocher's method of reduction, Step 4: inward rotation.

Step 3. Oudard placed a bone transplant, 3 to 4 cm. in length, on the anterior part of the joint, between the base and sawed off the tip of the coracoid process

so as to oppose the tendency of the head of the humerus to forward projection. Eden placed the transplant underneath the raised periosteum of

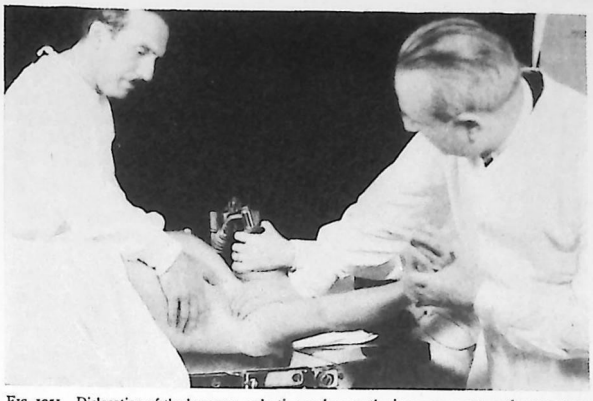


Fig. 1051. Dislocation of the humerus, reduction under anesthesia; surgeon attempting to return head of humerus into its socket.

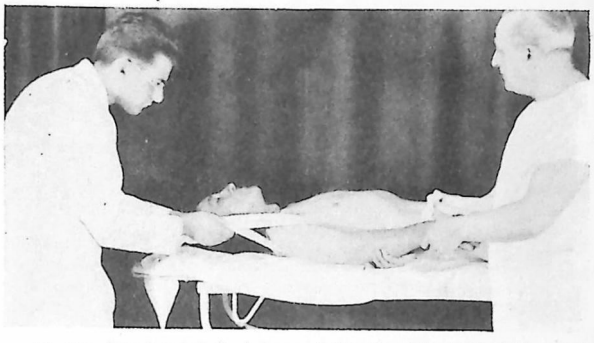


Fig. 1052. Doyen's method of reducing recent dislocation of the shoulder joint; general anesthesia. First step: Make sure there is no fracture (x-ray); surgeon grasps the dislocated forearm, pulling it toward himself; a counterextension bandage is put in the axilla and steadied by an assistant.

the neck of the scapula so that from ½ to 1 cm. protruded in front of the joint.

Step 4. Closure of the wound.

In dislocations of the humerus complicated by fractures of the greater tuberosity or a portion thereof where it is impossible to manipuluate the head of the humerus to bring it into apposition with a fragment in the hope that it will

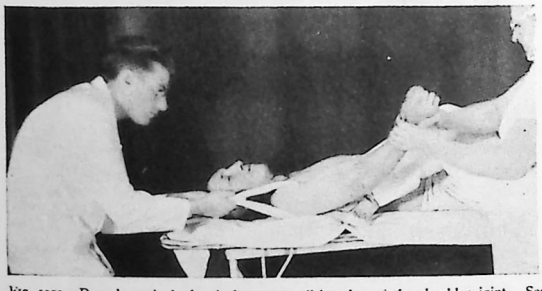


Fig. 1053. Doyen's method of reducing recent dislocation of the shoulder joint. Second step: Extend the arm in a direction perpendicular to the axis of the patient's body, put an unbooted foot in the axilla; the foot is placed against the protecting band held by the assistant; disengage the head of the humerus by pressure from the foot while the assistant draws it toward the glenoid cavity by forceful traction in a direction parallel to the axis of the patient's body.

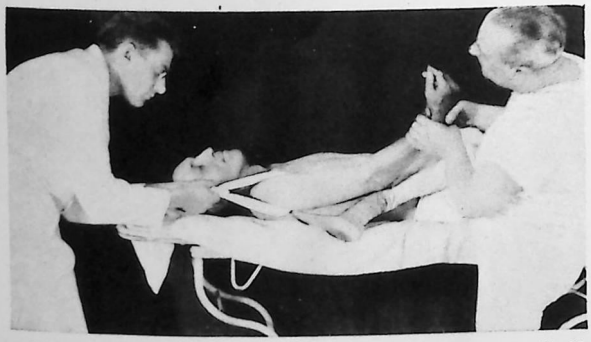


Fig. 1054. As soon as the head is placed back into the glenoid cavity, the surgeon slips his foot toward the scapula and brings the patient's arm toward the side of his body. Doyen remarked that while a certain amount of physical vigor is necessary to accomplish this reduction, it is the safest and surest method of all.

unite, operation is indicated for its removal or fixation. The operation described by Golder L. McWhorter[1] is an excellent procedure.

McWHORTER'S OPERATION

Step 1. Make an incision along the lower border of the spine of the scapula and the acromion process (Fig. 1055 A). The mesial end of the incision

[1] Surgical Clinics of N. A., Vol. 12, Oct., 1932.

extends rather sharply downward permitting adequate reduction of the deltoid muscle.

Step 2. Divide and retract the skin and subcutaneous tissue. Expose the deltoid muscle and divide it along the spine of the scapula leaving about 1 cm. of muscle attached to the bone (Fig. 1055 B). Retract the deltoid downward, thus exposing the posterior and lateral surfaces of the shoulder joint as well as the upper end of the humerus and bringing into full view the teres

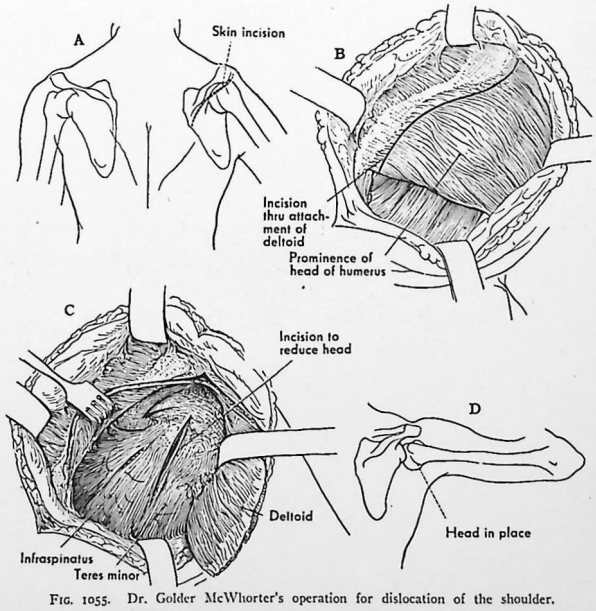


Fig. 1055. Dr. Golder McWhorter's operation for dislocation of the shoulder.

minor and infraspinatus muscles and their attachment to the fractured greater tuberosity of the humerus (Fig. 1055 C). If conditions are favorable, the detached greater tuberosity may be resutured to its normal site or it may be removed and the tendon sutured to the humerus.

Step 3. Abduct and externally rotate the arm bringing the tendons of the supra and infraspinatus muscles well over their original site on the humerus. Drill a hole through the cortex of the humerus just below the point of fracture. Through the drill hole thus made chromic catgut is passed and sutured to the tendons; the structures are firmly fixed in their original position (Fig. 1055 D). Drill holes may be dispensed with and mattress sutures substituted.

Following the operation immobilize the arm in abduction and keep it splinted for about 5 weeks.

Kellogg Speed describes his method[1] of dealing with habitual dislocation of the shoulder as follows: "An incision is made from just below the coracoid process straight down for about 4 inches and passing through skin, superficial tissue and fascia. The edge of the pectoralis major muscle is then identified at the lower angle of the incision. By blunt dissection the left index finger is pushed up under the muscle until its superior border is reached and at the point of junction with the deltoid the finger is hooked through and the muscle is cut transversely across its fibers for about 1½ inches from the tendinous insertion into the humerus. The axillary contents are exposed and the nerves and vessels placed out of the way; the edge of the glenoid fossa is palpated deep and brought into view.

"A chisel is inserted into the scapula, just anterior to the glenoid edge, and a slot, 1½ inches deep, is formed in the scapula into which a bone transplant from the tibia may be driven leaving about ¾ inch projecting anteriorly and obliquely across the lower anterior margin of the shoulder joint. The joint capsule is not necessarily opened. This procedure in no way interferes with the normal range of shoulder joint motion but it does prevent the head of the humerus from slipping forward in habitual dislocation."

CLAIRMONT'S OPERATION

Step 1. From the coracoid process, carry an incision outward and downward for six inches along the anterior border of the deltoid muscle. Carefully separate the deltoid fibers until the quadrilateral space is identified. Enlarge it by cutting the upper portion of the teres major.

Step 2. Palpate the posterior border of the deltoid and define its edge by a four-inch incision parallel to that in Step 1. Select a muscle bundle about one and one-half inches broad. Separate it from the main mass of the deltoid with great care. Detach it from its humeral insertion with a portion of adherent periosteum. Throughout these maneuvers have identified and protected the axillary nerves.

Step 3. Pass a hemostat from before backward through the quadrilateral space; grasp and draw the deltoid muscle slip forward. Bring the muscle slip snugly beneath the head of the humerus and suture the tip containing the periosteum to the coracoid process. If the muscle is too short unite it with adjacent muscle structures (Fig. 1056).

Step 4. Close the wound. Dress and maintain the arm in 65 degrees of abduction in plaster of Paris airplane splint for about six weeks.

FASCIAL FIXATION OPERATION

This procedure is expedited by having two operating teams, one to supply a fascia strip to be used for fixation, and the other to tie it in place.

A strip of fascia lata measuring ten by one-half to three-quarters inches is removed and immediately utilized as follows:

Step 1. A four-inch incision is made in line with the fibers of the deltoid muscle and one and one-half inches above its anterior border. The fibers are then carefully separated until the capsule of the humerus is exposed.

[1] "Fractures and Dislocations," 3rd Edit., 1935.

Step 2. In a similar manner a posterior incision is made and the capsule exposed.

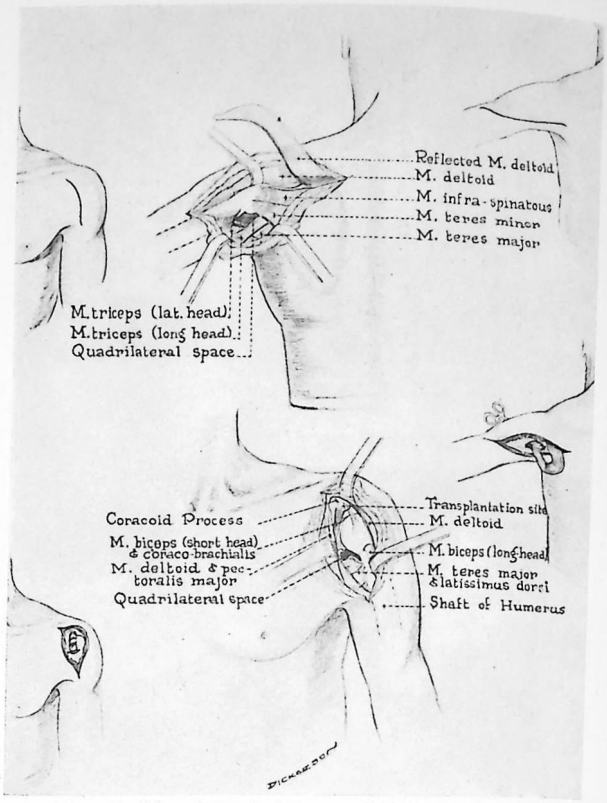


Fig. 1056. Clairmont's operation for recurrent dislocation of the shoulder.

Step 3. Bring the forearm to a right angle with the shaft of the humerus which is abducted at 65 degrees and firmly held. Palpate the head of the humerus and pierce its upper pole from behind forward with a drill hole (Fig. 1057).

Step 4. With a curved forceps form a subcutaneous tunnel from the upper limit

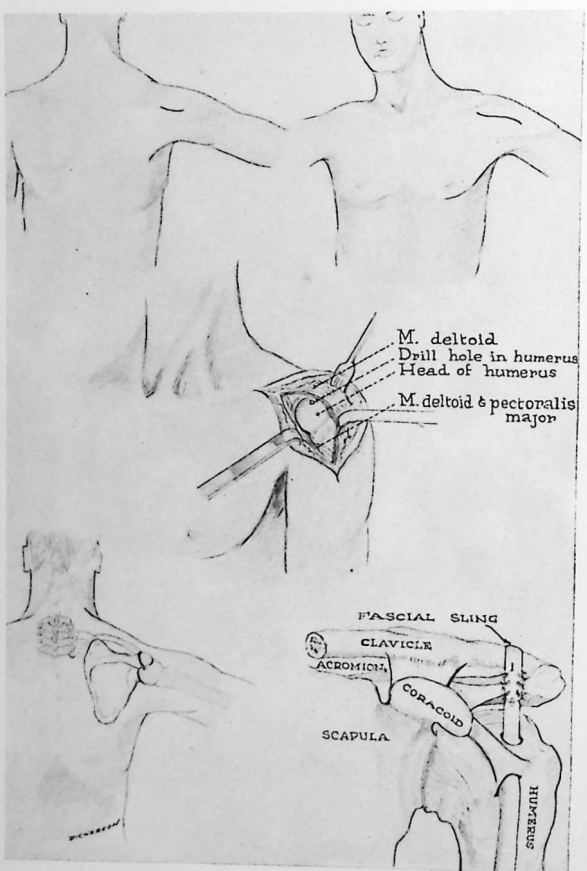


Fig. 1057. Fascial sling repair for recurrent shoulder dislocation. See text for description of steps.

of the posterior incision forward and over the acromion to the upper limits of the anterior incision. Roll the strip of fascia lata into a tubular form and pass it through the head of the humerus and thence over the acromion. Pull the sling thus created taut and very carefully suture the two ends.

Step 5. Close the wounds. Dress and place the arm in 65 degrees of abduction.

Commenting on the treatment of recurrent dislocation of the shoulder, G. E. Bennett[1] says that if the head of the humerus is to be prevented from slipping forward it must be stopped by a check ligament, transferred muscle or bony obstruction placed on the scapula anterior to the head of the humerus. Most cases need only a check which is equal to the tensile strength of the anterior part of the capsule of the joint which is usually the only damaged and weakened structure.

Bennett also stresses that while many operations have been described to remedy this condition it is best for convenience' sake to group these as

1. those designed for the repair and reinforcement of the capsule (Thomas and Keller);

2. those in which a bone graft is used to act as an abuttment to prevent the head of the humerus from passing forward (Eden and Speed);

3. those in which an attempt is made to establish a check ligament attached to the scapula and humerus in such a position that it is drawn taut when the arm is abducted and hyperextended. This form of surgical therapy embraces muscle-plastics, tenoplasties and free transplant of tendon and fascia (Joseph, Rich, Gibson, Löffler, Plummer and Pott, Wolfing, Hoke, Carrel and Bennett). Since the introduction of fascia in the repair of relaxed structures, there has been a constantly increasing use of this material in the repair of the capsule and the construction of a check ligament that prevents the head of the humerus from slipping forward into a dislocation.

These operations have one pivotal point, viz., to attach the fascia to the acromion process of the scapula. The attachment to the humerus varies. Bennett used this procedure in 14 cases with apparent success.

BENNETT'S OPERATION

Step 1. Approach the shoulder joint through an anterior incision beginning at the acromion process and extending downward, dividing the fibers of the deltoid and exposing the anterior and inferior part of the capsule. Identify the long head of the biceps as a guide to the line of fascial sutures.

Step 2. Take a strip of fascia from the tensor fasciae femoris and fix it to the Gallie type of needle. Rotate the arm externally to allow suturing as far forward as possible; lace the fascia into the capsule as shown in Fig. 1058.

Step 3. Draw the capsule taut (Fig. 1059) and fix the lacing firmly to the capsule by chromic catgut sutures. Insert the fascia through the tip of the acromion process with a needle or by drilling a hole through the process and secure it here and to the anterior part of the capsule. It is usually brought lower than shown in the illustration.

This transplant and suture take up the slack from the anterior capsule and establish a ligament reaching from the acromion to the anterior capsule; the

[1] International Surgical Digest, Vol. 5:67-70, February, 1928.

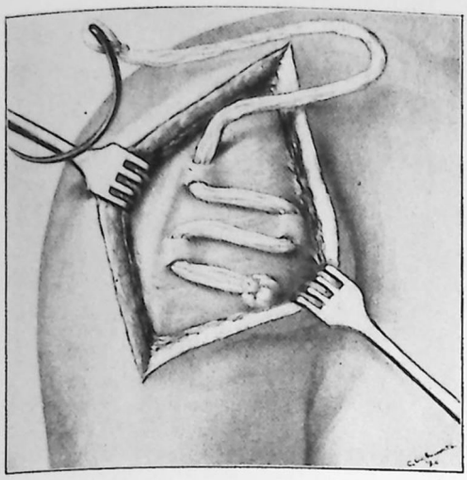


FIG. 1058. Bennett's operation for the treatment of recurrent dislocation of the shoulder. Fascial sutures introduced. (Courtesy Dr. G. E. Bennett and W. F. Prior Co.)

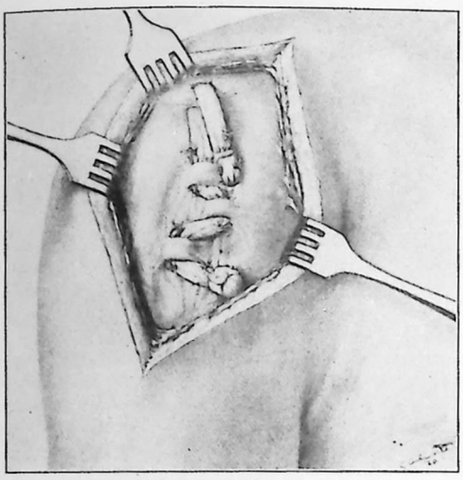


FIG. 1059. Bennett's treatment of recurrent dislocation of the shoulder. Relaxed capsule drawn taut and fixed; fascia inserted into acromion and reattached capsule. (Courtesy Dr. G. E. Bennett and W. F. Prior Co.)

may be nonunion for a long time after manipulative reduction and if the head of the humerus is dislocated it may compress the axillary vessels or nerves (Figs. 1060-1061-1062-1063-1064). The general surgical procedure is as follows:

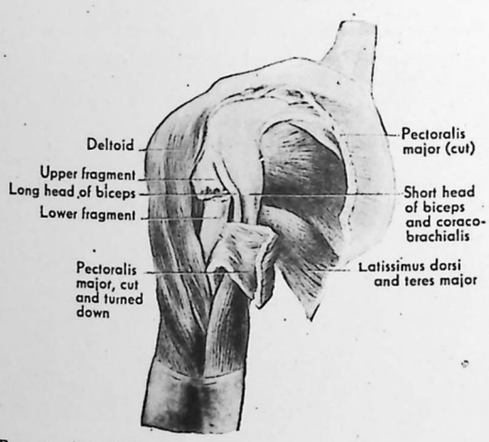


FIG. 1060. Dissection of fracture of surgical neck of humerus. (After Piersol.)



FIG. 1061. Fracture of surgical neck of humerus with marked overriding displacement.

Step 1. A long anterior incision is made, starting at the acromion, level to expose the head of the humerus over the interval between the pectoral and deltoid muscles; or Kocher's incision in front of the acromioclavicular joint

subscapular tendon may be included. This reinforces the capsule and prevents anterior dislocation of the shoulder. Immobilize the arm in a Velpeau type of bandage for four weeks; begin to use it gradually.

Comment: In a later communication[1] Bennett summarizes his findings as follows:

"In cases of old dislocation of the shoulder, operation is indicated for restoration of function and relief of discomfort.

"Operation is advised in all early cases. In the older cases, in which the shoulder has been dislocated for several months and there is painless adaptation with 50 degrees of free movement, operation is not advisable. Experience has shown that the end result in these cases is seldom perfect function of the shoulder with a free range of motion. In most instances the free movement obtained is in proportion to the duration of the dislocation. The early cases are much more successful.

"Weakness of the deltoid is present in a large percentage of cases following operation. This may be due either to the original injury or to the operation, as the nerve supply to the deltoid may be easily damaged by the division of the subscapularis muscle.

"The first step in the operation, in the author's opinion, is the clearance of the glenoid fossa and the division of the subscapularis muscle, but the most difficult step is the reconstruction of the anterior portion of the capsule. This may be accomplished by utilizing the long head of the biceps, as described by Nicolai in his treatment for recurrent dislocation of the shoulder, or by reenforcing the anterior part of the capsule with fascial sutures. In one or two instances the writer has transferred the tendon of the coracobrachialis and the long head of the biceps and attached them to the short superior portion of the capsule, thus reenforcing the anterior part of the joint. While operation for an old dislocation of the shoulder may not result in 100 per cent function, it is much more satisfactory than a resection of the head of the humerus for the same condition."

FRACTURES OF THE HUMERUS

Fractures of the humerus may be treated by the manipulative or open surgical method depending upon whether the fracture is simple or compound and upon several other factors. Generally, the manipulative method is preferred for uncomplicated fractures. In the Report of the Committee on Fractures of the American Surgical Association, published in 1922 (p. 91), it is stated that 38 per cent of the cases of simple fractures of the humerus reported upon were treated by the open operative method, indicating that anatomic reduction of these fractures without the assistance of vision directly upon the fragments is very difficult in a large number of cases. The Committee found that both in nonoperative and open operation methods when a good anatomic result was obtained a good functional result is likely to follow. This remark applies equally well to all other fractures besides that of the humerus.

Fracture of the Surgical Neck of the Humerus

Fracture of the surgical neck is a type of injury which may fail to be relieved by manipulative measures and open surgery is therefore indicated. There

[1] The Journal of Bone and Joint Surgery, July, 1936.

may be employed. The tendon of the pectoralis major is cut and the deltoid muscle is split. The circumflex nerve is located.



FIG. 1062. Same as preceding after closed reduction.

Step 2. When the head of the humerus is located, the capsule is split so as to expose the bone. If there is any callus it must be removed.

Step 3. According to conditions found, the surgeon must decide whether he will attempt reduction and anatomic reconstitution of the parts or excise the head of the humerus. If badly comminuted or necrotic, the head should be removed. Removal of the head fragment need not interfere with the integrity of insertion of the muscles in the surgical neck. If the head is removed the upper part of the diaphysis should be freshened and rounded off. If the fracture is very low, the muscles may have to be reinserted in the surgical neck. The use of internal metal or bone splints is inadvisable in this type of injury. If the head is not removed, attach it to the diaphyses by strong sutures.

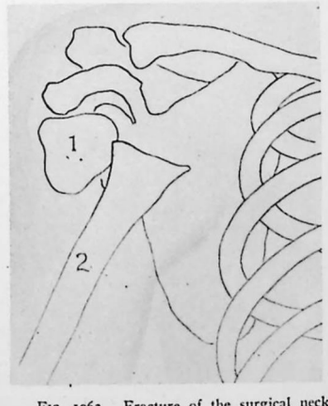


FIG. 1063. Fracture of the surgical neck of the humerus, reconstructed from x-ray: 1. head, 2. shaft.

Step 4. Closure of the external wound. Place the arm in a plaster cast and fix it in position of adduction close to the thorax with an axillary pad for 3 weeks.

The same type of operation applies to old dislocations of the head of the humerus.

The nonsurgical treatment of fracture of the surgical neck of the humerus is depicted in Fig. 1064.

Supracondylar Fracture of the Humerus

Like the foregoing, this fracture is difficult to reduce and maintain by manipulative methods (Fig. 1070). The line of fracture is usually from behind extending downward and forward. The short distal fragment is displaced backward and slightly upward and the long proximal fragment projects into the cubital space, occasionally injuring the ulnar or median nerve or neighboring blood vessels. When not surgically reduced, healing usually takes place with a mass of callus which seriously interferes with flexion of the arm and considerable deformity. Palsies may appear late. Open surgical correction is the better way of dealing with such fractures. Or, use skeletal traction through the proximal end of the ulna with the forearm in flexion supported by a Balkan frame.



Fig. 1071. Fracture of internal condyle of humerus.

Step 1. The fractured region is exposed by a medial incision along the inner side of the arm, about 3 inches above the elbow, passing over the internal condyle and down the forearm for about 2½ inches; a flap is turned up which exposes the ulnar nerve which is dissected and retracted and the fracture tract exposed and treated as indicated.

Step 2. The bone fragments are replaced in correct anatomic position and are wired or pegged; the elbow is put up in a position of extreme flexion (90-100°).

Step 3. The forearm and elbow region are placed in a plaster cast for about 12 days before motion is started.

Fracture of the Internal Condyle of the Humerus

This fracture is rather rare and results from an upward displacing force being transmitted through the ulna to the internal condyle (Fig. 1071). Reduction is usually easily effected and a plaster cast maintains the forearm flexed 90 degrees at the elbow and rotated into full pronation. There is, however, a tendency for displacement to recur when the reducing force is removed. For this reason and because the ulnar nerve is frequently involved, open operation is often necessary.

Step 1. Expose the fracture through an incision along the inner side of the arm being careful not to injure the ulnar nerve.

Step 2. Examine the canal of the ulnar nerve—the nerve, if damaged is dissected free and transplanted to the front of the elbow.

Step 3. Reduce and nail, screw or suture the fractured condyle to its original location.

Step 4. After closing the wound, maintain the arm in the position previously described.

DISLOCATIONS AT THE ELBOW JOINT

Posterior dislocation is readily discerned on account of the backward projection of the olecranon process with the triceps inserted into it and of the articular surface of the humerus in front (Fig. 1072). Either or both bones may be dislocated either backward, forward or laterally; the condition encountered most frequently, however, is that in which both bones are displaced backward.

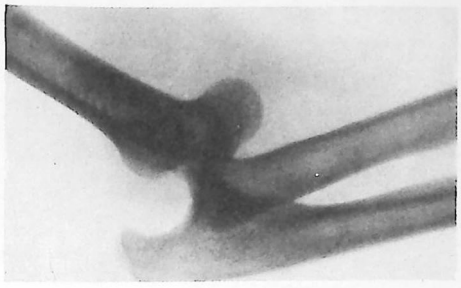


Fig. 1072. Dislocation of the elbow.

If the ulna alone is dislocated, it is always displaced backward; the radius, more frequently forward. In case of dislocation of the ulna alone, or both bones, reduction is brought about by flexing the arm around the knee of the operator. After the patient has been seated in a chair, the surgeon places his foot on the seat and bends the elbow around his knee. In this way, the coronoid process of the ulna is levered over the end of the articular surface of the humerus.

In case of dislocation of the radius alone, hold the arm above and below the elbow, straighten and bend it at a right angle. At the same time press the head of the bone into position.

Where muscular spasm is marked, administer a general anesthetic. Figures 1073-1074 depict the method of reduction of a backward dislocation of the elbow and that of the head of the radius.

After reduction has been accomplished, bandage the arm at right angles, keeping the hand midway between pronation and supination. In case the radius has been displaced, place a pad over its head to hold it in position. Begin passive movements in about 7 days.

FRACTURES OF THE OLECRANON

The most usual site of fracture of the olecranon is at its junction with the shaft of the ulna (Fig. 1075). The method of repair generally is by suturing or wiring, but special methods such as bone inlay may be employed.

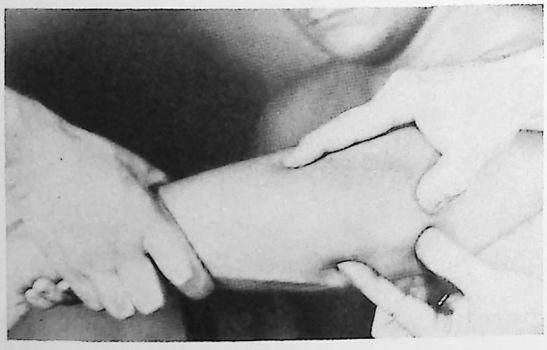


Fig. 1073. Reduction of backward dislocation of the elbow.

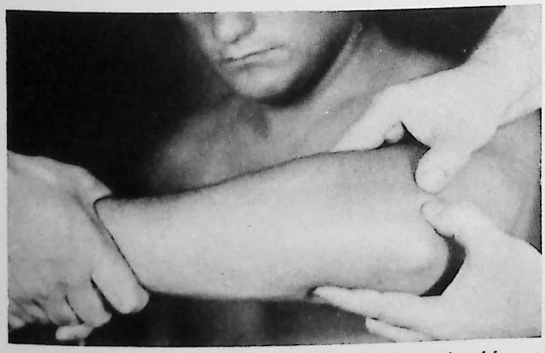


Fig. 1074. Dislocation of the head of the radius which is reduced by traction of forearm and direct pressure on the head of the radius.

Step 1. Either an oval incision is made with its convexity upward passing around the olecranon or a median longitudinal incision beginning and ending considerably above and below the line of fracture but not involving the muscles above or below. The incision is carried down to the bone.

Step 2. The procedures here—exposing the fractured ends of bone, drilling the two fragments, passing and tightening of the wire, suturing the torn periosteum and fascia and closure of the wound—are identical with the method of dealing with a fractured patella by suturing or wiring.

Step 3. The limb is put up in full extension supplemented by anterior plaster of Paris cast.

If the fracture is compound, if there is considerable effusion of blood and if the proximal fragment is retracted very much and is very mobile, the following surgical treatment is indicated.

Step 1. The fracture fragments are exposed by cutting and turning up a U-shaped flap or by a transverse incision or by enlarging the wound in case of a compound fracture. If a transverse incision is employed, it is placed a little above or below the line of fracture.

Step 2. Cleanse the whole fracture area and excise any ragged ends of synovial bursa.

Step 3. The continuity of the bony parts is reconstituted by drilling, wiring, or other selected osteosynthetic procedure, the periosteum being first dissected back for a few centimeters from the fractured bone ends.

Step 4. The fibroperiosteal tissues are again united over the fractured area and the external wound closed.

Step 5. The elbow is kept elevated and in full extension. Put up in anterior splint. Movements of flexion and extension should be begun as soon as possible.



Fig. 1075. Fracture of the olecranon process of the ulna.

FRACTURE OF CORONOID PROCESS OF THE ULNA

This fracture is usually associated with posterior dislocation of the elbow. Old cases causing interference with flexion should be surgically treated.

Step 1. A lateral incision is made in front of the condyles of the humerus. The muscles are separated from the anterior surface of the condyles until the brachialis anticus and coronoid process are exposed.

Step 2. The disability is usually due to excessive callus formation or formation of bone in the tendon of the brachialis anticus. They should be removed and the tissues restored as far as possible to normal conditions.

Step 3. Close the wound. Dress and apply a sling. Passive and active movements should be begun early.

FRACTURES OF THE BONES OF THE FOREARM

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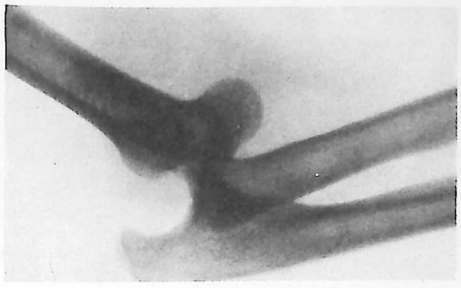


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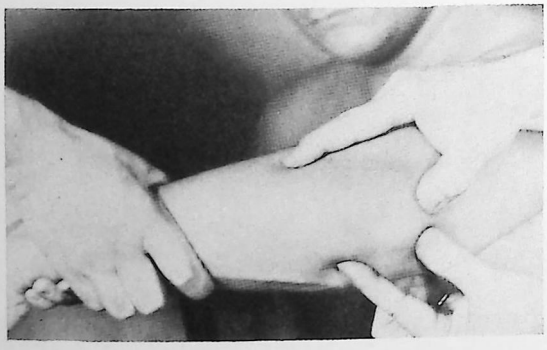


Fig. 1073. Reduction of backward dislocation of the elbow.

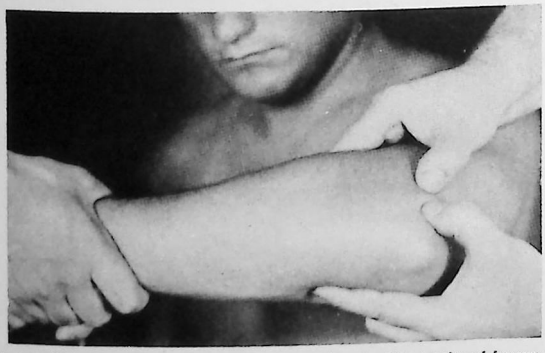


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Step 3. Close the wound. Dress and apply a sling. Passive and active movements should be begun early.

FRACTURES OF THE BONES OF THE FOREARM

Generally speaking, open surgical treatment of fractures of the bones of the forearm is only rarely indicated and manipulative methods on the whole give

better results (Figs. 1076-1077). The Committee on Fractures of the American Surgical Association in its Report issued in 1922, states that these fractures treated nonoperatively gave good functional results in 78 per cent of the cases as compared with 68 per cent of those treated by open operation; furthermore, the nonoperated cases showed only 2 per cent of bad functional results as compared with 13 per cent in the operated cases. However, it should be taken into account that the surgically operated cases in the main were those in which injury was most extensive and delay in adequate treatment most pronounced. Figure 1078 shows the method of reducing fracture of the forearm (reduction by traction and manipulation followed by immobilization).



Fig. 1076. Fracture of radius and ulna.

In open fractures of one or both bones of the forearm, the general surgical treatment is that of all other open fractures, namely, exposure of the fragments, uniting them by one of the ordinary osteosynthetic methods, removing bone fragments, cleansing the area and closure of the wound.

There are, however, several cardinal points which should be borne in mind. Do not hesitate to make two incisions for the exposure of the two bones but do as little sharp dissecting as possible. Before employing pegs or plates for reduction endeavor to draw the fragments into position by tying around them with chromic gut or kangaroo tendon, or by pulling them together with gut passed through drill holes in the bone. Do not close the wounds until both bones are in place.

Preserve this relationship by continuous traction during closure and dressing (Figs. 1079-1080).

Colles' Fracture

This fracture is caused by falling on the outstretched hand. The line of fracture occurs in the distal part of the radius; however, usually there is no involvement of the wrist joint; the distal portion is forced backward and upward; at the same time it leans toward the radial side causing the articular surface to face downward, backward and outward. Displacement of the lower fragment includes the hand and carpus. The fragments are very often impacted. Frequently the internal lateral ligament of the wrist is torn or the styloid process of the ulna is torn off (Fig. 1081).

Treatment

An anesthetic is commonly used during the correction of this deformity.

Step 1. Grasp the patient's hand (as for the salutation of "shaking" it); if the fracture is on the right side, use your right hand; if on the left side, the left. Disimpact and make longitudinal traction, keeping in mind the direction of the displacement. An assistant grasps the elbow and makes countertraction.

Step 2. Fix the fracture area with the free hand and press the displaced lower portion into position with the thumb, finally replacing the radius by wrenching the hand into a position of ulnar adduction.

Step 3. Secure the hand in position by means of a Carr splint (Fig. 1082). The Carr splint may be modified as follows to increase its efficiency: (a)

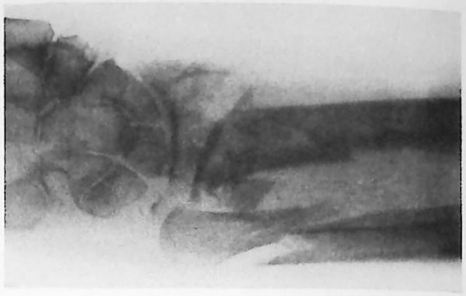


Fig. 1077. Comminuted splintering fractures of radius and ulna with separation of the epiphyseal line.

A broader posterior splint may be substituted for the usual one which is frequently too narrow; (b) A pad placed over the fractured area and one under

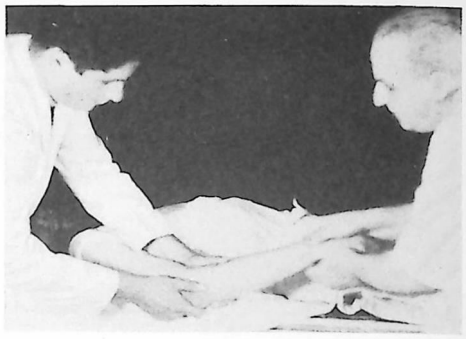


Fig. 1078. Method of reducing fracture of the forearm.

it will assist in keeping it in place; (c) There is likely to result an unpleasant swelling of the fingers if the splints are applied too tightly.

ROBERT JONES' METHOD

In the more complicated types of Colles' fracture, Sir Robert Jones' method should be used:

Step 1. Take the patient's forearm in the left hand while your right hand is placed on the back of the patient's wrist (Fig. 1083). While firmly gripping the wrist, slightly pull and twist it, reducing the fracture.

Step 2. Place a wool pad over the lower end of the upper fragment in front, and over the small lower portion in back. Secure these with metal splints, giving them a slight spiral twist. The metal splints are strapped and the forearm is placed in a sling (Fig. 1084).



Fig. 1079

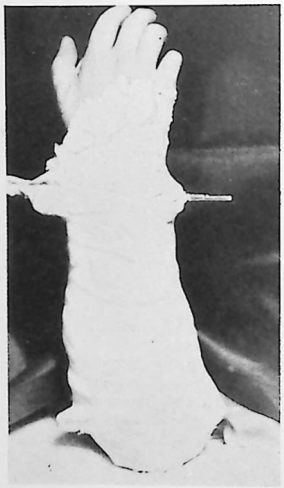


Fig. 1080

Fig. 1079. Method of treatment of fractured radius and ulna shown in Fig. 1077.
Fig. 1080. Fracture of radius and ulna (middle third). Patient 32 years of age. Double-pin fixation with two Steinmann nails incorporated in plaster of Paris cast which is continued upward to the middle third of the humerus. (Surgical Service, Cook County Hospital.)

If a Colles' fracture is properly treated, it should never cause trouble. Care should be exercised so as not to strain the newly formed callus which is likely to result in a stiff and painful wrist. The splints are kept on for three weeks during which time light exercise of the fingers is advised. Massage is more beneficial after the fracture has united.

Comment: Colles' fractures are best treated by: a, disimpaction by extension; b, application of traction; c, flexion at wrist; and d, pronation of distal fragment, followed by; e, immobilization in plaster of Paris dressing.

DISLOCATIONS AND FRACTURES OF THE WRIST BONES

Although these are almost always treated by manipulative methods, yet persistent dislocation, persistent stiffness, pain and loss of function occasionally demand open surgical correction (Figs. 1085-1086-1087).



Fig. 1081. Colles' fracture.

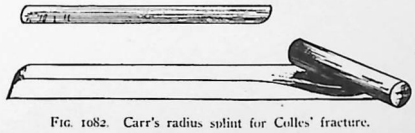


Fig. 1082. Carr's radius splint for Colles' fracture.

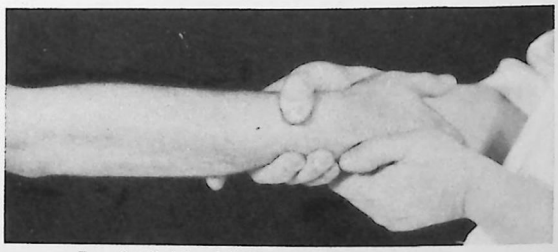


Fig. 1083. Reducing Colles' fracture by Sir Robert Jones' method.

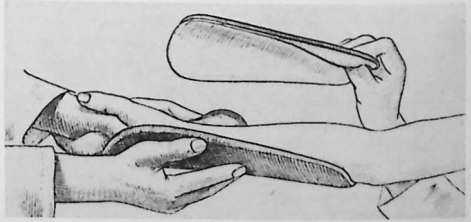


Fig. 1084. Sir Robert Jones' method of splinting Colles' fracture.

1. Dislocation of the semilunar (Figs. 1088-1089).
2. Backward dislocation of the distal row of carpal bones on the proximal row.

Manipulative Treatment

Dislocation of the semilunar: Here the bone is usually dislocated forward and is felt as a hard lump underneath the flexor tendons. Flexion is limited and there is frequent involvement of the median nerve (paresthesia in the palm and fingers along the distribution of the nerve). X-ray diagnosis is not a simple matter and is often misinterpreted. If attempts at reduction by manipulative methods fail, the semilunar should be removed (Figs. 1088-1089).



Fig. 1085. Normal wrist joint.

Reduction is accomplished by: a) dorsal flexion of the hand, b) direct pressure by the surgeons thumbs on the anterior surface of the wrist, over the dislocated semilunar bone and c) flexion of the wrist. This will usually result in the replacement of the dislocated semilunar bone. Keep mobilized in plaster of Paris dressing in full flexion for 4 days, followed by partial flexion for 6 days, after which, begin physical therapeutic measures.

Backward dislocation of the carpus: The diagnosis is difficult. The distal row of carpal bones projects backward. Swelling takes place and motion is impaired. Reduction soon after the injury is not difficult. It is effected by direct pressure forward on the distal row of carpal bones while an assistant makes long axis traction. If reduction fails, open operation comes into consideration.

Surgical Treatment

Step 1. An incision about 1½ inches long is made on the dorsum of the wrist or a 1½ inch incision on the volar side of the wrist, according to the nature of the displacement of the wrist bone to be removed. The incision passes over the bone to be removed and slightly above the lower end of the radius.

Step 2. Tendons and nerves are retracted, the annular ligament incised and the affected bone, lunar, capitate or navicular usually, either one or more, removed in fragments. The greatest difficulty lies in removing the distal fragments and separating them from their ligaments. Care must be taken not to injure neighboring intact bones or their cartilage. When the fragments are removed the area is thoroughly cleansed and put in the best anatomic position.

Step 3. The wound is closed in layers. No splinting is necessary. Active movements may be begun after a week.

Comment: Open surgical treatment is indicated when the fracture is accompanied by much dislocation, when there is pseudarthrosis after manipulative treatment, with absorption of bone, persistent pain, stiffened wrist and restricted function.

Open surgical treatment can be classed under four heads: (a) drilling;

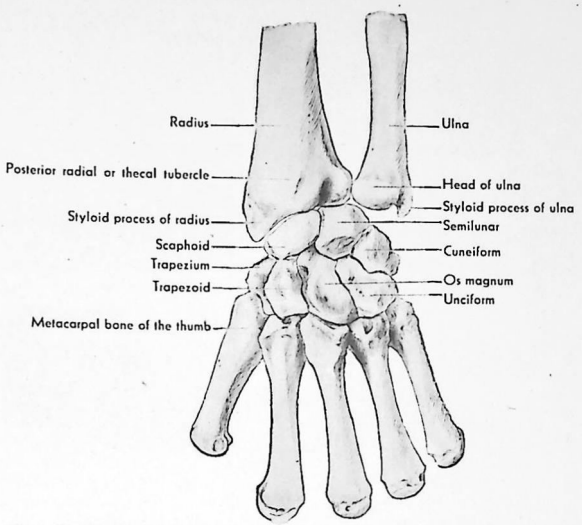


Fig. 1086. Posterior view of the lower end of the radius and ulna and the carpal bones. (From Davis' Applied Anatomy.)

(b) drilling followed by bone grafting; (c) obtaining fusion with neighboring bones; (d) excision of the affected bone.

If fusion is the method employed it must not be to the radius as that would ankylose the radiocarpal joint; the fusion should be with the lunar or capitate bones preferably.

Cave says: Our end-results from the bone graft operation have been very gratifying as far as the clinical aspects are concerned, but bony union occurred in only 4 of 7 cases (57 per cent). . . . All 7 cases were rendered symptom-free by the operation and economically and functionally are almost perfect.

Of carpal bone dislocations, that of the os magnum with complete separation of the semilunar bone, following a fall on the extended hand, is the most common type demanding surgical intervention. Figs. 1090-1091 depict manipulative treatment of dislocation of the os magnum.

Step 1. The anterior carpal surface is exposed by a longitudinal incision over the front of the wrist, a little to the inner border of the palmaris longus; the flexor tendons are retracted.

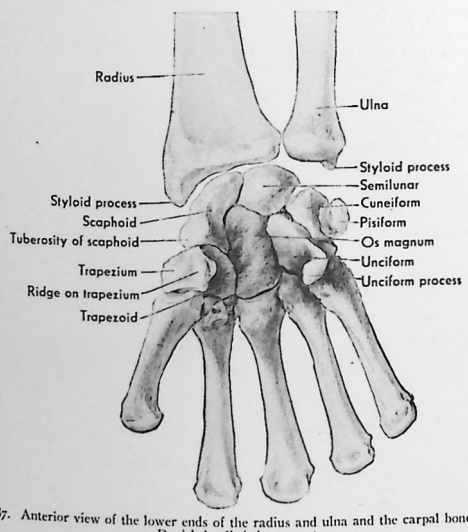


Fig. 1087. Anterior view of the lower ends of the radius and ulna and the carpal bones. (From Davis' Applied Anatomy.)

Step 2. The prominence formed by the displaced semilunar bone is exposed and the semilunar bone ligaments are separated; the periosteal covering of the bone is dissected.

Step 3. The semilunar bone is removed as well as any fragments of it or other bones in its vicinity. The soft parts are replaced, the wound closed and movements of the hand begun at an early date.

DISLOCATION OF THE THUMB

The three types of thumb dislocation are referred to as complete, incomplete and complex. The dislocation is complete if the glenoid ligament rests vertically on the dorsum of the metacarpal; it is incomplete if the glenoid ligament and sesamoids still rest on the head of the metacarpal bone; it is complex if the phalanx is placed straight and the glenoid ligament is inserted between the dorsum of the metacarpal and the dislocated bone (Fig. 1092).

Complete Dislocation

Flexion should not be used.

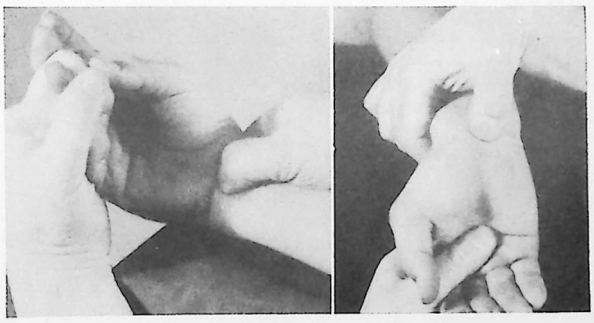


Fig. 1088 Fig. 1089

Fig. 1088. Flexion. The surgeon's thumb manipulates the semilunar into place.
Fig. 1089. Hyperextension. The surgeon's thumb is on the semilunar bone.

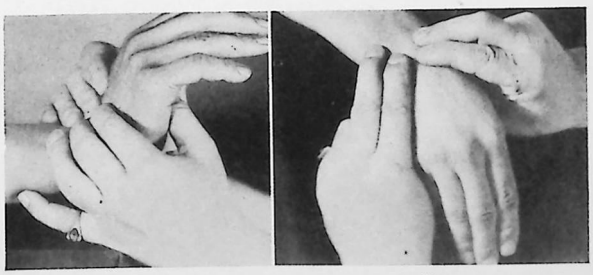


Fig. 1090 Fig. 1091

Fig. 1090. Reduction of dislocation of the os magnum of the wrist joint; general anesthesia. Step 1. Persistent traction and hyperextension.

Fig. 1091. Reduction of dislocation of the os magnum of the wrist joint. Step 2. Flexion. Observe the thumbs of the surgeon are now resting on the anterior surface of the wrist opposite the os lunatum.

Step 1. Place the patient's hand in a vertical position.

Step 2. Grasp the thumb in the whole hand, push it further backward. Force the end touching the metacarpal obliquely forward and downward; the dislocated end should always precede and be kept close to the metacarpal bone.

Step 3. Reduction takes place when the glenoid ligament passes the border of the articular surface.

Incomplete Dislocation of the Thumb

Avoid flexion here also.

Step 1. Grasp the dislocated thumb firmly. Elevate it and supply traction and extension. Bend the thumb further backward.

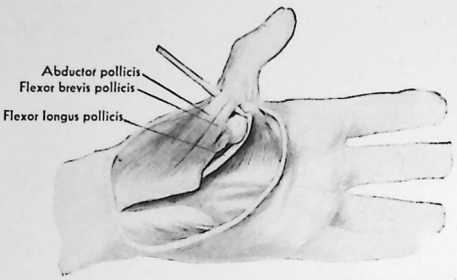


FIG. 1092. Dorsal luxation of the proximal phalanx of the thumb; division of the tendons of the abductor and flexor brevis pollicis muscles. (From Davis' Applied Anatomy.)

Step 2. Push its upper end forward and downward. Reduction follows in the path of dislocation.



FIG. 1093. Farabeuf's method of reduction of a complex dislocation of the thumb. Step 1. General anesthesia. Traction in the long axis of the thumb until its natural length is restored.

Complex Dislocation

Anesthetize the patient if it is deemed advisable.

Step 1. Stretch the thumb lengthwise until its normal length is restored (Fig. 1093).

Step 2. Elevate the thumb, at the same time forcing it backward until it is vertical to the metacarpal (Fig. 1094).

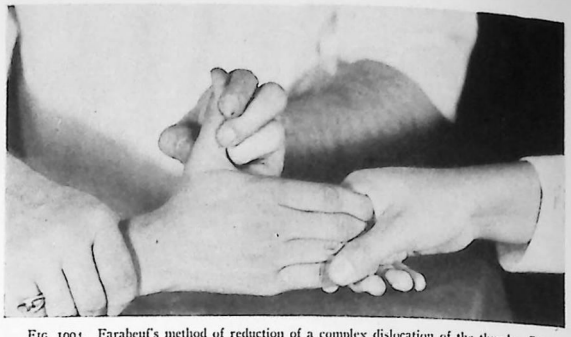


FIG. 1094. Farabeuf's method of reduction of a complex dislocation of the thumb. Step 2. Do not relax the tension in the axis of the metacarpal. Turn the thumb backward to a right angle; this will disengage the glenoid ligament and the sesamoid bones placing them lengthwise of the back of the corresponding metacarpal bone.



FIG. 1095. Farabeuf's method of reduction of a complex dislocation of the thumb. Step 3. Push the disengaged thumb from behind forwards along the dorsal surface of the metacarpal bone pressing the base of the phalanx against it. While exerting pressure in this manner as far forward as possible the thumb is depressed by the surgeon's thumb resting over the base of the first phalanx which is being depressed forward until reduction is completed.

Step 3. While maintaining the thumb in a perpendicular position, force it distally along the back surface of the metacarpal against which the base of the phalanx is pressed (Fig. 1095).

Step 4. Force it distally as far as possible, then palmward, avoiding sudden flexion. Push the first phalanx forward and downward with the thumb.

Farabeuf's forceps are very useful where the thumb is short and swollen. Figure 1096 illustrates how it is used. Observe how the phalanx is placed at right angles to the metacarpal; it is during this maneuver that the sesamoid bones and glenoid ligament are freed. If the forcing forward is begun too soon or if it is incomplete, there will be no reduction. Great care should be exercised in carrying out the procedure and if failure results the first time, try it over two or three times. However, do not be too persistent and under no circumstances insert a



FIG. 1096. The use of Farabeuf's forceps in reducing any variety of dislocation of the thumb.

tenotomy knife and blindly incise everything which appears to obstruct reduction. Farabeuf and Verneuil both recommend at this point dorsal arthrotomy and open section of the glenoid ligament. This is carried out as follows:

Step 1. Disinfect the skin. Make an incision about an inch long on one side of the extensor tendon immediately over the dislocation. Divide the subcutaneous tissue.

Step 2. Draw back the extensor tendon and margins of the wound thus exposing the focus of the luxation, the dorsal end of the phalanx and the back of the metacarpal bone which is covered by the glenoid ligament.

Step 3. Incise the ligament longitudinally in the midline, cutting down to the metacarpal bone and to the articular surface of the phalanx. In some instances, it may be necessary to make two small transverse incisions in addition to the above.

Step 4. Pull and bend the thumb. Reduction should follow easily.

If, however, reduction does not take place, remove a wedge-shaped piece of the central portion of the glenoid ligament between the two sesamoid bones; then while stretching the thumb longitudinally, carefully insert an elevator from above down between the two bones; lever the metacarpal into place with the elevator while bending the thumb.

In cases where complete reduction is impossible, it may be necessary to remove the head of the metacarpal. This has given satisfaction in several instances where it has been followed by the proper after-treatment.



FIG. 1097



FIG. 1098

FIG. 1097. Fractures of the metacarpal bones.
FIG. 1098. Fracture dislocation of the thumb.

DISLOCATIONS AND FRACTURES OF THE METACARPALS

Forward Dislocations of Metacarpals

Step 1. Have an assistant draw back the finger.

Step 2. Exert pressure on the dislocated phalanx with the thumb at the same time pulling the head of the metacarpal bone in the opposite direction with the fingers.

It is advisable to carry out this procedure under general anesthesia.

Fractures of the Metacarpal Bones

These fractures usually follow direct trauma, are oblique in type and involve most frequently the third and fourth metacarpal bones. The diagnosis is usually easy. The deformity and treatment is illustrated in Figs. 1097-1098-1099.

Dislocations of the Fingers

These are treated much the same as a dislocated thumb. Never bend the finger: stretch it longitudinally first, then stretch it backward, pressing the dislocated end against the back of the metacarpal so that it returns the way it became dislocated, forcing the glenoid ligament before it.

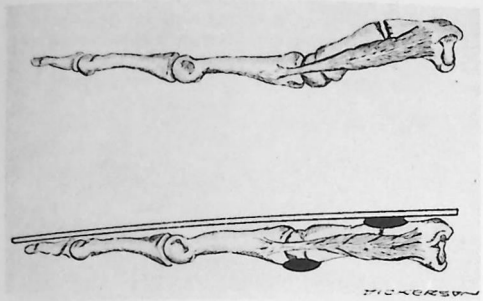


Fig. 1099. Fracture of the metacarpal bone showing the resulting deformity produced by the interosseus muscle and the treatment of the fracture using a splint and pads. (After Magnuson.)



Fig. 1100. Dislocation of proximal phalanx.

In cases which do not respond to the usual treatment open section is resorted to or subcutaneous division is carried out as follows:

Step 1. Make a puncture in the skin half an inch behind the phalanx base, near the outside of the extensor tendon, with a tenotome.

Step 2. Hold the handle of the instrument parallel to the tendon and insert the point under the skin toward the articular surface of the phalanx.

Step 3. When the point reaches the articular surface, raise the handle, thus depressing the point and directing it against the palmar ligament appearing on the dorsum of the metacarpal.

Step 4. Divide the ligament by pressing the point of the tenotome against the posterior surface of the metacarpal and drawing it backward for about one-third of an inch.

Dislocated phalanges (Fig. 1100) are usually successfully reduced by combining traction and direct pressure. Fig. 1101 illustrates this procedure. An assistant pulls the finger while the surgeon holds the phalanx with index fingers crossed below and thumbs above and exerts pressure on the dislocated region.



Fig. 1101. Reduction of a dorsal dislocation of the terminal phalanx of the index finger.

Fractures of the Phalanges

These are very common fractures, and although not considered serious are often difficult to treat (Fig. 1102). This is especially true of fractures through the base of the phalanges. The reduction of such injuries is illustrated in Fig. 1103. There are many traction and splinting methods designed especially for these injuries.



Fig. 1102. Splintering fracture of proximal phalanx of index finger.

FRACTURES OF THE THORAX

RIBS

Simple rib fractures may be treated by manipulation and immobilization (Figs. 1104-1105). Complete open fracture of the ribs is uncommon. If the skin is opened it is generally caused by the object that causes the injury not by the fractured bone ends. The fractured bone ends may, however, penetrate the pleura or lung or a depressed rib fragment may cause the pleura or lung to split. The nerves or the intercostal artery may be involved (see Surgery of the Chest). When there is a lung puncture emphysema and pneumothorax may result. A compound fracture, or a simple fracture with hemorrhage from the intercostal vessels or lung, call for open surgical operation.

Step 1. An incision is made in the intercostal space over the fracture site. The

superficial tissues are dissected and search is made for any bleeding vessel which is ligated.

Step 2. It may be necessary to resect part of the fractured rib or ribs. If the lung is lacerated and bleeding, the ribs and parietal pleura in the vicinity are divided until there is space enough to grasp the lung with forceps and pull it

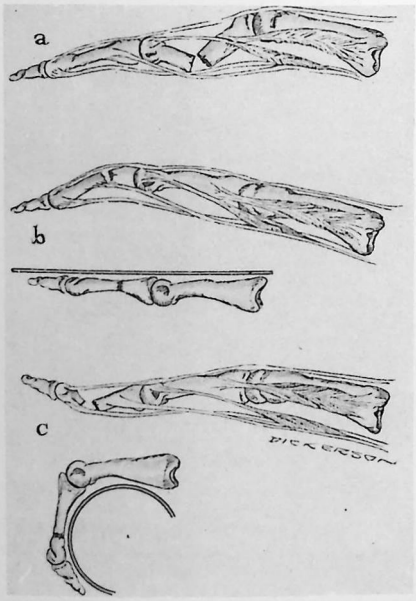


Fig. 1103. a. Fracture of the proximal phalanx with the deformity produced by the pull of the lumbricalis muscle. b. Fracture of the middle phalanx proximal to the flexor insertion and the resulting deformity corrected by a straight dorsal splint. c. Fracture of the middle phalanx distal to the flexor insertion and the resulting deformity corrected by a curved palmar splint.

into the wound opening. The lacerations are then sutured with catgut, anatomic conditions are restored as far as possible and the chest closed without drainage.

In an old thoracic cage fracture if the symptoms suggest that the intercostal nerve is pinched or involved in callus, or if necrosis of the injured bone is suspected, the callus must be removed and dead bone cut away.

In severe crushing injuries, such as those following automobile accidents, with increasing, spreading emphysema multiple incisions are made through the

skin and fascia to allow the escape of air. If this is not sufficient a thoracotomy may be necessary.

STERNUM

In fractures of the sternum when ordinary manipulative reduction and retention methods fail and there is marked deformity, an open surgical operation is indicated.

Step 1. A convex incision along the outer border of the sternum permits the reflection of a flap down to the bone.



Fig. 1104. Palpating the chest wall for fractured ribs.

Step 2. The costochondral junctions from the first to the ninth may be resected in order to permit the sternum being raised up and levered into a correct anatomic position. A grooved director or periostotome may be employed as a lever to lift the bone. Any deformities on the bone are then chiseled off.

Step 3. The flap is returned to place and sutured and maintenance is effected by suitable bandaging or retraction of the shoulders.

DISLOCATIONS AND FRACTURES OF THE SPINE

DISLOCATION OF THE VERTEBRAE

Dislocation of the vertebrae is rare and was thought, at one time, to be impossible except as a complication of fracture. It is essential but sometimes difficult to distinguish between cases in which displacement is the result of fracture and those in which the fracture is an insignificant complication of dislocation (Figs. 1106-1107-1108-1109-1110).

Non-Surgical Reduction of Cervical Vertebra

Attention should be given to proper reduction of the dislocation and to fixation. An anesthetic should be administered cautiously so that the relaxation resulting will not result in a sudden movement of the head which is held in traction by the surgeon while the anesthetic is being given.

Spontaneous reduction quickly follows relaxation in many cases of diastases and partial dislocation. The special treatment consists of reduction, fixation and methods employed to correct the injuries sustained. If reduction is advisable it should be attempted promptly although success has followed reductions which were made from one week to two months following the accident. It should be borne in mind that attempts at reduction are accompanied by danger from pressure on the cord and may result in death, therefore, diagnosis should be carefully made. If reduction is impossible and surgery is contraindicated, immobilization is indicated so that necessary repair may be assured.

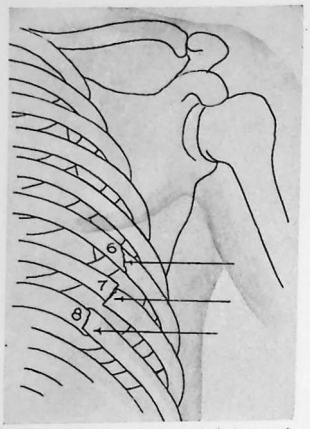


FIG. 1105. Transverse fracture of sixth, seventh and eighth ribs. Reconstructed from x-ray.

When the occiput is dislocated, steady, firm traction on the head accompanied by direction pressure and forward or backward movements of the head, are indicated; in complete dislocation, extension and rotation of the head toward the dislocated side in unilateral displacement, affords a satisfactory method of restoration.

In dislocation of the atlas, great caution should accompany any manipulations.

In bilateral dislocation steady, firm traction in the line of the axis of the upper segment should be made while the neck is held rigid with the hands. Manipulations, if employed, should be made cautiously and with a clear knowledge of their dangers.

In cases of unilateral dislocation, the head is rotated to the sound side while extension is made; it is returned to its normal position afterward.

Where the lower six cervical vertebrae are dislocated, the type of manipulations depends on the type of displacement. In case of subluxation, follow lateral flexion by slight rotation toward the dislocated side with lessening abduction. Failure of the attempt should be followed by a repetition, cautiously increasing the force.

In cases of complete unilateral dislocation, Kocher recommends stretching the ligaments of the affected side by increasing the lateral deflection and simultaneously employing slow traction and rotation toward the involved joint. Rotation toward the sound side disengages the articular processes of the opposite side while abduction to the sound side with rotation toward the unsound carries the displaced articular process into correct position. In cases of bilateral complete dislocations, reduce first one side and then the other in accordance with the above suggestions. Keep in mind that rotation of the spine above the point of injury should be made by grasping the upper segment and not by turning the head. After reduction is accomplished, the head is supported and fixed in position with the aid of an apparatus maintaining occipito-mental traction or a high plaster-of-Paris yoke and collar may be worn from three weeks to two months.

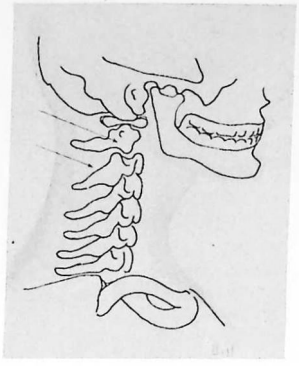


FIG. 1106

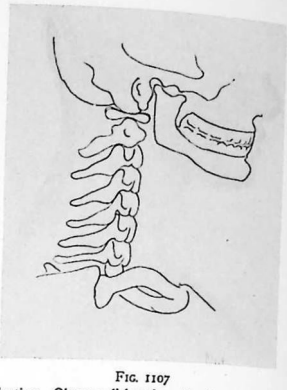


FIG. 1107

FIG. 1106. Dislocation of cervical spine, before reduction. Observe dislocation of axis and distance between it and the third cervical vertebra. Reconstructed from x-ray.
FIG. 1107. Dislocation of cervical spine, after reduction. Note straight line. Reconstructed from x-ray.

With the best of mechanical treatment, these dislocations are likely to heal with some slight imperfection of a fractured process or malposition in the case of union of a torn ligament, which results in limitation of movements.

The degree of primary injury and extent of displacement govern the amount of damage suffered by the cord. The usual causes of dislocation are forcible flexion of the spine and direct violence due to moving vehicles and other heavy objects. Loss of power and deformity may result from injury or complications of the spinal cord which will be revealed by careful examination. If fracture is present, prominent bony points and movable fragments may be detected. In the presence of thin abdominal walls, inequality of the outline of the bodies of the lower vertebrae may be noted. Dislocation and fracture symptoms are so similar that definite diagnosis without the assistance of operation or autopsy is uncertain, hence the term "fracture-dislocation." Nonsurgical treatment begins and ends with the advantages gained from extension and counterextension, accompanied by manipulation directed anteriorly to adjustment of the vertebral bodies when advisable.

The patient should be placed in a recumbent position with immobilization by plaster of Paris or similar material. Strict attention should be paid to personal hygiene.

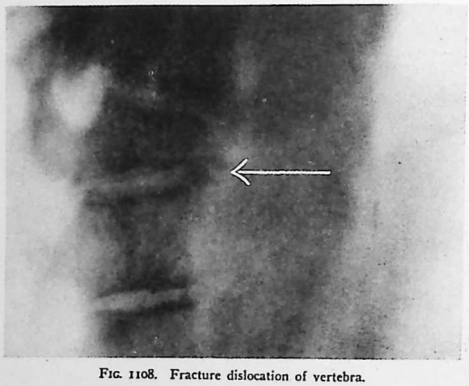


FIG. 1108. Fracture dislocation of vertebra.

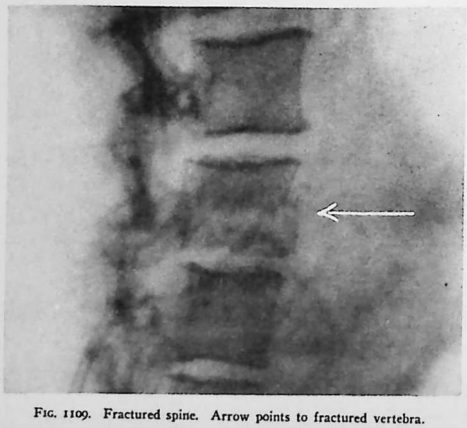


FIG. 1109. Fractured spine. Arrow points to fractured vertebra.

Dislocation of a lumbar vertebra is uncommon. In the few cases recorded great force caused grave injuries to the vertebrae accompanied by displacement

of the bodies of the bones. The symptoms are not clear cut and are not the same as those which accompany injury of the cord. Local deformity and tenderness associated with bony irregularities of the vertebral bodies may be ascertained by careful examination.

Reduction of backward dislocation may be accomplished by direct pressure on the spinous process, with extension and counterextension of the spine. In forward dislocation extension and counterextension accompanied by pressure in front may be effective.

Upper Cervical Vertebrae

SURGICAL REDUCTION

Open operation is indicated when reduction is difficult or when there is much pain.

Step 1. A six-inch incision is made over the suboccipital spines, the hooked spine of the axis identified and the forwardly dislocated arch of the atlas exposed.

Step 2. Strong silk sutures are passed through the arch of the atlas taking care to avoid injury to the spinal cord. Finger pressure is made on the anterior arch until reduction is effected.

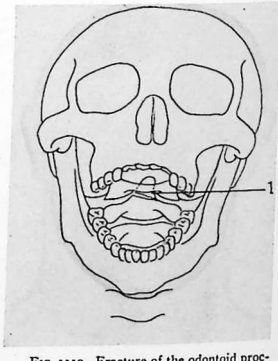


FIG. 1110. Fracture of the odontoid process with dislocation of the axis and the atlas. Reconstructed from x-ray. 1. fractured odontoid.

Step 3. The reduction is maintained by passing a silk ligature around the spine of the axis. A plaster cast is applied for at least 4 months.

If reduction is impossible by this method a laminectomy may be called for.

FRACTURE-DISLOCATIONS OF THE DORSAL SPINE

These are usually reduced by manipulative methods accompanied by hyperextension.

FRACTURES OF THE LUMBAR VERTEBRAE

The time and method of surgical operation will depend upon the nature of the injury and whether or not there are symptoms pointing to involvement of the spinal cord.

The main point to be considered by the operating surgeon is whether or not the spinal cord is injured. In crushing injuries, it may be as well to delay operative measures for a while to watch the course of events and to decide upon a laminectomy only when the symptoms demand it. A late laminectomy will avoid adding operative shock to the traumatic shock because vertebral fractures of themselves do not usually call for immediate intervention. If the patient is not improved by manipulative reduction in hyperextension, and if there is a rising temperature and increasing pressure symptoms which threaten life, then operation by the open method is mandatory. (See laminectomy.)

The Technic of Ambulatory Treatment of Fractures of the Spine[1]

Step 1. Reduction is done as soon as the condition of the patient permits. One-fourth gr. morphine and 1/100 gr. scopolamine is given one hour before reduction is to take place.

Step 2. The patient is placed upon the table face downward and anesthesia is induced by either nitrous oxide or ethylene. When the patient is anesthetized, reduction of the fracture is done. Disappearance of the pre-existent kyphosis or the cracking sound produced by the disimpaction of the fracture signifies the accomplishment of the reduction.

Step 3. As soon as reduction has been achieved, the anesthetic is stopped and a body cast applied.

Step 4. The patient is now turned on his back with two pillows under the curvature of the spine and permitted to remain in this position for at least five hours. A small window is cut in the epigastric portion of the cast.

Step 5. Twenty-four hours later the cast is cut where desired and the patient permitted to be ambulant.

Step 6. As soon as the cast is satisfactorily trimmed, the patient is permitted to walk about.

Step 7. Graduated exercises are next given, the patient remaining ambulant, while still wearing the cast, for about four to four and one-half months, depending on existing circumstances.

Step 8. Finally, physiotherapy is resorted to and the patient is permitted to resume his work at the end of eight or nine months.

DISLOCATIONS AND FRACTURES OF THE COCCYX

These result from the patient falling with great force in a sitting position or in any manner that brings the coccyx suddenly and forcefully in contact with a hard substance. Dislocation results more frequently than fracture; the latter frequently occurs at the junction of the sacrum and coccyx. The injury, although very painful, frequently fails to visualize on a roentgenogram.

Reduction

The fragments should be replaced as soon as possible after diagnosis has been made. This is done by placing the index finger in the rectum and with the assistance of the thumb placing the fragments in their usual position. Anesthesia may be required. The buttocks should be tightly cross strapped and the patient should rest in bed for two or three weeks. Opium suppositories should be administered and heat applied locally.

Pain is sometimes felt for two or three months due probably to the contusion of the coccygeal plexus and sacrococcygeal sprain. If this persists coccygectomy is indicated.

Coccygectomy

Step 1. Make a small vertical incision over the articulation point of the sacrum and coccyx.

Step 2. Separate the articulating surface of the coccyx and holding it firmly, free it to its tip by sharp dissection.

[1] As practiced by Drs. Wm. R. Cubbins and Carlos S. Scuderi at the Cook County Hospital.

Step 3. Round and smooth the end of the exposed sacrum and close the wound. Carefully avoid injuring the rectum.

FRACTURES OF THE HEAD

FRACTURES OF THE SKULL

(See also chapter on Skull Fractures)

These comprise about 15 per cent of all fractures and derive their importance from the possibility of injury to the brain. The mortality in cases of intracranial injury may vary from 20 to 50 per cent. Even with a comparatively mild bone injury, brain injury may be fatal.

Open surgical treatment of skull fractures depends upon the nature of the brain tissue pathology. In cases with little or no shock, open treatment may be primarily indicated. In a comminuted fracture when there is evidence of marked cerebral or dural hemorrhage, if other conditions permit, and if shock has subsided, the indication is for open surgical treatment; but this should usually not be attempted in the presence of great shock, rapid pulse and profound unconsciousness.

In the case of a linear fracture, with a hematoma beneath the scalp in the region of evident contusion, the surgeon must use his judgment in regard to opening up the area. The actual bone fracture is of little consequence in itself.

Unlike fractures elsewhere, the cranial bones are not subject to displacement; there is no muscle pull and the fracture, if there is no brain injury, usually unites.

Puncture fracture of the cranial vault with depression of bone, hemorrhage from within the skull or with the presence of brain tissue in the wound, calls for immediate surgical treatment, if the patient's condition permits it.

In nonpuncturing injuries or comminuted fractures accompanied or not by scalp wounds the indications for craniotomy must be clear with a leaning toward conservatism. An indication for open surgical treatment is given by evidence of increasing intracranial pressure due to extravasation of blood from injured cortical vessels, or from extradural meningeal irritation or edema of the brain. Meningeal infection, manifested by a spinal fluid containing pus and under increased pressure, is an indication for surgical operation. Generally speaking, craniotomy for exploration is indicated in all extensive, open fractures of the skull or when the signs of increasing intracranial pressure threaten life.

For technic of decompression see pp. 148-150 in chapter 8 on Skull Fractures.

DISLOCATIONS AND FRACTURES OF THE FACIAL BONES

In the case of an accident with much nasal bone injury, the general surgeon generally limits his efforts to elevating depressed bones with replacement of fragments maintaining them in place by packing the nares with gauze. External splints to correct lateral angulation have little value.

Fracture of the Nose

Fracture of the nose is characterized by trauma, epistaxis, swelling, redness, deformity, and painfulness. Crepitation is also a symptom which is best determined by the surgeon holding the patient's head against his chest and determining by lateral manipulation whether there is any abnormal mobility or crepitation (Fig. 1111).

TREATMENT FOR SIMPLE FRACTURE

The air passages should be kept very clean and a nasal splint introduced into each nostril to act as a support and also for hemostatic purposes. Internal fixation is best accomplished by inserting a curved, perforated rubber splint for this purpose and leaving it in place for about two weeks.

Externally, the nose may not appear the same as before the accident but if the air passages are kept clean and clear, the reduction is considered a success.

TREATMENT FOR COMPOUND FRACTURES OF THE NOSE

Compound fractures are comparatively rare and are usually the result of direct violence. The treatment consists in clipping off the tags of injured tissue and applying an antiseptic solution such as mercurochrome or iodine. Follow this procedure with the same treatment as is given in the case of simple fracture. Suture the skin edges with fine horsehair and remove the sutures in 3 days to avoid scar formation. If it is impossible to obtain intranasal splints a packing of mercurochrone may be inserted into each nostril and tongue depressors are properly fitted to either side of the nose and fastened with collodion or adhesive.

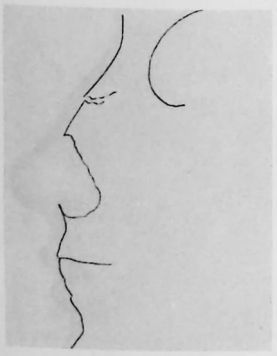


Fig. 1111. Fracture of nasal bones. Reconstructed from x-ray.

The patient should be kept under the surgeon's care for two or three weeks. Occasionally, resection of the septum is necessary if the nostrils have not been correctly molded and protected.

Fractures of the Malar Bone and Zygoma

A simple open fracture without depression of bone calls only for the usual surgical treatment of open fracture—cleansing, reduction, removal of any small fragments and closure of the wound. A fracture with depression deformity, whether impacted or not, which interferes with functioning of the jaw calls for open surgical operation especially if there is nerve pressure with sensory disturbance.

Step 1. The incision should be small, not more than half an inch in length, to avoid facial scar. This will permit the introduction of a chisel or hook to elevate the bone into its correct place. When replaced in anatomic position, the bone tends to remain so.

Step 2. Close the wound and avoid pressure on the area for some weeks.

FRACTURE OF THE SUPERIOR MAXILLARY BONE

In closed fracture the patient has the alternatives of possible deformity or of open operative reduction and correction. Although the fractured bone may be reduced by manipulative methods, it is hard to keep the reduction maintained. Opening up by surgical incision affords an opportunity for correct replacement of the fractured fragments.

Open fractures of the superior maxilla are treated surgically in the same general way as an open fracture anywhere else, namely, aseptic débridement, reduction and closure. If the fragments cannot be maintained in replacement the teeth may be wired and the fragments held by intradental splints. The services of a dentist are called for in such a procedure.

FRACTURES AND DISLOCATIONS OF THE LOWER JAW

(See Chapter on Surgery of the Head, pp. 289-297, Figs. 319-337)

Like fractures of the superior maxilla, reduction and maintenance of fragments is difficult in fractures and dislocations of the mandible. The age of the patient, the occupation, the time elapsed since the injury and the probable cosmetic result have all to be considered in operating for a fracture or dislocation of the mandible.

Step 1. The skin incision is made below the zygoma and the dissection carried down to the mandible by splitting the muscles and retracting them. Care must be taken to avoid any important blood vessels or branch of the facial nerve. If the fracture is condylar, Murphy's approach by a 2-inch incision starting on the level of the zygoma and half an inch in front of and on a line with the external auditory meatus can be used. If necessary, this affords an opportunity for the use of a flap of temporal fascia should an arthroplasty be called for to avoid jaw ankylosis.

Step 2. The fractured mandible is reduced. If the condyle cannot be managed satisfactorily it should be removed and an arthroplasty done as described. The use of a prosthetic apparatus may be necessary to maintain the reduced fragments in position.

FRACTURES OF THE PELVIS

As a general rule, closed fractures of the pelvic bones—ilium, ischium, pubis, acetabulum, sacrum and coccyx—do not call for open surgical operation (Figs. 1112-1113). These injuries are treated by manipulative methods, which include placing the patient on a fracture table and applying continuous or skeletal traction through the ischium and by immobilization in a cast after the fragments have been reduced. Operation may be necessary when some internal viscus is injured concomitantly with the fracture.

SACRO-ILIAC JOINT

Sprains and dislocations of the sacro-iliac joint (Fig. 1114) are usually followed by incessant and excruciating pain and complete disability. In such cases, as well as for irreducible separation of the surfaces of this joint accompanied by a pelvic fracture, open surgical treatment is indicated. The operation

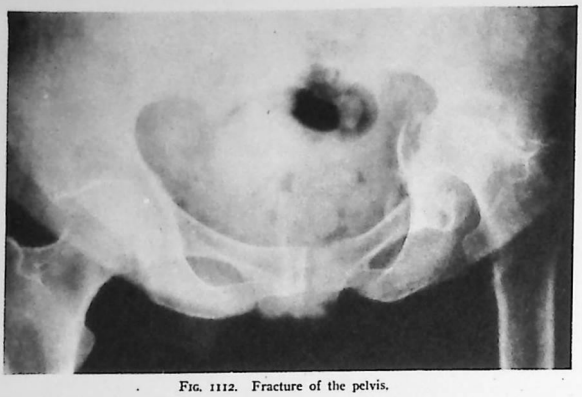


FIG. 1112. Fracture of the pelvis.



FIG. 1113. Multiple fractures of both pubic bones, with displacement of fragments.

four inches. Reflect the flap and underlying muscles laterally exposing the surface of the ilium (Figs. 1115 A-B).

Step 2. Define the sacroiliac joint. Remove a generous rectangular bone wedge which includes the whole thickness of the ilium and passes through the sacroiliac joint. With the joint thus exposed cartilage and underlying cortex are removed down to cancellous bone.

Step 3. Remove all cartilage from the bone wedge and then replace the block in its original site. Cancellous bone surfaces are thus brought into approximation.

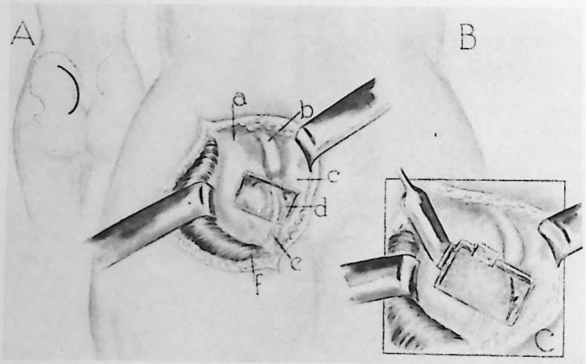


FIG. 1115. Operative treatment of sacro-iliac sprain. A. Line of incision. B. a. Denuded surface of ilium; b. post. sup. iliac spine; c. denuded sacral surface; d. bone segment removed showing sacro-iliac joint; e and f, retracted muscles. C. Bone wedge after being reshaped is countersunk and the bone edges are broken with a chisel.

Step 4. The surface of the bone wedge now lies below the surface of the ilium. To promote stability the edges of the latter are broken in over the wedge with a bone chisel (Fig. 1115 C).

Step 5. Carefully replace and firmly suture the reflected structures. Dress and confine the patient in continuous recumbency for about three months.

Gaenslen's Technic of Sacro-Iliac Arthrodesis

Place the patient in a semiprone position. In the case of stout or short-waisted persons raise the table in the center with the peak in the flank thus bringing out the crest prominently. Mark the location of the posterior superior and posterior inferior spines before preparing the skin for identification and proper placement of the skin incision.

Step 1. Make an incision along the posterior two-thirds of the iliac crest, curving around behind the posterior superior spine and ending over the posterior inferior spine of the ilium. Penetrate the skin and subcutaneous fat to the

consists in excising the joint surfaces followed by bony fixation by means of a bone graft.

Step 1. An incision is made downward and outward from the third lumbar spine to the crest of the ilium or below it. The skin, fat and fascia are dissected up and retracted away from the joint which is exposed.



FIG. 1114. Diagnostic maneuver: Helpful in differentiating between sacro-iliac and lumbosacral lesions. The sketch shows forcible hyperextension of left hip, with pelvis and lumbar spine fixed by means of extreme flexion of the right hip. Pain is generally present in sacro-iliac, absent in lumbosacral lesions. (Courtesy of Dr. F. J. Gaenslen.)

Step 2. The joint is opened and curetted. An autogenous bone transplant about 3 inches in length is taken from the tibia and driven diagonally across the sacro-iliac joint from above downward into the sacrum in which a gutter must first be prepared for it.

Step 3. Close the wound in layers. No plaster cast is necessary but the patient should be kept in bed for about 6 weeks after which he is allowed to walk.

Smith-Peterson Operation

Step 1. Begin a curvilinear incision at the iliac crest midway between the anterior and the posterior superior iliac spines. Carry the incision posteriorly around the posterior iliac spine and thence down and outward for about

deep fascia. Liberate the wound margins and retract them thus exposing the crest to the posterior superior spine (Fig. 1116).

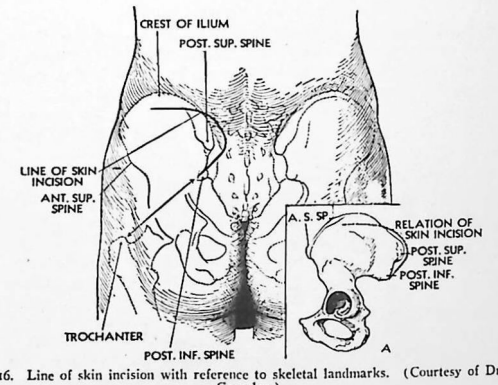


FIG. 1116. Line of skin incision with reference to skeletal landmarks. (Courtesy of Dr. F. J. Gaenslen.)

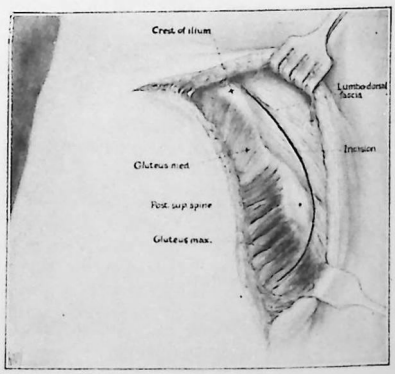


FIG. 1117. Curved skin incision along crest; skin edges retracted; incision down to bone along posterior third of crest. (Courtesy of Dr. F. J. Gaenslen.)

Step 2. Make an incision over the posterior third of the crest and over the posterior superior spine, leaving a small margin of fascia and muscle on the outer lip of the crest to facilitate the closing (Fig. 1117).

Step 3. Split the posterior portion of the ilium flatwise with a broad chisel to a depth of 2½ inches forward from the posterior superior spine into an inner

and outer leaf, the latter being the thickest. Keep the plane of the joint and its relation to the normal bony landmarks well in mind. The chisel

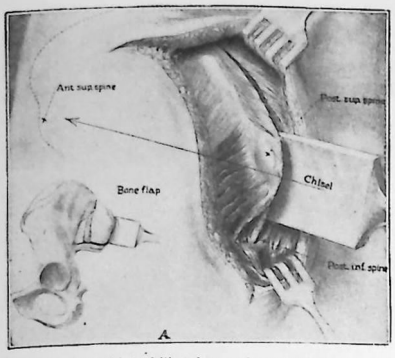


Fig. 1118. Division of posterior third of ilium into an inner leaf, which remains standing, and an outer leaf, which is deflected. (Courtesy of Dr. F. J. Gaenslen.)

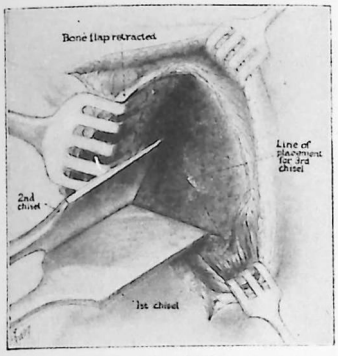


Fig. 1119. The outer leaf of the split ilium is deflected laterally. A triangle is now marked out on the standing leaf of the ilium by three chisel cuts. This triangle, as shown in Fig. 1020, lies roughly within the articulating area of the joint. The first cut lies on a line connecting the posterior inferior spine of the ilium with the anterior superior spine. The second arises from the front end of the first at slightly less than a right angle to this. The third line completes the triangle. (Courtesy of Dr. F. J. Gaenslen.)

set against the posterior superior spine should be held in a plane parallel with that of the posterior third of the ilium, and should be directed forward and slightly outward in the direction of the anterior superior spine of the same side (Fig. 1118). In splitting the ilium, center the chisel over the posterior superior spine in the direction above recommended; widen the split upward and downward enough to separate the entire posterior third close down to the posterior inferior spine.

Step 4. Split the ilium to a depth of about 1½ inches (it cannot be split to the required depth in an unbroken leaf on account of its curve). Reflect laterally the outer leaf of bone with the attached gluteal muscles and overlying tissues (Fig. 1119). Further split the remaining portion of the posterior third with the chisel and reflect it out thus obtaining satisfactory exposure of the sacro-iliac joint. Danger of going too deeply is averted if the anterior superior spine is used as a landmark.

Step 5. Next attack the part of the inner leaf overlying the joint. Dissect a triangular area of bone corresponding in size and location to the sacro-iliac joint on the inner or standing leaf of the ilium. The portion of bone to be removed is identified as follows: (Fig. 1120). The base line BC, two inches long, extends forward from the posterior inferior spine directly toward the anterior superior spine. The line BA, one and one-half inches long is erected almost perpendicularly from the anterior end of the first incision toward a point on the crest joining the middle and posterior third; the resulting angle is a little less than a right angle. Join the points CA. It is not necessary to remove this triangular area of bone in one piece; it is better to remove it in pieces and save the healthy parts for filling in the defect later.

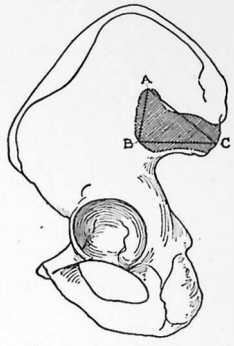


Fig. 1120. Lateral aspect of left iliac bone: The area of articulation with the sacrum is shown by shading; the triangle outlines the area through which the joint is approached. (Courtesy of Dr. F. J. Gaenslen.)

Step 6. The entire joint is readily exposed after the cartilaginous surface is identified in the center of the triangle, especially in a tuberculous joint where the opaque white cartilage partially loosened by granulation tissue is readily followed. The iliac part of the cartilage is removed in fragments as the joint is uncovered with chisel and curet (Fig. 1121).

Step 7. Pack the cavity thus made with pieces of healthy bone chips removed during the procedure (Fig. 1121—insert). Bring the deflected outer leaf of the ilium into apposition and hold it in place with a few interrupted sutures into the dorsolumbar fascia and muscle. Complete closure with a subcutaneous catgut and silk skin suture.

Comment: Gaenslen recommends that a plaster spica be worn for ten or twelve weeks followed by a pelvic belt in the case of tuberculous patients. This procedure does not weaken the posterior sacroiliac ligaments in any way; exposure is ample; danger from hemorrhage is negligible and closure is simple and secure.

Putti's Technic for the Removal (Apophysectomy) of the Transverse Process of the Fifth Lumbar Vertebra (Sacralization)

V. Putti and O. Scaglietti[1] give as an indication for this operation persistent low backache caused by an osteoarthritis in a false joint formed by the approximation of the transverse process of the fifth lumbar vertebra with the wing of the ilium.

Step 1. (Fig. 1122 A) Make a midline cutaneous incision extending from the second lumbar vertebra to the spine of the fifth lumbar and having a hockey stick curve over the corresponding sacro-iliac joint.

Step 2. (Fig. 1122 B) Expose the lumbo-sacral aponeurosis.

Step 3. (Fig. 1122 C) Retract the lumbosacral muscles and remove the posterior portion of the crest of the ilium thereby exposing the sacralized transverse process of the fifth lumbar vertebra.

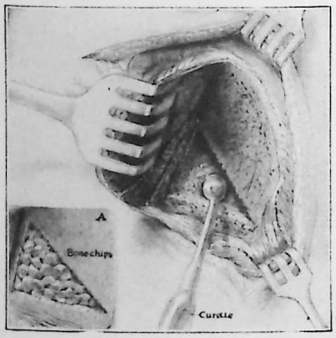


Fig. 1121. Exposure of sacro-iliac joint and removal of articular surface with curet. The inset shows the joint packed firmly with healthy bone hips. (Courtesy of Dr. F. J. Gaenslen.)

Step 4. Make an incision for the removal of the sacralized transverse process of the fifth lumbar vertebra as shown in Fig. 1122 D.

Comment: Fig. 1122 E shows conditions after removal of the sacralized process of the fifth lumbar vertebra with the exposure of the iliopsoas muscle and branches of the lumbo-sacral plexus. The postoperative care in these cases is bed rest without any cast for a period of four to six weeks.

DISLOCATIONS AND FRACTURES OF BONES OF THE LOWER LIMB

DISLOCATIONS OF THE HIP

Simple dislocation of the hip is usually readily replaced by such a maneuver

[1] Chir. d. Org. di mov. Vol. XVII, 1932.

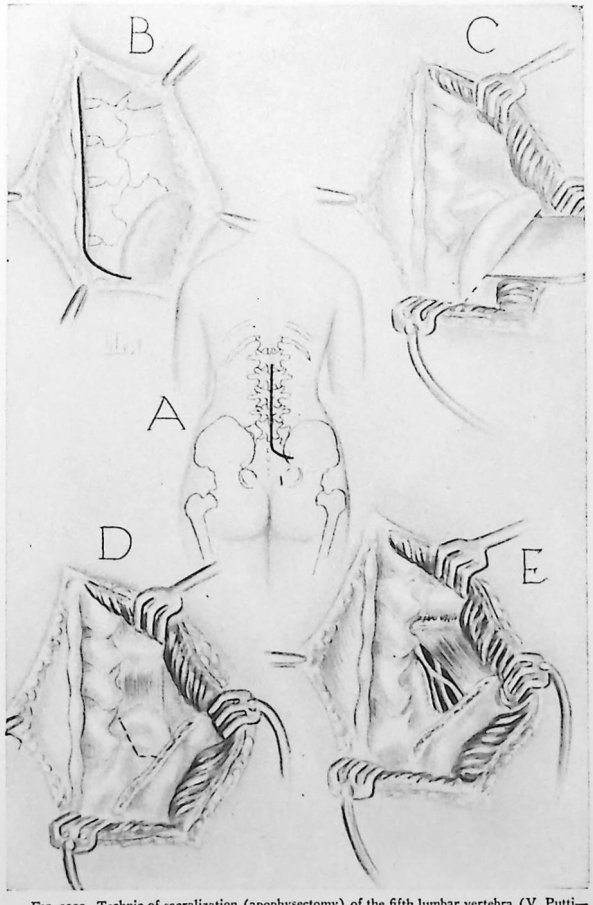


Fig. 1122. Technic of sacralization (apophysectomy) of the fifth lumbar vertebra (V. Putti—O. Scaglietti). A. Cutaneous incision. B. Incision of the sacro-lumbar aponeurosis. C. Removal of a segment of the iliac crest after the superimposed muscles have been dissected away. D. The sacralized apophysis appears to view after a portion of the ilium has been ablated. The dotted line indicates the segment of lumbar vertebra to be removed. E. Removal of portion of lumbar vertebra as illustrated in D. exposes the ilio-psoas muscle and medially to same the nerves coursing in this area.

as shown in Figs. 1123-1124-1125. For severe crushing injuries and old-standing hip dislocations, due to any cause, with functional disability, open surgical treatment is generally demanded. Following an accident, if the patient is in a state of shock, operation should be deferred until shock has subsided; the blood vessels are rarely injured. A dislocation may be posterior, medial or anterior and the approach will be different in each case.

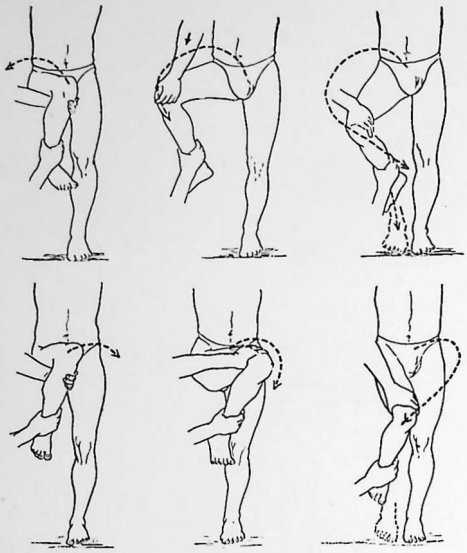


FIG. 1123. Maneuvers in Bigelow's method of reducing hip dislocated posteriorly.

Reducing a Dislocated Hip by the Shoulder Method

The patient is placed on the manipulating table, the pelvis projecting a little over the edge of the table. The sound limb is supported by one surgeon while the other steadies the spines of the ilium. The individual entrusted with reducing the dislocation stands between the patient's legs.

Step 1. The knee of the patient is placed over the shoulder of the surgeon. The left hand supports the lower part and the right hand the upper part of the leg.

Step 2. The person so supporting the limb rises slowly, keeping the limb somewhat abducted. When the upright position is attained, the affected limb

will be vertical and flexed at a right angle to the pelvis. A sharp movement of the shoulder increases the upward traction and disengages the head of the femur from its abnormal position.

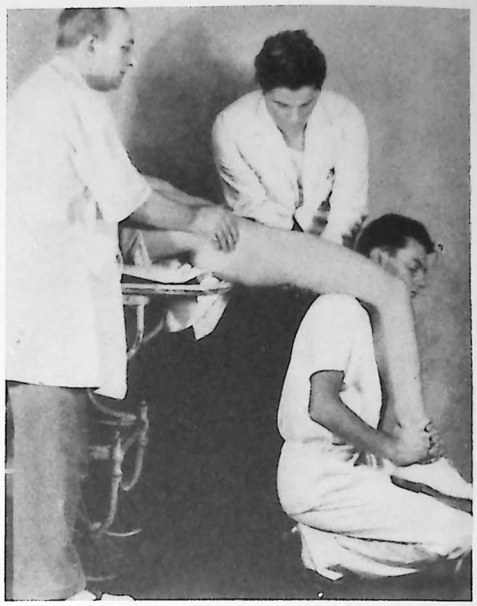


FIG. 1124. The shoulder method of reducing iliac dislocation of the hip. Step 1. Observe the position of the patient, of his affected limb over the shoulder and the relative position of the surgeon and assistants.

Posterior Dislocations

Step 1. The surgical incision usually runs from the postero-inferior iliac spine to the base of the large trochanter. In old standing cases the head of the femur is usually found under the gluteus maximus muscle; the obturator internus, the gemelli and the pyriformis muscles are generally found stretched over the acetabulum.

Step 2. The femoral head must be detached from all pelvic connections, the muscles stretched over the acetabulum pulled away, the acetabulum cleaned out and the femoral head levered into place by circumduction.

Step 3. Close the wound. Immobilize in plaster of Paris cast.

Anterior Dislocation

Step 1. The access to the acetabulum is covered by the trochanter and by the muscles already mentioned which must be retracted downward or incised and the acetabulum cleaned out.

Step 2. Flex and inwardly rotate the thigh which removes the trochanter from its blocking position.



FIG. 1125. The shoulder method of reducing iliac dislocation of the hip. Step 2. Elevation of the dislocated limb.

Step 3. Dissect the femoral head free and lever it into its anatomic position. Both in anterior and posterior dislocations it may be better, in some inveterate cases, to resect the head of the femur. An arthroplasty is then done, a flap of fascia being inserted between the reformed head of the femur and the acetabulum to avoid ankylosis; however, an ankylosis to the ilium in a position of abduction may often be the preferential mode of dealing with a given case.

Open Hip Fracture or Dislocation

Here the general surgical indications are in order:

Step 1. Aseptic preparation of the site of injury. Then careful débridement of the wound and search for the injured area.

Step 2. If the head of the femur is found broken, or if the acetabulum is so damaged that a reduction cannot be effected or maintained, resection of the head of the femur may be necessary. The upper end of the femur is reformed and reduced into the acetabulum.

Step 3. If there is no fracture, after thoroughly cleansing the area, reduce the head of the femur to its anatomic position and close the wound with a

capillary drain under the skin. The great desideratum in such cases is the avoidance of infection and subsequent ankylosis.

CONGENITAL DISLOCATION OF THE HIP

Congenital dislocation of the hip, consisting of a partial or complete displacement of the head of the femur from the acetabulum, is one of the most common and important of congenital orthopedic disabilities. It has been recognized since the time of Hippocrates and efforts at closed reduction methods were made by Humbert as early as 1830. Paci demonstrated that manual reduction was possible but it remained to Lorenz to effectively immobilize and thus retain the correction. Surgical reduction by altering the femur head was carried out by Poggi in 1888

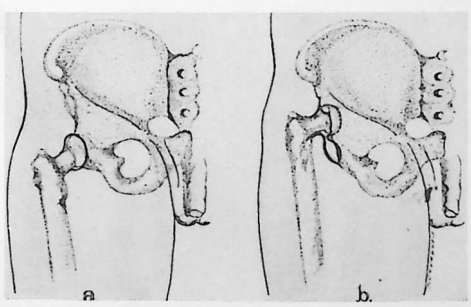


FIG. 1126. a. Illustrates the normal hip joint and capsule; b. Shows a congenital dislocation with the formation of a false acetabulum and an "hour glass" capsule.

and a well executed open operation was performed by Hoffa in 1894. At the present time there is a justified tendency in children, to resort most frequently to manipulative methods reserving surgery for established cases which reoccur or which cannot be reduced. In adults surgical intervention is always necessary.

Hey-Grove has aptly stated that, "Congenital dislocation of the hip joint is a deformity which is mysterious in its origin, insidious in its course, and relentless in its final crippling results." Present at birth the real cause has not been satisfactorily explained. There are those who believe that a malposition in utero is responsible and others that the deformity arises from an imbalance in the growth of cartilage and osseous tissue in the formation of the acetabulum. Of the sufferers, 85 to 90 per cent are females. In both sexes about 30 per cent of the cases have a familial history extending over two or more generations. As a rule the patient is of average physique and coexisting deformities are not common. The dislocation is twice as frequent single as double.

The pathologic changes seen in the acetabulum consist of an underdeveloped rim resulting in a shallow cavity into which a fibro-cartilage overgrowth takes place. The head of the femur leaves the acetabulum being displaced backward and upward. Secondary changes result and it becomes small, mis-

shapen and generally flattened. The joint capsule is carried upward by the femur head and the resulting strain is responded to by hypertrophy of the capsule until it assumes the role of a suspensory ligament for the pelvis (Fig. 1126). The femur neck is shortened, depressed and appears to project straight forward from the shaft (Fig. 1127). These combined changes, when bilateral, cause the pelvis to tilt forward and the normal lumbo-sacral lordosis to increase. A unilateral deformity provokes a downward list of the affected ilium and a distortion of the pelvic outlet.

Children with congenital dislocation of the hip tend to begin walking late. Examination at this time will reveal a broadened perineum and prominence of the greater trochanter in the gluteal region. Early there is no pain or tenderness but a limitation of abduction and external rotation of the affected limb may be

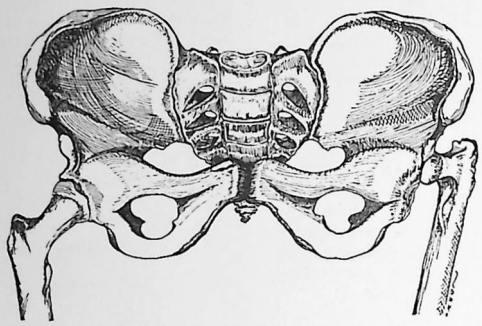


Fig. 1127. Unilateral congenital dislocation of the hip.

noted. When walking is attempted the unilateral cases lurch toward the affected side, bilateral cases develop a so-called "duck waddle" or "sailor's gait." There is an increase in the normal lumbo-sacral lordosis and upon measurement the involved limb is found to be shortened. Trendelenburg's sign (Figs. 1128-1129) is present and upon stereoscopic x-ray views the dislocation of the head of the femur onto the dorsum ilii will be seen above Nélaton's line (Fig. 1130).

The object of treatment is to reduce the existing dislocation by placing the head of the femur into the acetabulum and there maintaining it. This is followed by therapy designed to restore function to the joint. Several real obstacles exist which tend to prevent the surgeon's success, mainly the very shallow acetabulum, the anteversion of the femur neck, and the shortened muscles of the hip joint and thigh. Reduction may be effected by manipulative methods or surgical means. Successful manipulation is generally not difficult in the child that has not reached the age of six; however, if the age of the patient approaches ten years the surgeon must choose his cases very carefully. After the age of ten and in those cases which are irreducible or which redislocate after successful manipulative procedures, open operation must be resorted to.



Fig. 1128



Fig. 1129

Fig. 1128. Trendelenburg's sign. Due to a change in the fulcrum produced by the dislocation of the femur the patient upon lifting the sound leg, the buttock on that side drops.
Fig. 1129. Trendelenburg's sign. When the patient lifts the leg of the dislocated hip the buttock raises slightly with the leg.

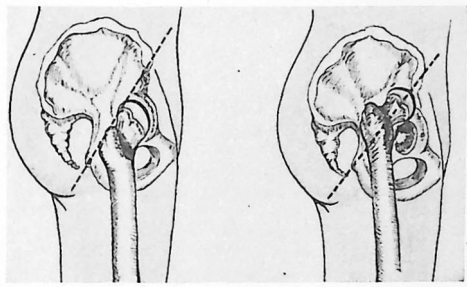


Fig. 1130. Illustration on left shows normal relations of hip to Nélaton's line. The figure on the right shows the changes in the dislocated hip.

Before resorting to manipulative procedures have the child in traction for about three weeks.

Manipulative Reduction

Step 1. Place the child on her back upon a low table. Bring the hip to be manipulated to the table's edge and have an assistant fix the opposite thigh and pelvis.

Step 2. The operator then gently puts the affected limb through its full range of motion by forcibly flexing, extending, abducting and rotating it.

Step 3. The knee is then flexed to 90 degrees where it is maintained as the thigh is flexed to about 120 degrees.

Step 4. The thigh is rotated inward as it is slowly abducted, at the same time counter pressure is applied behind or under the trochanter in order to push the femur head forward. Success is recognized when a snap is heard and the head is felt to slip into place over the rim of the acetabulum.

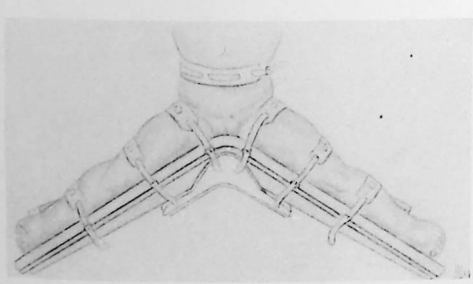


Fig. 1131. Putti's apparatus for the treatment of congenital dislocation of the hip in abduction. The degree of abduction is regulated by means of a screw on the posterior aspect of the apparatus.

Step 5. Repeat Steps 3 and 4 several times, if necessary.

Step 6. With the deformity reduced abduct the thigh at right angles with the body so that the medial surface of the knee comes to lie in a plane including the anterior superior iliac spine. The femur head is carefully steadied in the acetabulum by an assistant.

Step 7. Apply a plaster-of-Paris spica from the nipple line downward to include both legs to the ankle (even in unilateral cases).

The careful application of the spica is exceedingly important. Following its setting an x-ray visualization is made. In event the position attained is unsatisfactory allow the cast to remain in place for one week before attempting a second reduction. A satisfactory reduction is kept in place for three months and then replaced with new casts, which bring the limbs, after three or four correct replacements, into their normal position. Physiotherapy is then utilized to help rehabilitate the hip joint. (Fig. 1131.)

Certain cases are subject to redislocation after primary reduction, while in

other instances the shallowness of the acetabulum or a gross deformity of the femur head makes reduction impossible or unsatisfactory. Soft tissue changes may be so advanced and bony changes at the site of the dislocation of the femur

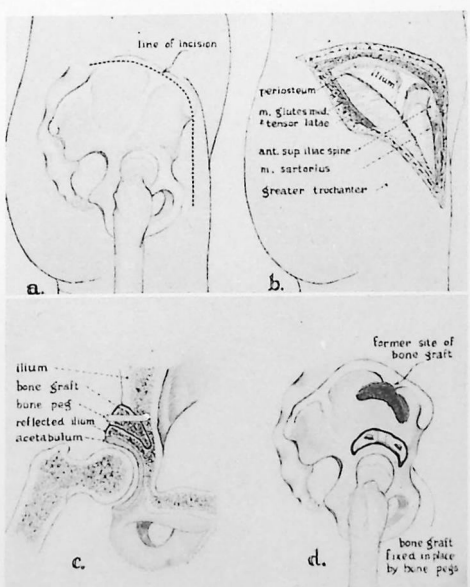


Fig. 1132. Reconstruction operation for congenital dislocation of the hip.

head so complete as to make it necessary to form an acetabulum at a new location. The operative treatment of these cases is as follows:

Operative Treatment of Congenital Dislocation of the Hips

Step 1. Carry a curved incision forward in the line of and just below the iliac crest from well back on the ilium to the anterior superior iliac spine and thence down the thigh for four inches (Fig. 1132-a). Identify the sartorius muscle at its insertion on the anterior superior iliac spine. With a sharp curved gouge detach the tensor fascia latae muscle with a thin line of attached cartilage from its insertion on the iliac crest. Incise the gluteal muscles down to the bone and strip them away from the ilium by subperiosteal dissection (Fig. 1132-b). (Smith-Peterson.) The exposure of the capsule

is complete when the anterior inferior iliac spine is brought into view and the attached rectus femoris muscle detached.

Step 2. Retract the soft tissues thus exposing the joint capsule which is opened parallel to its fibers. The state of the acetabular cavity is determined and its upper limits accurately outlined. The fibrotic tissue making up the false socket is stripped downward from the ilium until the upper edge of the acetabulum is reached where the tissue is then trimmed so as to contribute to the upper surface and brim of the natural joint.

Step 3. Using a gouge the superior half of the acetabular cavity is carefully deepened and cupped to as great a depth as the thickness of the ilium will permit.

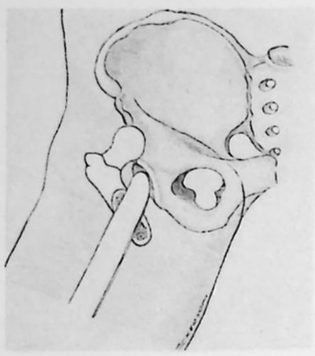


Fig. 1133. Lorenz bifurcation operation.

Step 4. With a bone chisel a crescentic incision is carried around the acetabular margin one centimeter from its border. The bony tissue which is thus loosened represents a "half cup" form and is pried down over the head of the femur until the normal cavity of the joint is restored (Fig. 1132-c).

Step 5. Remove a crescentic piece of bone from the ilium designed to fit the defect created between the ilium and the restored superior acetabular margin. When properly arranged nail or screw the graft securely in place (Fig. 1132-d).

Step 6. Test the joint thus restored. Carefully close the capsule (a reconstruction may be necessary) and then close the wound in layers seeking to bring about a strong anatomic union.

Step 7. Place the hip in a plaster spica like that used following manipulative procedures. Remove the cast in two to four months and instigate physiotherapy for the joint.

Comment: In those cases in which a manipulative reduction cannot be effected although roentgenograms reveal no gross deformity an open operation is indicated. The exposure is that of Step 1 in the preceding technic. The capsule is opened and any constricting areas incised, the femur head is then levered into the acetabulum. The capsule is then closed and the tensor fascia latae and the glutei muscles are sutured to the lateral abdominal muscles which overlap the iliac crest. No reconstructive procedures are carried out upon the head of the femur or the acetabulum.

Adults with unreduced dislocations of long standing may complain of pain resulting from a traumatic arthritis in the false hip joint and abnormal muscle pull in back. When other methods fail the bifurcation operation of Lorenz is an excellent palliative procedure. An incision is

made vertically down the lateral thigh region over the anterior inferior iliac spine. The femur is exposed and an acutely oblique osteotomy performed. The limb is then abducted, the upper end of the lower bone fragment is introduced into the acetabulum and there maintained by means of a plaster spica (Fig. 1133). Union occurs and the resulting "bifurcated" femur end rests upon bone instead of soft tissue.

FRACTURES OF THE FEMUR

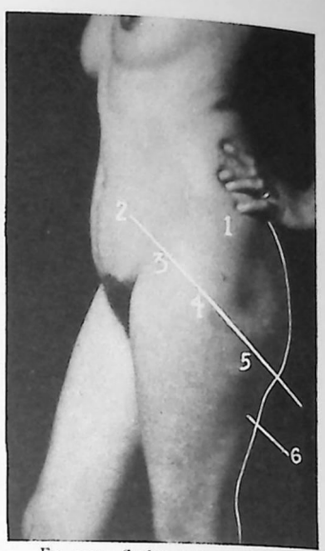


Fig. 1134. Surface anatomy of the region of the hip. 1. Crest of ilium. 2. Nélaton's line. 3. Anterior-superior spine. 4. Tip of trochanter. 5. Tuberosity of ischium. 6. Glutea femoral fold.

According to the Report of the Committee on Fractures of the American Surgical Association, published in 1922, surgeons in the United States by average, nonoperative treatment obtained good functional results in 62 per cent of femur fracture cases. Twenty-three per cent of fractures of the femur of all regions were treated by open surgical operation, the majority being shaft fractures, especially of the middle third. The Report states that "although anatomical results are rated good in 68 per cent of the open, operated cases as against 40 per cent in the non-operated, good functional result is only 77 per cent as compared with 87 per cent in the non-operated cases." The operated cases were mostly in adults.

The open surgical treatment of fractures of the femur when indicated will vary according to the position and type of fracture. Operation is indicated in case of a simple fracture when there is evidence of internal bleeding, the object being to seek the injured vessel and ligate it (Figs. 1134-1135).

Compound Fractures

No matter what may be the site of fracture, the general surgical indications are always the same for open treatment, namely, to enlarge the wound, to open up and irrigate the whole area of injury with physiologic salt solution, to wash away clots, to remove débris and bone splinters, to reduce fragments with exact coaptation, and to immobilize the limb.

The general procedure will vary somewhat according to the site of fracture and its nature.

COMPOUND COMMINUTED FRACTURE OF THE FEMUR

Operation for fractures with large fragments but without serious vascular lesions:

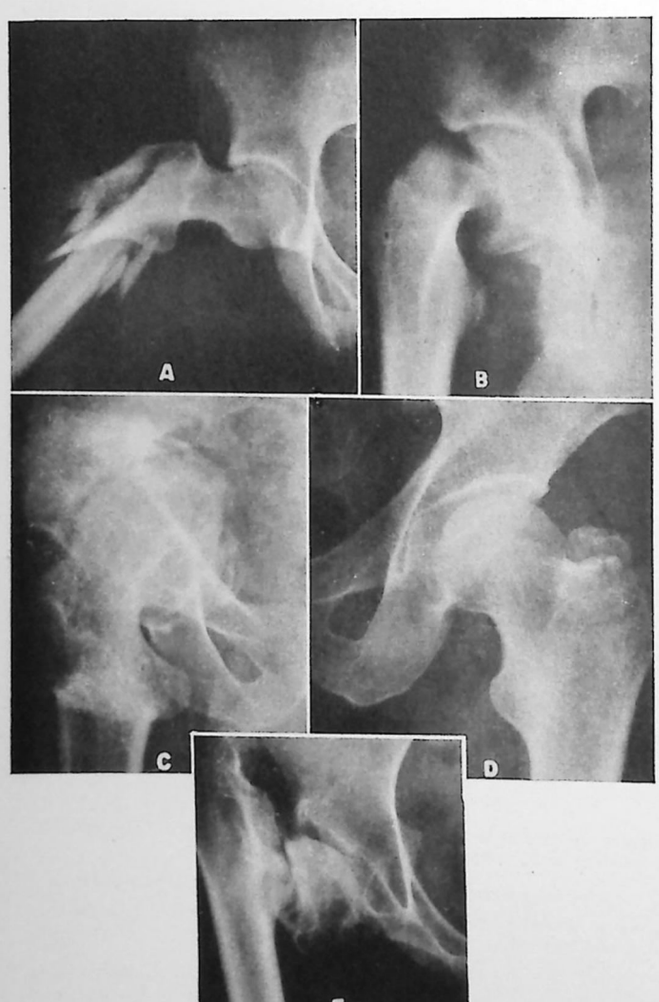


Fig. 1135. A. Comminuted, impacted fracture upper end of femur. B. Fracture through epiphyseal line, femoral head with upward displacement of shaft. C. Central dislocation of femur through acetabulum and transverse fracture through shaft below trochanter. D. Comminuted fracture of greater trochanter. E. Old intracapsular fracture of femur with upward displacement of shaft.

Open Treatment

Step 1. Prepare the region, irrigate and remove tags and débris. If there are any completely detached bone splinters remove them also.

Step 2. Open up the wound by an extensive longitudinal incision and, if necessary, enlarge it transversely. Cleanse thoroughly and examine all tissues minutely. If any protruding piece of bone is found widely stripped of periosteum, excise it or chisel away its extremity, fashioning it into a wedge.



Fig. 1136. Fracture of the neck of the femur.

Treat the other fracture fragment the opposite way, so that the two fragmental ends can be brought into close contact.

Step 3. Coapt the two fragment ends as well as possible; leave everything open placing drainage tubes in suitable positions and pack the wound lightly with gauze only when primary closing of the wound seems inadvisable. Immobilize the limb in plaster of Paris cast.

Closed Treatment for Fracture of the Neck of the Femur

Step 1. The patient is placed in position on the fracture table, traction being applied, the leg being in inversion and abduction (Fig. 1136).

Step 2. Following reduction, a plaster cast is applied, all bony points being well protected by padding to avoid pressure necrosis. Buck's extension and a Thomas splint may be used but usually gives poor results.

Step 3. Immediately after reduction and at the end of six weeks roentgenograms are made to determine the position of the reduction and to ascertain the condition of the head of the femur. The cast is generally removed after 16 to 18 weeks, and massage, passive and active movements begun.

Open Treatment for Fracture of the Neck of the Femur

Several incisions have been devised to approach the hip joint. One of these incisions will form the first stage of the operation.

Step 1. (a) The anterior angular incision, between the tensor vaginae femoris and the sartorius muscle, which avoids cutting of muscles. Division of the fascia and deep separation immediately exposes the femoral neck.

(b) The Kocher or posterior incision which necessitates cutting the glutei and the pyriformis muscles.

(c) The lateral U-shaped or straight incision about the trochanter and reflection of a flap of skin, fat and fascia. The great trochanter and its attached muscles is cut through with a Gigli saw and reflected upward which exposes the femoral neck and the joint capsule.

Whatever incision is employed, and when the joint is exposed if it is not open, it is incised and, by abducting and rotating the limb outward, the fragments are brought into view.

Step 2. The fracture is examined especially as to viability of the femoral head and the feasibility of approximating the fragments. If the head is viable, the fractured ends are freshened and may be united by an autogenous bone peg driven through the trochanter into the head of the femur, the leg being held in abduction and inversion with mechanical traction.

Step 3. The joint capsule is closed by catgut sutures and the trochanter again attached to the femur by a nail or sutures and the soft parts united.

Fracture-Dislocations of the Neck of the Femur

In old fracture-dislocation cases, when the acetabulum has become filled with fibrous tissue, it is gently scraped out without injuring the cartilaginous surface before the reattached femoral head is replaced in the cavity; the turned-in part of the capsule must be cut away from the margin of the acetabulum to prevent ankylosis; or some other plastic procedure adopted.

This type of operation is called for: (a) in cases of old unrecognized fracture with disability and shortening; (b) following nonunion after any kind of treatment; (c) for unsatisfactory functional results following any type of treatment.

Step 1. An angular incision is made running from the anterosuperior spine of the ilium to the trochanter and then turning down along the shaft of the femur.

Step 2. The trochanter of the femur is exposed, cut and reflected upward and the hip joint capsule and fracture field opened up. It may be necessary to trim away a considerable part of the trochanter and the head of the femur.

Step 3. Ununited fracture may be treated by simply freshening the bone ends with subsequent treatment as if it were a recent fracture, or by nailing, bonepegging, etc.; an autogenous bone peg being preferentially used. Bony

union may and usually is obtained with some shortening and lameness but otherwise there is a useful limb.

Step 4. If the head of the femur is found in such a condition that its removal is necessary, an effort must be made to obtain bony union of the proximal end of femur to the pelvis which, of course, gives shortening and lameness.

In children the best surgical operative treatment of old fracture of the surgical neck of the femur is a cuneiform osteotomy or subtrochanteric osteotomy to permit the leg to be swung into abduction to make up for the lessened angle of the neck of the femur.



Fig. 1137. Patient, 64 years of age. Intertrochanteric fracture of the right femur of nine weeks' duration. Patient is shown with walking caliper inserted into heel of the shoe. (Surgical Service, Cook County Hospital.)

Fractures of the Greater and Lesser Trochanters of Femur

These fractures are usually treated by manipulative reduction and immobilization (Figs. 1137-1138).

Fracture of the Shaft of the Femur

Continuous suspension traction has become generally adopted in the treatment of closed fractures of the shaft of the femur as otherwise it is very difficult to maintain accurate reduction of the fragments (Figs. 1139-1140). Skeletal traction obtained by means of a Steinmann's nail or wire passed through the calcaneum, is employed with excellent results. The point for insertion of the nail or wire is usually the outer side of the heel about the middle of the bone; the nail is driven parallel to the sole of the foot right through the inner side of the foot so that part of it projects at each side which may be used as a means of fixing the harness traction. Of course, the strictest aseptic precautions must be observed.

Steinmann nail or wire traction is also employed in open surgical treatment of shaft fractures (Fig. 1141). Operative treatment is usually reserved for cases of delayed or nonunion, or very faulty union resulting from manipulative methods.

Step 1. Preparation for continuous or skeletal traction as above. The patient is placed on a fracture table.

Step 2. The surgical approach is by an incision on the lateral aspect of the thigh in the axis of the femur; opening up of the site of the fracture; exposure of fragments and their reposition after freshening bone ends and removal of callus, if any. The fragments are locked together by the use of internal splints, nails, screws, metal plates or bone splints as may be decided upon.

Step 3. Closure of the wound with capillary drainage. Application of plaster

cast or external splints. Usually, no matter how carefully the fragments are aligned, some degree of shortening results. Immobilization is necessary for 7 to 8 weeks and walking calipers must be employed for 3 to 6 months while the patient is ambulatory (Fig. 1142).

Open Fractures of the Shaft of the Femur

The surgical treatment is the same except for the preliminary cleansing and débridement of the wound and controlling hemorrhage, if any.

Supracondyloid and Intercondyloid Fractures of the Femur

The treatment of such fractures is usually manipulative but open surgical operation is indicated if there are complications such as laceration of the popliteal vessels or when the fragments are very widely separated.

Step 1. Incision is made on the outer aspect of the thigh and the dissection is carried down to the bone.

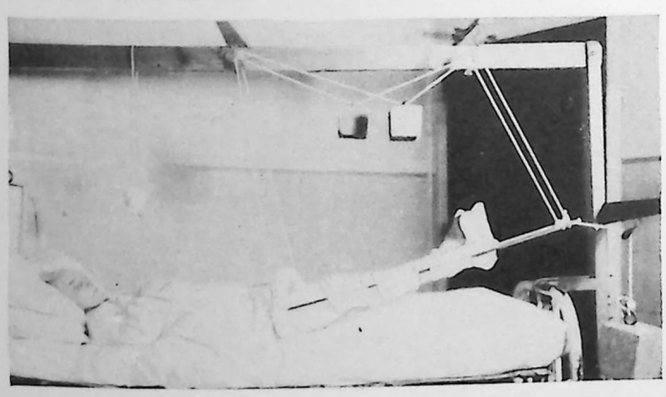


Fig. 1138. Intertrochanteric fracture of the right femur treated with Buck's extension and 20 pounds of weight. Foot at right angles and leg in abduction. Patient 60 years of age. (Surgical Service, Cook County Hospital.)

Step 2. Exposure of fracture fragments. Identification and examination of blood vessels and repair if necessary.

Step 3. Alignment of fractured bone ends and their maintenance by plate, screw or nail. Plates are of little use.

Step 4. Application of plaster cast or splints for 8 to 9 weeks. Opening of the knee joint must be avoided.

Epiphyseal Separation of the Distal End of the Femur

Open surgical treatment is usually indicated as manipulation generally fails.

Step 1. Open up the site of injury.

Step 2. An attempt should be made to adjust the fracture fragments by leverage and traction without resection of the diaphysis or any part of the epiphysis;

if successful, maintain with nail or screw driven through the diaphysis to hold the lower fragment; but if the lower fragment is split it may be nailed to the diaphysis by a nail or screw from either the joint or shaft side.

Step 3. When the bone ends are united, examine the fracture site for injuries to vessels, nerves, etc. Do not open the knee joint unless imperative. Close.

UNUNITED FRACTURE—PSEUDARTHROSIS

Separation of the fragments, unsatisfactory immobilization and the interposition of tissues between the fragments are responsible for nonunion of fractures (Fig. 1143). This condition is remedied by operative procedures designed to

(a) Remove interposed tissue,

(b) Freshen the fractured bone ends and

(c) Fix the fragments in position.



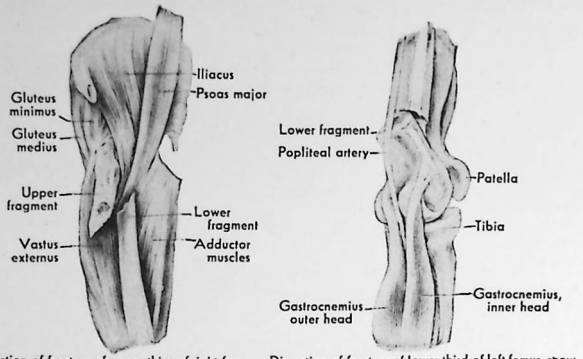
Fig. 1139. Fracture of the shaft of the femur.

Operation

Step 1. Obtain exposure via the route requiring the least destruction of tissues. In case of fracture of the humerus, avoid injuring the musculospiral nerve and other important structures. Incise between muscles rather than through them. A longitudinal incision is usually preferred. An elastic constrictor should be used only when absolutely necessary.

Step 2. Make a vertical incision through the skin down to the fascia. Reflect the skin from the fascia for a short distance on either side of the incision to locate an intermuscular septum. Incise the fascia here and penetrate the intermuscular septum to the bone by means of sharp and blunt dissection. Expose the bone by means of retractors. Let the incision be ample. The surgeon must have plenty of room to see what he is doing and to accomplish his task without being hampered by obstructing structures.

Step 3. The bone ends are prepared in accordance with conditions found at the site of fracture. All fibrous tissue, muscle, etc., are cut away from between the bone ends. Deliver each fragment from the wound and vitalize it by sawing off thin slices of bone end until a healthy bleeding bone surface is obtained. If the bone ends cannot be satisfactorily delivered, the ends may be effectually sawed off in situ with a Gigli saw or chisel. It is often possible



Dissection of fracture of upper third of right femur, showing forward and inward displacement. Dissection of fracture of lower third of left femur, showing displacement of popliteal artery by lower fragment.

FIG. 1140. Fracture of upper third of femur. (Piersol: Human Anatomy.)

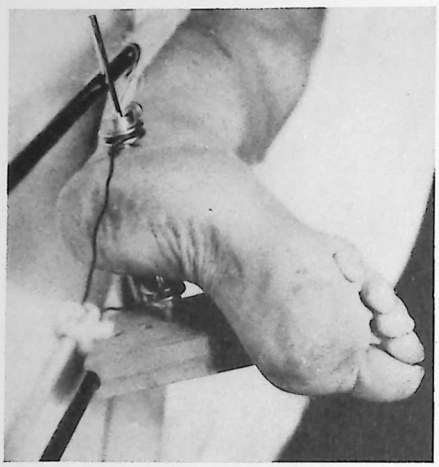


FIG. 1141. Use of Steinmann nail through the os calcis. Note block for subserving the purpose of either inversion or eversion in aligning the foot.

to saw the bones in such a manner that they may be mortised together and thus obtain fixation.

A. G. Wildey[1] describes a method of operating on ununited fractures as follows:

Step 1. Expose the fracture site and pull the bone ends out into the wound. Vivify the end surfaces by sawing off thin slices as described in Step 3 of the foregoing procedure.

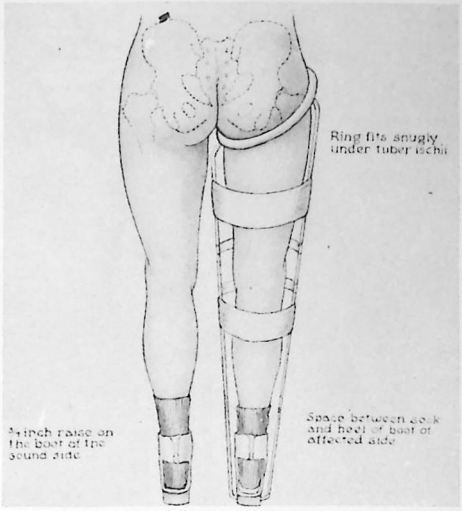


FIG. 1142. Weight-relieving caliper.

Step 2. With a gouge or drill remove the plugs of callus or fibrous tissue. By means of drills Nos. 1 and 3 penetrate the hardened bone in four or five places parallel to the long axis of the bone. The drills penetrate until they reach normal bone which is made known by bleeding and lessened resistance to the instrument—usually a depth of one or two inches.

Step 3. After thus treating both fragments fixation is accomplished by means of Lane's plates.

Wildey comments that satisfactory and firm union takes place despite the existence of callus redundancy.

[1] Brit. J. Surg., II, No. 7, p. 423.

Methods of Uniting Bones

In some few cases the fragments of bone show signs of remaining in place permitting the wound to be closed and splints applied. However, it generally becomes necessary to inaugurate other measures to bring about direct union.

Transverse or oblique fractures may be united with stout wire or chromicized catgut as depicted in Fig. 1144 [B, C, D].

Another method used where the fractured surfaces are oblique is to drill a hole transversely through both bone fragments; leave the drill in place; bore another hole through both fragments with another drill. Remove the first drill and put a bone peg in its place. After the pegs are in position, any protruding part may be cut off even with the bone surface; metal nails or screws may be substituted for the bone pegs.

In some instances the drills used to pierce the bone are left in situ with their nearest ends emerging through the soft parts of the wound. The drills become loose after two or three weeks and are then easily removed.

Fixation is also brought about by the use of intramedullary pegs, internal splinting, long screws and external clamps. Figures 1144 and 1029, p. 919 depict various methods of fixation.



FIG. 1143. Fracture of both bones of the leg. Improper reduction. Malunion. Reconstructed from x-ray.

DISLOCATIONS AND FRACTURES OF THE KNEE

Dislocation of the knee is usually due to injuries to the cartilages about the joint. Such dislocation, if recurrent or habitual, may call for open surgical correction.

Dislocation of Cartilages

Step 1. An angular incision about 2½ to 3 inches long is made over the lateral aspect of the joint on the side affected, with the knee hanging over the edge of the table.

Step 2. The muscles are retracted and the cartilages—usually the semilunar—are exposed, grasped by forceps and dissected out. No attempt should be made to suture the cartilage in place as such procedure has generally been abandoned. The knee joint is not manipulated in any way.

Step 3. The wound is closed in layers.

Note: If there are any loose pieces of cartilage in the posterior recesses an incision in the popliteal space may be necessary for their removal.

DISLOCATION OF THE PATELLA

This is usually due to rupture of the joint capsule without bone fracture. The dislocation is likely to become habitual and hence open surgical operation is indicated to close the joint firmly.

Step 1. Make an arthrotomy incision 6 to 8 inches long on the inner aspect of the front of the knee joint. The joint capsule and quadriceps muscle, which is also usually injured, are exposed.

Step 2. The injured structures—capsule, muscle and ligaments—are repaired layer by layer. The semilunar cartilages should be carefully examined. In recurring dislocations, especially if there is knock knee, a preliminary osteotomy may be necessary.

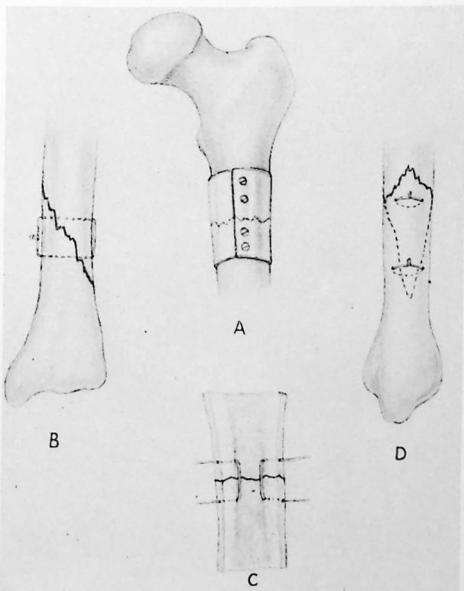


FIG. 1144. A. Metal collar for fixation of fractures. B. C. D. Wire sutures for oblique and transverse fractures.

Step 3. Close the wound without drainage and use walking calipers for an extended period.

A great many methods of surgical treatment of recurrent dislocations of the patella have been devised.

Recurrent Dislocation of the Patella

The patella may be dislocated either as a result of trauma or congenital abnormality or both. The direction of most frequent displacement is lateralward. The congenital type is usually associated with an underdeveloped lateral condyle combined with a weakness of the ligaments of the quadriceps extensor

muscle. The traumatic type occurs most frequently in females especially if there is a tendency to genu valgum.

The original dislocation in either type is usually traumatic in origin. Reduction is at first most difficult and painful but after frequent recurrences it becomes exceedingly easy. The patient finds that by extending the leg and then flexing the thigh the kneecap can be manipulated into position. This procedure when often repeated eventually produces an unstable joint.

Effective treatment is surgical in nature. The operative procedure of choice depends upon the cause of the dislocation. See Soutter's operation, p. 1

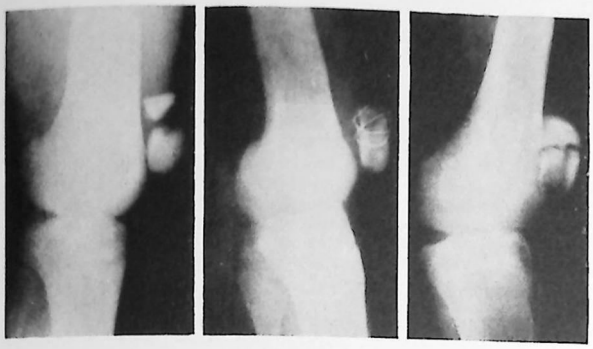


Fig. 1145 Fig. 1146 Fig. 1147

Fig. 1145. Fracture of the patella with marked separation of the fragments.
Fig. 1146. The fragments united with silver wire.
Fig. 1147. Same patient. Ten weeks after fracture. Silver wire removed.

Fracture of the Patella

In fractured patella manipulatively treated, the average result is fibrous union with varying functional loss; but even if bony union is obtained anatomic adjustment is often unsatisfactory and refracture is quite common, owing to the limitation of movement in a very active joint. Under such circumstances, open surgical treatment in the first instance is considered to be the treatment of choice (Figs. 1145-1146-1147-1148-1149-1150).

Step 1. All the basic precautions applicable to aseptic surgery of the joints must be very strictly observed in the case of the knee joint as there is here a strong tendency to infection with all of its calamitous sequences.

There are various incisions: straight, longitudinal or transverse, semilunar concave or convex downward or convex outward or inward. The semilunar convex downward incision from the condyles of the femur nearly to the tibial tubercle seems to be preferred by most surgeons.

Step 2. Dissect the flap back until the ruptured capsule, ligaments and fracture fragments are exposed.

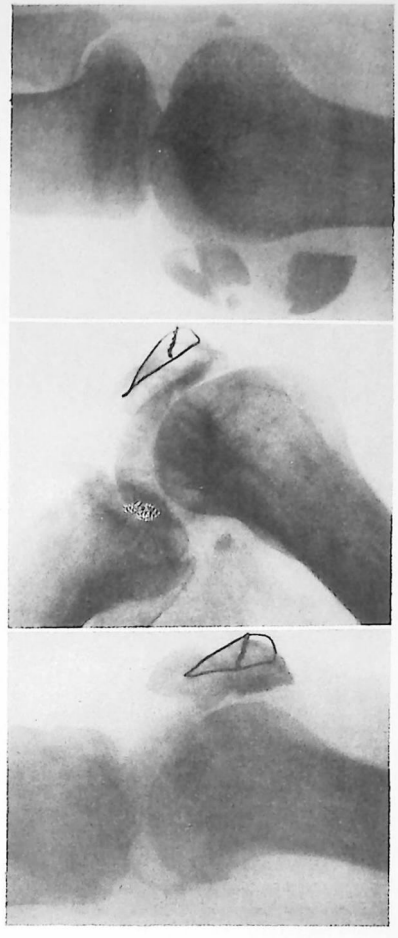


Fig. 1148
Fig. 1149. Same as preceding after wiring, with leg in flexion. No impairment of motion.
Fig. 1150. Same as preceding six months after uniting the fragments with wire.
Fig. 1149
Fig. 1148. Splintering fracture of the patella.
Fig. 1150

Step 3. Evacuate the knee joint; remove any blood clots. Separate the fragments and cleanse the joint cavity. The bone fragments are carefully lifted up and any fibrous tissue removed. Spicules of bone are frequently impaled in the torn fascia; this prevents apposition of the fragments (Fig. 1151).

Step 4. With the leg extended, the bone fragments are rarely more than 1 inch apart. The surgeon must decide upon one of the many methods in vogue for uniting the bone fragments. These are principally: 1. "Cerclage" of the patella fragments with fascial bands, kangaroo or other tendon or wire (Fig. 1152). This consists of exposing the bone and freeing it sufficiently. The suture selected is then made to encircle the fractured fragments. After this, the fibrous capsule, fascia and periosteum are sutured over the united patella followed by skin closure. 2. Transverse or longitudinal bone suture, holes being drilled in each fragment and using sutures of tendon, fascia, wire or silk. The holes must not penetrate into the joint. 3. Some cases, especially badly comminuted fractures, demand removal of the patella with the turning down of a flap of the quadriceps tendon to fill the defect.

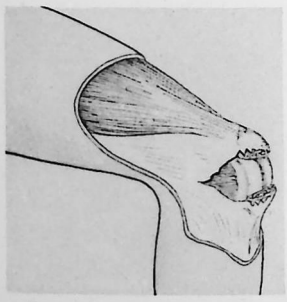


Fig. 1151. Torn fascia in fractured patella showing impaled spicules of bone preventing apposition. (After Helferich.)

Step 5. Following union of the bony fragments, examine the lateral ligaments and other structures about the joints, repairing them as may be necessary.

Step 6. When the patient has recovered from the anesthesia, place a longitudinal padded posterior splint. This may be left in place for a week if the patient is an adult and can be trusted not to flex the leg after removal of the splint. For further treatment, Buck's extension or other splint or a permanent plaster cast may be applied for at least 4 weeks. Massage and passive and active movements may be commenced early. Good bony union is the rule and ankylosis is rare. Figure 1153 depicts Barker's operation for fractured patella.

In old malunited or nonunited patellar fractures, the open surgical treatment is the same except that, following exposure of the fracture fragments, callus must be removed and the bone ends freshened. An Albee inlay bone transplant may be used advantageously to hold the fragments in approximation when the separation requires such a bridge.

DELBET'S METHOD OF TREATING FRACTURE OF THE PATELLA

Two main factors must be kept in mind in treating these cases, according to Eugene St. Jacques. First, solid union and, second, mobilization of the knee joints after the operation, in order to prevent ankylosis.

Kangaroo tendons are used to maintain the apposition of the fragments, as

chromic catgut or silk will not insure solid apposition and prompt mobilization. When the latter materials are used for suturing the soft prepatellar tissues one must immobilize the knee for many weeks and then allow only very gradual movements. The suture material of choice is metallic-bronze-aluminum or so-called "metallic silk." This is pliable and unbreakable.

Operation

Step 1. A hole is bored from the upper edge of the upper fragment down through both fragments.

Step 2. Draw a double strand of the "metallic silk" through the holes.

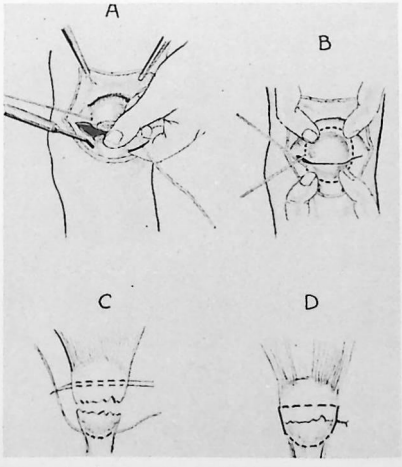


Fig. 1152. Repair of fractured patella by cerclage. Gloves should be worn. (After Labey.)

Step 3. Draw each strand through the soft tissues, one to the left and one to the right, knotting the lower with the upper one of the outer side, repeating the same thing on the inner side—the fragments having been brought together and kept in juxtaposition with the aid of a proper bone clamp held by an assistant.

Step 4. A few catgut sutures complete the apposition of the soft parts—and an intradermal or silkworm-gut suture closes the skin. No drainage.

Comment: Before closing the patella or apposing its fragments the joint is filled up with Calot's Liquid (Creosote, 3 parts; Iodoform, 7 parts; Sulf. Ether, 25 parts; add to Olive Oil—sterilized—50 parts)—this serves as an antiseptic medium, prevents adhesions and facilitates early movements.

Apply a posterior splint; replace it after 5 days by a simple bandage around the knee; begin flexion, gradually loosening the knee joint. On the 10th day, permit the patient to walk around with a posterior splint; after a day or so, omit the splint and have him use a cane. St. Jacques used this method for 20 years with gratifying results.

SOUTTER'S OPERATION

This method gives good results when genu valgum is not present.

Step 1. Remove a strong eight-inch strip of fascia lata from the outer aspect of the thigh. Place the tissue in warm physiological saline and close the operative wound.

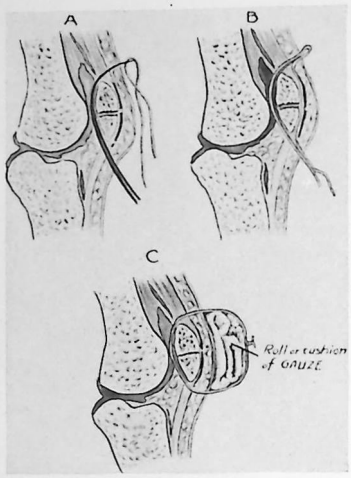


Fig. 1153. Barker's operation for fractured patella.

Step 2. Carry a vertical linear incision along the medial side of the patella down and over the median condyle of the tibia.

Step 3. Drill a hole through the patella from its midposteromedial aspect in a slightly anterior direction. With the leg extended make a drill hole through the medial femoral condyle on a level with that in the patella.

Step 4. Thread the fascial strip previously prepared through the holes and securely fix the free ends.

Step 5. Close the wound and dress. Immobilize the joint in a few degrees of flexion for six weeks.

ALBEE'S OPERATION

This procedure is frequently resorted to in the presence of genu valgum and lateral condyle deformities associated with recurrent dislocation.

Step 1. Carry a lunate incision from above the lateral condyle forward and along the lateral border of the patella and thence backward below the tibial tuberosity.

Step 2. Expose the condyle; locate the anterior articular surface and one-half inch behind and three-quarters inch below it make a longitudinal incision with a 2-inch osteotome. Drive the instrument inward and upward, elevate the bone wedge thus loosened.

Step 3. Remove a similar wedge of bone from the crest of the tibia and snugly insert it into the wedge shaped defect created by the osteotome.

Step 4. Close the soft tissues and skin. Immobilize in a plaster of Paris cast for 4 or 5 weeks before passive motion is begun.

FRACTURES OF THE BONES OF THE LEG

The Report of the Committee on Fractures of the American Surgical Association, published in 1922, showed that about 20 per cent of fractures of the tibia and fibula are treated by open surgical operation. The Report states: "In regard to operative treatment these (accompanying) tables appear to show that it has proved less easy to secure anatomical reposition of the fragments by operation at any age period than when no operation is done. The operated cases were not those in which non-operative methods had been tried and failed and had overriding displacement. In compound fractures only about one-fourth of the patients will secure good functional results unless accurate reduction is secured. In comparatively few cases can gross displacement of the leg bones be corrected by manipulation alone; such manipulations may do more damage to the soft parts than open operation." (Figs. 1154-1155-1156.)

Fractures of the Proximal End of the Tibia Alone or of the Tibia and Fibula Together

In closed fractures if there is wide separation of the tuberosities or if the knee joint is involved open surgical operation is indicated.

Step 1. A long incision is made over the fracture fragments. The knee joint is not opened.

Step 2. The displaced parts are dissected up and correction made both toward the joint surface and tibial edge. The fragments are maintained in position by nail or screw.

Step 3. Splints are applied for four weeks (Figs. 1157-1158).

Pott's or Dupuytren's Fracture

It is an established practice to reduce the fracture and immobilize it as quickly as possible (Fig. 1159). Reduction should be accomplished with the aid of x-ray checkups. General anesthesia is generally called for but spinal anesthesia is by some considered far superior. The method of reduction is as follows:

Step 1. Grasp the affected foot in the palm of the right hand. Place the foot at right angles to the leg. The object of this maneuver is to reduce the backward dislocation.



Fig. 1154



Fig. 1155

Fig. 1154. Fracture of both bones of the leg.
Fig. 1155. Fracture of the tibia.

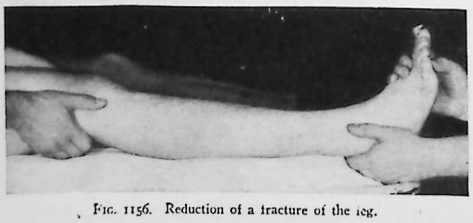


Fig. 1156. Reduction of a fracture of the leg.

Step 2. Bring the foot now in an exaggerated supinated position. In this manner one corrects the valgus resulting from the fracture. Hyper-correction in a supinated position is warmly recommended by Savariaud.

Step 3. Encase the limb in a plaster of Paris bandage.

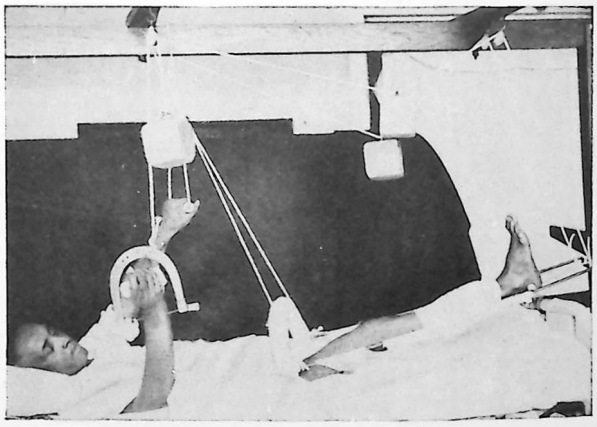


Fig. 1157. Fracture of both bones of the right forearm. Kirschner's wire through the radius and ulna; also compound fracture of both bones of the right leg. Steinmann's nail through the os calcis.

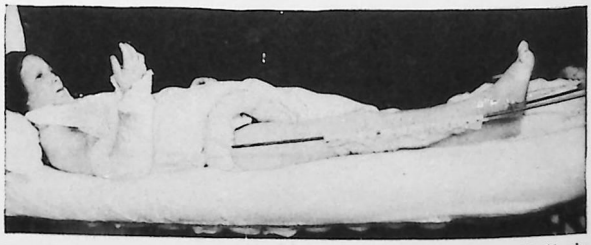


Fig. 1158. Fracture of both bones of the right leg and both bones of the forearm. Double pin fixation of the forearm. Steinmann nail through the os calcis.

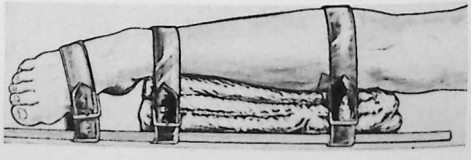


Fig. 1159. Dupuytren's splint applied.

Open Fractures of the Leg Bones

are treated in accordance with the general rules governing the surgical treatment of open fractures anywhere. If reduction cannot be effected Steinmann's nail through the heel bone, as previously described, should be used for skeletal traction.

Open surgical treatment of leg fractures is practically reserved to cases of malunion with overriding and shortening or nonunion following manipulative treatment.

Step 1. Make an incision over the site of the fracture, retract the muscles and expose the fracture ends.

Step 2. Removal of the fibrous union, deperiostization and freshening of the bone fragment ends are done. Skeletal or continuous traction will restore the proper length and the fragments are maintained in position with metal plates preferably applied on the lateral aspect of the tibia where they can be covered with thick muscle and not immediately under the skin. Intramedullary autogenous bone grafts may, of course, be used or any other method of osteosynthesis.



Fig. 1160. Fractures of tibia and fibula at ankle joint with slipping of tibial epiphysis.

Step 3. Closure and immobilization.

Fracture Dislocation of Distal End of Fibula

If this dislocation cannot be reduced by manipulation, open surgical treatment is indicated (Figs. 1160-1161-1162).

Step 1. Make a lateral incision over the lower end of the fibula and expose the bone by dissection.

Step 2. Any fibrous tissue interposed between the fibula and tibia is trimmed away and the fibula pressed close to the tibia. It is maintained in position by pegging into the tibia with a nail through a hole carefully drilled in the smaller bone.

Step 3. Repair any torn ligaments or tissues.

Step 4. Close the skin wound and enclose the leg in a plaster cast.

Fracture Tearing the Head of the Fibula

In such a fracture the external popliteal nerve is often injured giving rise to acute pain. Manipulative reduction is very difficult and the indication is for open operation (Fig. 1163).

Step 1. Make an external lateral incision in the line of the upper part of the fibula; retract the lacerated muscle fibers.

Step 2. A search is made for the external popliteal nerve, working from above downward and from behind forward keeping the tendon of the biceps in view as a guide. When found the nerve is disengaged and drawn aside.

Step 3. The bone fragments are found, united and fixed by one or two sutures in such a way as not to again injure the nerve. It may be necessary

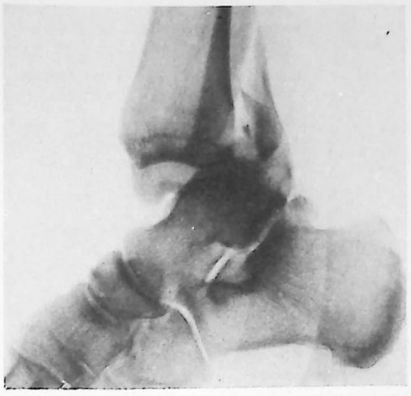


Fig. 1161. Dislocation of ankle joint with fractures of tibia and fibula.

to excise the head of the fibula, rounding off the diaphyseal end of the bone.

Malleolar Fractures

Malleolar fractures are generally treated by manipulative methods but in certain cases, as given below, open surgical operation is called for:

1. In irreducible tipping fractures.
2. When the tibio-fibular ligament is ruptured with wide separation of the bones. In such case, it is necessary to nail the leg bones together to correct the position of the foot or to use skeletal traction by a nail or wire through the calcaneum.
3. In bi-malleolar and tipping fractures nailing of one or both malleoli in place is indicated.
4. Old malunited fracture cases with deformity and pronated malfunctioning foot may necessitate surgical correction. An arthrodesis of the ankle joint is the usual method of choice. If pain is the greatest complaint and there is but little malposition, Cotton's device of excision of the inner side of the fibula with closure and splinting may suffice. This permits of new bone formation on the inner



Fig. 1162. Dislocation of ankle joint with fracture of fibula.

side of the fibula which assumes a shape to accommodate the talus and pain ceases. If there is much shortening an ankle arthrodesis may be carried out with insertion of a bone transplant to lock the talus to the tibia and fibula.



Fig. 1163. Fracture of the upper end of the fibula.

FRACTURES AND DISLOCATIONS OF THE BONES OF THE FOOT

FRACTURE OF TUBEROSITY OF OS CALCIS

This particular variety of fracture requires surgical fixation (Fig. 1164). After reducing the fracture by manipulation, make a small incision in the middle of the posterior surface of the fragment of bone attached to the tendo Achillis. Drill a hole through this fragment, penetrating the os calcis, and insert a nail or bone peg. Suture the skin wound if necessary. Flex the knee and immobilize the extremity in a position of plantar flexion.

Cheyne and Burghard recommend the formation of a flap of skin with its convexity turned upward, reaching high enough up the back of the ankle to escape friction from the hard part of the foot. In cases of long standing, one may have to resort to lengthening of the tendo Achillis before reduction can be accomplished.

Fractures of the Os Calcis

A tearing fracture of the os calcis which involves the posterosuperior part of the bone is best treated by the open surgical method (Fig. 1165).

Step 1. Make a vertical lateral incision with the leg flexed and the foot strongly extended.

Step 2. The fracture area is opened up and the detached fragment is brought into contact with the fractured surface of the os calcis and fixed in position by lateral sutures or other osteosynthetic methods. If necessary, a wedge-shaped piece of the os calcis may have to be excised.

Step 3. Close the wound and immobilize.

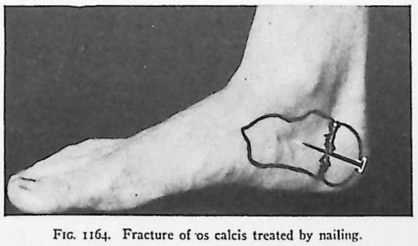


Fig. 1164. Fracture of os calcis treated by nailing.

In avulsion fracture of the os calcis, open operation is indicated when there is much separation and displacement with a large detached fragment.

Step 1. Make an incision about five inches long parallel to the inner margin of the tendo Achillis, carried down to the inner side of the heel. The skin and superficial parts are reflected.

Step 2. A tenotomy of the tendo Achillis is done. The avulsed bone fragment is stretched down to the site of its former level. The bone surface of the body of the calcaneum is freed from clots or scraped with a dull instrument and the loosened fragment is held in place by absorbable sutures introduced through it into the body of the bone. Plantar flexion of the foot is necessary in order to obtain this approximation.



Fig. 1165. "Y" shaped fracture of os calcis.

Step 3. If the loose fragment is large, it may be affixed in its proper place by a screw or staple. Close the wound.

Step 4. The foot, leg and thigh are placed in a plaster cast for six weeks and weight bearing is not allowed for about 14 weeks.

The same general surgical treatment is followed for any other kind of irreducible fracture of the os calcis; or, if preferred, a Steinmann nail may be

driven just above the calcaneum and beneath the tendo Achillis. A Kirschner wire may be used advantageously at times.

Old improperly treated compression fractures of the calcaneum may call for open surgical treatment owing to the constant pain and disability caused by walking or standing. The pain is due to the fact that the external malleolus is pressed down by weight bearing against the partly flattened calcaneum.

Step 1. A curved incision is made under and around the external malleolus. The skin and subcutaneous fat are retracted, the tendons pushed out of the way or cut and the calcaneum exposed.

Step 2. There is usually much callus and new irregular bone formation extending out and under the external malleolus. This is chiseled away and



Fig. 1166



Fig. 1167

Fig. 1166. Transverse fracture through base of fifth metatarsal bone.
Fig. 1167. Transverse fracture proximal phalanx little toe.

normal anatomic conditions restored as far as possible. The wound is then closed, no effort being made in these old cases to restore the collapsed or compressed feature of the fracture, it being expected that motion in such a foot will always be imperfect.

Magnusen's Method of Treating Fractures of the Os Calcis

Commenting on fractures of the os calcis, Paul B. Magnusen[1] states there is still considerable disagreement among authors as to the best method of treating this type of fracture. There is one fundamental rule and that is whatever treatment is decided upon must be vigorous and thorough because if the heel is not molded back into position properly, serious and permanent disability ensues. Magnusen points out that since the tendo Achillis is attached to the posterior fragment of the os calcis transmitting the power of the gastrocnemius and soleus directly to this fragment, this pull must be relaxed or dispensed with by putting the foot in full plantar flexion after the fracture has been reduced and do a tenotomy on the tendo Achillis.

[1] "Fractures," J. B. Lippincott Company, 1933.

Step 1. Do a tenotomy of the tendo Achillis. Place the inner and inferior surface of the os calcis across an orthopedic block. By means of a felt mallet or a small hard sandbag the impaction is broken up by a firm hard blow delivered to the lateral and superior surfaces of the affected bone.

Step 2. This having been accomplished the instep is brought over the orthopedic block and the posterior fragment of the os calcis brought downward, inward and forward. They are then molded into as nearly normal contour as possible. Effect slight over-correction.

Step 3. Place a felt pad over the posterior and superior surface of the os calcis and over the dorsum of the foot and instep. The leg and foot are placed in a cast.

DISLOCATION AND FRACTURE OF THE TALUS (ASTRAGALUS)

An open surgical operation may be necessary to reduce a dislocation of the talus.

Step 1. Approach is made by an incision on the lateral aspect of the ankle. The peroneal tendon usually must be resected in order to expose the talus.

Step 2. The talus may be removed by flexing the foot laterally in order to permit its re-entrance into the ankle mortise. The general surgical rule is to remove the dislocated portion of the bone and leave the fragment which is in place in the ankle mortise. If this cannot be done the talus may have to be entirely removed and the foot put up at right angles to the leg or an immediate arthrodesis of the ankle done in order to obtain fusion.

Step 3. The peroneal tendon is sutured and the wound closed.

If the talus is fractured with an open wound, following the usual aseptic procedures for an open fracture, removal of the talus as above mentioned is usually the surgical method of choice. The same applies to other fractured bones in this vicinity.

DISLOCATIONS AND FRACTURES OF THE METATARSAL AND PHALANGEAL BONES

As a general rule these injuries are treated by special manipulative methods and no surgical operation is called for except in the case of open fractures. Such are very vulnerable to infection and gangrene and these must be guarded against, the fracture or dislocation being of secondary importance. (Figs. 1166-1167.)

Step 1. Observe careful aseptic precautions; opening up and débridement are done, the foot being kept warm and circulation fostered.

Step 2. If there is pus, institute drainage.

Step 3. Avoid all weight-bearing. A plaster boot fitted with a metal stirrup is applied. This will relieve the sole of the foot from pressure and permit ambulation during the healing period.

Comment:[1] Summarizing "Fractures of the Ankle and Foot," Frederick J. Cotton points out the following:

[1] Address to the New York and New England Association of Railway Surgeons, November, 1932.

Class I. Outward Dislocation With Malleolar Fracture (Pott's fracture). This is readily recognizable even without x-ray (displacement; ease of reduction by inward pressure; impossibility of over-reduction). (Fig. 1168.)

Later, x-ray may call for modification of position before the foot goes into plaster, but often does not, and the advantages of immediate reduction are great, in the way of avoidance of swelling and formation of blebs.

For this and the next two classes, Cotton recommends the pillow-splint technic, as perfected by Gurd of Montreal.

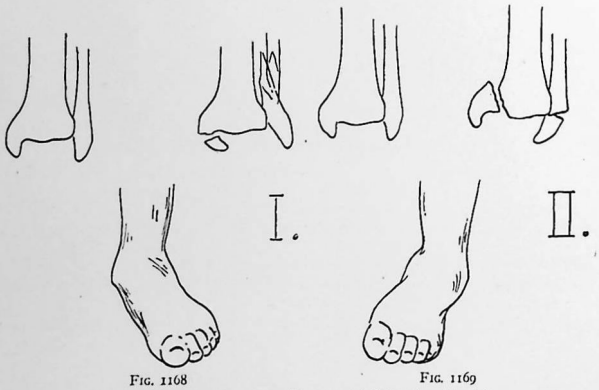


Fig. 1168 Fig. 1169

Fig. 1168. Type 1. Fracture with outward dislocation (Pott's).
Fig. 1169. Type 2. Fracture with inward dislocation (Reversed Pott's).

Class II. Inward Dislocation with Malleolar Fracture, Reversed Pott's fracture. This fracture is produced by inversion of the foot; it can be reduced by pushing outward (not inward). This also cannot be over-reduced, and can be held. (Fig. 1169.)

Treatment: Early reduction and immobilization. X-rays may be delayed if need be. Cotton points out:

"Oddly enough, the x-ray may lead to harm, not good, for this, like the Pott's fracture, involves breaking of both malleoli and, as it is not common enough to be familiar, confusion may arise. I have seen ghastly results in good hospitals from treating such cases by inversion.

"Class III. Backward Dislocation with Fracture (Cotton fracture). It involves fracture of both malleoli, with also a wedge off the back articular edge of the tibia, with displacement backward of the foot, malleoli and tibial fragment, all together. Here again the same principle holds—the

foot can be displaced back without resistance—cannot be carried forward beyond normal limits. (Fig. 1170.)

"Treatment. Prompt reduction. This is especially indicated in these cases—not quite as easy as in Classes I and II, but it is usually necessary to swing the foot down into plantar flexion before carrying it forward. If then it is carried into dorsal flexion, with the grip on the front part of the foot, it usually locks and can be put up in a pillow splint temporarily. In this injury the pillow splint is not usually permanent, nor even long continued, for the x-ray is apt to show slight displacement backward, recurring if replacement is done.

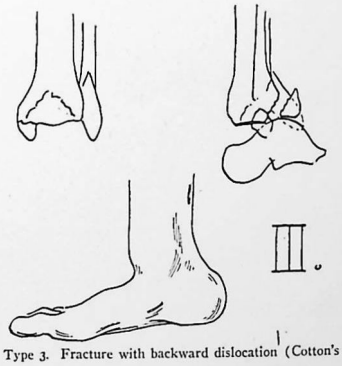


Fig. 1170. Type 3. Fracture with backward dislocation (Cotton's fracture).

"There is much more tendency to redislocation in these cases than in those of Classes I and II. Occasionally there is a case encountered which can be treated only by open operation and pinning. (Fig. 1171.) This is in definite contrast to the other varieties which practically never come to open interference except to correct old imperfect reductions.

Classification (Cotton)

I. Dislocation outward—'Pott's.'
II. Dislocation inward—'Reversed Pott's.'
III. Dislocation backward—Cotton.
IV. Dislocation upward (Tibial fracture, with or without fibular lesion)—Diastasis. (Fig. 1172.)"

SPRAINS

Disability resulting from slight or extensive rupture of the soft parts (ligaments and muscular attachments around the joint) resulting from forced activity or direct trauma is known as sprain. One should never diagnose sprain without an x-ray check-up. Many fractures without displacement effectually mimic

sprains (greenstick fractures, compression fracture of the os calcis, fractures of the malleoli, etc.).

Sprains of the Ankle Joint. Here the external ligament of the joint is usually ruptured. It is counteracted by promptly applying pressure over the ruptured ligament. Resort to adhesive plaster strapping, early massage, avoidance of the use of the affected limb for about a fortnight. The patient should not be permitted to wear an ordinary shoe without having it raised for three-fourths of an inch on its outer side in order to relax the injured external lateral ligament

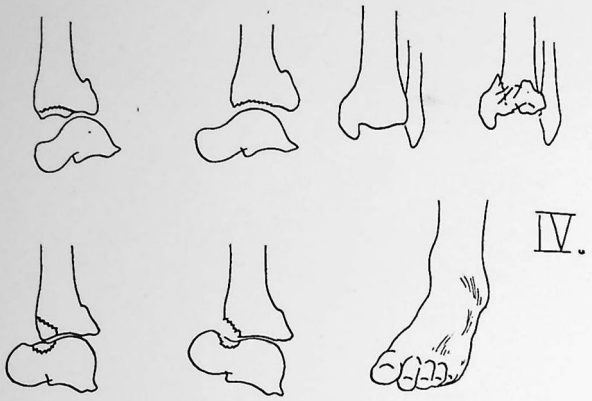


FIG. 1171 FIG. 1172

FIG. 1171. Operation for deformity following type 3 fracture. Above, reconstruction of new joint with deformity corrected. Below, clearance of blockading bone only.
FIG. 1172. Type 4. Fracture with comminution—upward displacement in relation to fibula.

thus promoting union of its ruptured fibers. The raised shoe may be dispensed with toward the end of a month.

Sprain of the internal lateral ligament is usually accompanied by some form of Pott's fracture. Such injury should be treated by strapping the affected foot in a position of *inversion*. Here also before the patient is permitted to resume walking the shoe should be raised three-fourths of an inch of its *inner border* thus relaxing the internal ligament and favoring union. The shoe must be worn about two or two and one-half months.

Sprains of the knee usually affect the internal lateral ligament which is partially ruptured. If the extent of the trauma is severe there may be a concomitant injury to the internal semilunar cartilage. The treatment consists of proper bandaging, early massage and absolute rest for about a week. Walking should not be allowed except in a shoe the inner border of which has been raised one-half inch.

In injury to the internal semilunar cartilage, the symptoms are more marked; besides pain, swelling and tenderness there may be a locking of the joint in partial flexion.

Check the findings by x-ray. The treatment consists of

1. Reduction of the dislocated cartilage.
2. Immobilization of the affected joint.
3. Early massage.

In reducing the cartilage general anesthesia should be administered. Sir Robert Jones pointed out that the surgeon should be able to tell whether he feels the cartilage in its place or not.

To reduce a displaced cartilage, the limb is put in abduction, flexion and external rotation followed by sudden adduction, internal rotation and extension.

Sprains of the Shoulder. Usually the parts injured here are the superior external portion of the capsule in the region of insertion of the flat tendon of the supraspinatus muscle. The subacromial bursa is also affected in which case Codman's bursitis is spoken of. The treatment is usually rest. Carry the affected arm in a sling without attempting to lift the arm from the side of the body. Massage—passive motion and active motion after the acute manifestations have subsided.

Sprains of the Elbow. Here ruptured muscle fibers, torn and displaced ligaments, formation of an adventitious bursa (Mills, Osgood) may give rise to the so-called "tennis elbow." If the usual treatment fails, Osgood points out that there is an adventitious bursa of the painful spot, the ablation of which by partial dissection cures the condition. In recent cases, locate the painful area, rest the affected limb and apply gentle pressure.

In **sprains of the wrist**, adhesive strapping over the affected wrist should be resorted to, for some time.

Sprains of the Sacro-Iliac Joint. Rest, strapping and the wearing of a sacro-iliac belt is advisable. In chronic cases general anesthesia may be administered and with the patient in the reclining position the lower limb of the affected side is flexed at the hip to a right angle with the knee extended and pressure is exerted downward on the pelvis. Then turn the patient to the side and hyper-extend the affected hip.

Part IV

SURGERY OF THE BREAST AND CHEST

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31. Surgery of the Heart and Pericardium	1203

ORIENTATION

Chapters 25 to 31 (incl.) deal with surgery of the breast, bronchi, pleura, lungs, the pulmonary artery, affections of the heart, of the mediastinum, pericardium, etc. While the surgical treatment of carcinoma of the breast is still buffeted about on the sea of surgical opinions, there is nevertheless a tendency toward stabilization. The more accurate classification of tumors of the breast (still far from complete), and understanding of the indications and types of surgical procedures suitable for specific cases, have considerably clarified and standardized operative procedures. These are being referred to in connection with the operations described. Frozen sections at the operating table for the purpose of ascertaining the presence or absence of malignancy have frequently yielded erroneous information. The contributions of Handley and Halstead are still the guiding posts to many, while others abstain from "clearing out the axilla" arguing that carcinoma is a systemic and not a local disease. Radiation therapy and electrosurgical procedures as a palliative, alone, or in combination have their place. Radiation as a pre- and postoperative measure is of value in the hands of the surgeon who evaluates, eliminates and combines to fit the formula represented by the morbid condition of the patient.

Lilienthal, Sauerbruch, Nissen, Churchill, Archibald, Rienhoff, Jr., Graham and others have done much to throw light onto the problems confronting the surgeon in chest surgery. A thorough perusal of the operative procedures described in this chapter will point out the remarkable results achieved in the last decade or two, the result of their contributions. Unfortunately, pulmonary embolus is still the *bête noir* in surgical practice. Some progress has been made in these tragic situations, the result of the corner stone built by Trendelenburg and furthered by the contributions of Willy Meyer, Howard Lilienthal, Elliott C. Cutler, Gunnar Nÿstrom and others.

The surgical treatment of pulmonary tuberculosis has made rapid strides. Unfortunately, the lack of serous investment of the thoracic esophagus is still a vulnerable point and is responsible for a dark chapter in surgery despite the fine contributions of Torek, Lilienthal, Grey Turner and others. Much remains to be done here. However, it is stimulating to contemplate that while a few decades ago surgery of the heart was as a whole *terra incognita*, real progress is in the making. To mention only Claude S. Beck's contributions to the surgery of the heart (suture, resection of the pericardium, attempts at creating a new blood supply to the myocardium, etc.) and the admirably conducted researches in other quarters is sufficient.

CHAPTER 25

SURGERY OF THE BREAST

Anatomic Considerations. The breasts consist of a parenchyma, stroma, and adipose tissue (Fig. 1173).

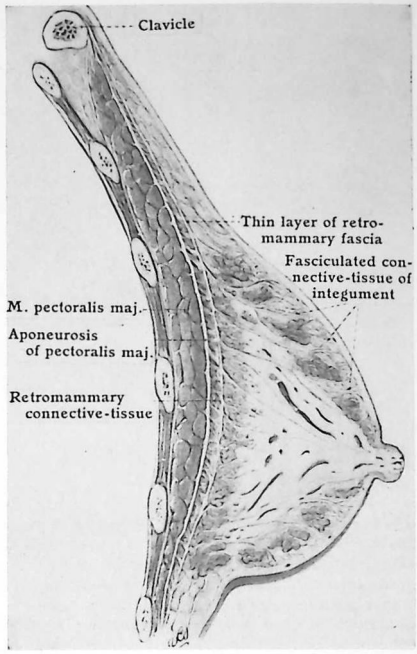


FIG. 1173. Gross anatomy of the female breast, longitudinal section.

Arteries. The first, second, third and fourth perforating branches of the internal mammary artery; the long thoracic, the pectoral branch of the acromiothoracic; the superior branches of the axillary artery; the perforating branches of the internal mammary artery and branches from the subscapular artery (Fig. 1174) extending from the inner side from the second to the sixth rib.

Veins. The veins correspond to the arteries. The veins anastomosing around the nipple are known as the circle of Haller.

Nerves. Intercostal, thoracocostal, long thoracic, descending cutaneous branches of the cervical plexus and branches from the brachial plexus.

Lymphatics. (Fig. 1175.) There are two sets of lymph nodes, superficial and deep. The deep lymphatics lie within the interlobular connective tissue forming a plexus around the mammary lobules. They follow the course of ducts and converge upon the surface beneath the areola where they enter the subareolar plexus of Sappey. In addition this plexus receives cutaneous lymphatics from the nipple and areola. The deep lymphatics also communicate with the pectoral plexus, situated beneath the pectoral fascia. From the pectoral and subareolar plexus the lymphatics course outward forming several large trunks which terminate in the pectoral group of the axillary nodes. From the inner side of the breast a few lymphatic trunks course along the anterior perforating arteries and terminate in the anterior mediastinal lymph nodes. From the upper part of the mamma they terminate in the subclavicular group of nodes after perforating the costo-coracoid membrane. There is a free intercommunication between the lymph channels in the axilla, and the pectoral plexus also communicates through the upper part of the anterior abdominal wall with the subperitoneal plexus of the abdomen.

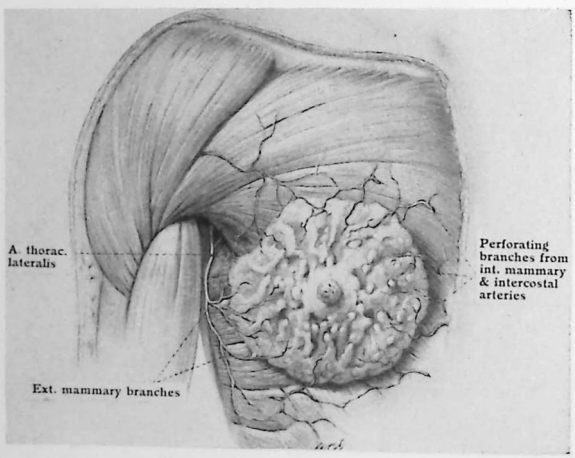


FIG. 1174. Arterial supply of the breast.

The Relation of the Lymph Nodes of the Subclavicular Fossa to Cancer of the Breast is discussed by Carajannopoulos (Athens, Greece) and Henri Godard (L'Oeuvre Scientifique) and Professor Pierre Delbet. They point out that in certain cancers of the breast one finds an involvement of the supraclavicular lymph nodes in cases in which the axillary nodes are not involved. In these cases, malignant extension has taken place along a different route than that commonly observed where the axilla is involved before the supraclavicular

fossa is invaded. These facts led Delbet to advise his pupil Pierre Mornard to make a detailed study of the lymphatics of the breast. Using Gerota's method, Mornard injected one hundred mammary glands in 8 to 9 month fetuses and children one to two years old. A study of these specimens led him to distinguish six distinct types of lymphatic distribution.

In Type I (classical type) the lymphatics empty into the lymph nodes of the axilla following the lower border of the pectoralis major muscle between the breast and the axilla. There may exist a paramammary node which is inconstant. This classical type Mornard met in only 25 per cent of the cases.

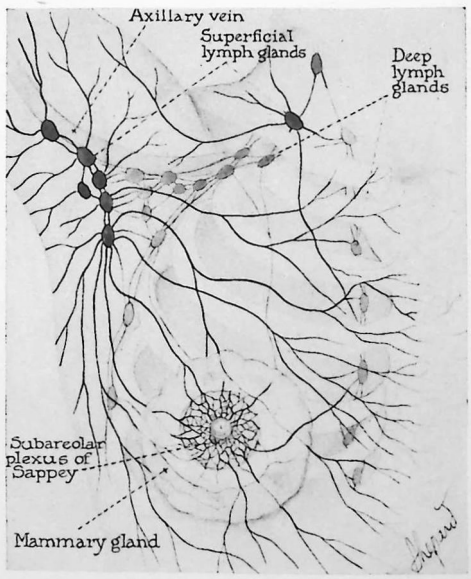


FIG. 1175. Lymphatics of the breast.

In Type II Mornard injected more external efferent lymphatic vessels which followed the lower border of the pectoralis major and emptied into a humeral lymphatic node, twice in 100 cases.

In Type III the mammary gland has two lymphatic pedicles; first, the classical axillary pedicle; second, a direct supraclavicular pedicle formed by two or three vessels arising from the superior internal portion of the mammary gland and passing beneath the pectoralis minor muscle near its costal insertions and emptying into the supraclavicular nodes without passing the axilla.

Type IV is a variant of Type III. It differs from it in that the lymphatics of the clavicular pedicle pass between the two pectoral muscles instead of passing beneath the pectoralis minor.

In Type V the lymphatics of the clavicular pedicle empty directly into the lymphatic nodes found above the clavicle. These vessels pass under the pectoralis minor, between the subclavius muscle and the subclavian vein and empty into the node at the confluence of the jugular and subclavian veins. The supraclavicular nodes are divided into two groups—an external and an internal. The latter group is invaded by the direct route, the main and constant node of this group being at the angle formed by the internal jugular and subclavian veins. The external group is situated upon the anterior surface of the brachial plexus between the subclavian artery and the omohyoid muscle. It receives the efferents coming from the axilla.

Type VI. This is the internal mammary pedicle. The lymphatics pass through the thoracic wall from in front backward and empty into the mediastinal nodes (second, third and fourth intercostal spaces). These nodes are practically inaccessible. Happily, this lymphatic path is of only minor importance. Mornard succeeded in injecting it only ten times out of one hundred.

From the clinical viewpoint, it is important to seek carefully for supraclavicular adenopathies. To explore the supraclavicular fossa, stand behind the patient who holds her head straight and immobile. Explore simultaneously the two sides by placing the index fingers in the angle formed by the sternomastoid muscle and the clavicle. The node is at the confluence of the jugular and subclavian veins. Do not mistake the inferior belly of the digastric muscle for a lymph node. This can be avoided by having the patient swallow. You can then feel the muscle contracting and relaxing. Continue the exploration laterally as far as the trapezius muscle. At times, one feels the chain of lymph nodes along the internal jugular vein and at times along the border of the trapezius muscle. The primary clearing of the supraclavicular fossa is done at the same time as the amputation of the breast. It was performed seventy-one times; in sixteen cases the nodes were clinically palpable; in four of these cases the nodes were not involved; in the other twelve they were cancerous. In a second group of cases, the supraclavicular nodes though not palpable clinically were found cancerous in three cases out of fifty-five. In studying postoperative neoplastic recurrence, it seemed the recurrence took place at the supraclavicular nodes. In all cases in which the cancer is situated in the superior medial part of the breast, the supraclavicular fossa must be cleared. The authors recommend the following technic for the clearing of the supraclavicular fossa:

CLEARING THE SUPRACLAVICULAR FOSSA

The apex of the incision should correspond to the clavicular extremity of the sternomastoid muscle. The triangular flap, having its base at the trapezius, includes the platysma myoides muscle and external jugular vein. The middle cervical fascia stretched by the omohyoid is exposed. It is there the nodes are found and they must be removed. Cut the omohyoid at the level of the internal jugular vein and remove the nodes following along this vessel. If the node at the confluence of the jugular and subclavian veins is mobile, it should be removed with the finger; if adherent, it is better not to proceed further. Suture without drainage.

Results. The operation was performed in seventy-two cases. There were three deaths, one due to cardiac complications, the others to metastases. There is a frequent complication of lymphorrhagia. It occurred in six cases owing probably to injury of the right lymphatic duct or of the thoracic duct. It is preferable not to ligate these vessels even if they be wounded; though a marked edema may develop, it will not be permanent if the permeability of the vessels is preserved. This lymphorrhagia may last from two to three weeks. This step is anatomically and clinically justifiable. It enables us to cure a few cases formerly considered inoperable and abandoned to fate.

OPERATIONS FOR MAMMARY ABSCESS

Abscesses arising in connection with the breast are of three types, viz.:

1. The Premammary or Subcutaneous Abscess
2. Mammary Abscess Proper and
3. Retromammary Abscess in the areolar tissue separating the breast from the pectoral fascia.

PREMAMMARY ABSCESS

Make a liberal radial incision, evacuate the pus, and drain with dental rubber or a cigarette drain.

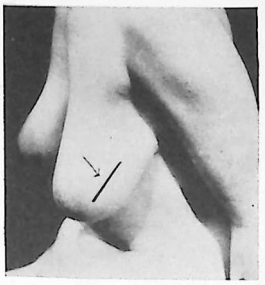


FIG. 1176

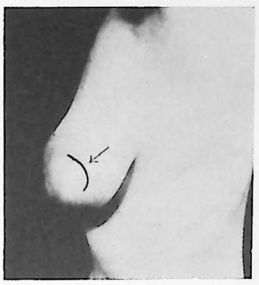


FIG. 1177

FIG. 1176. Proper direction of the incision in opening an abscess of the breast. This line represents the normal direction of the galactophorous ducts. Never cut across.
FIG. 1177. Wrong direction of incision in suppurative mastitis.

MAMMARY ABSCESS

This is often multiple, fibrous partitions from the stroma of the breast dividing individual pus pockets.

Step 1. Make an incision radiating from the nipple, never transversely across (Figs. 1176-1177). The incision must not encroach upon the areolar tissues (injury to an areolar venous sinus or a duct ampulla).

Step 2. Introduce a finger into the pus pocket and break down septa which might interfere with efficient drainage.

Step 3. Introduce cigarette drains or strips of dental rubber into the evacuated pus pockets.

Step 4. Counter drain at the periphery of the infected area if deemed necessary. (Fig. 1178.)

RETROMAMMARY ABSCESS

Step 1. Make an incision in line with the thoraco-mammary fold (Fig. 1179.) Deepen the incision until the deep fascia is reached; define the lower edge of the breast and enter the space occupied by the retromammary abscess.

Step 2. Drain. If there is a sinus connecting the abscess and source of infection, trace it and remove it. The wall of the abscess cavity may be gently curetted. Dress.

FIG. 1178

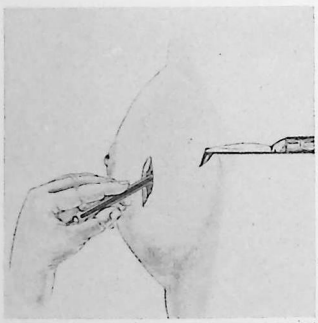


FIG. 1179



FIG. 1178. Abscess of the breast. Incision has been made in the anterior part of the breast and a counteropening in the mammary fold. A grooved director or curved artery forceps creates a tunnel between the two through which a tube may be introduced.
FIG. 1179. Draining a retromammary abscess. After the incision has been made with the scalpel the opening is explored with a grooved director.

OPERATIONS FOR TUMORS AND CYSTS OF THE BREAST

TUMOR OR CYST LOCATED IN THE SUPERFICIAL PORTIONS OF THE BREAST

Local anesthesia may be used. (Figs. 1180-1181-1182.)

Step 1. Expose the tumor through a radiating incision placed directly over the neoplasm.

Step 2. Clear the tumor of overlying breast tissue by careful dissection and enucleate it.

Step 3. Obliterate the dead space resulting from the removal of the tumor with interrupted catgut sutures which approximate the remaining healthy tissues.

Step 4. Close the skin (Michel clips; subcuticular silk suture).



FIG. 1180. Position of patient on the operating table showing the degree of extension and elevation of the arm in operations involving the breast and axilla.

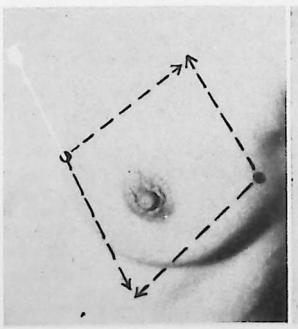


FIG. 1181

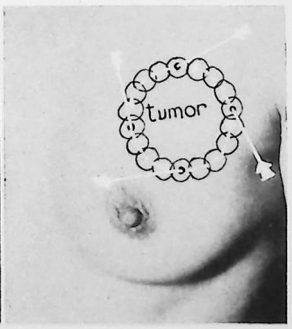


FIG. 1182

FIG. 1181. Conservative removal of a breast tumor. A diamond-shaped area embracing the portion of the breast involved is outlined and the injection made as indicated by the points of entrance (black dots) and projected in the direction of the arrows, or,
FIG. 1182. A wheal of intradermal infiltration is made surrounding the tumor as outlined in the illustration. Through the same needle punctures deeper infiltration is accomplished.

TUMORS OCCUPYING DEEPER PORTIONS OF THE BREAST

Step 1. A Gaillard-Thomas premammary incision is used (Fig. 1183). This is a curved incision in the thoraco-mammary fold beginning at the nipple line and extending to the anterior axillary border.

Step 2. Separate the posterior surface of the breast from the pectoral fascia exposing the portion of breast overlying the tumor.



Fig. 1183. Gaillard-Thomas' crescentric incision in the thoraco-mammary fold.

Step 3. Incise the breast tissue and shell out the tumor.
Step 4. Obliterate the resulting space by interrupted catgut sutures.
Step 5. Close the skin. Dress.

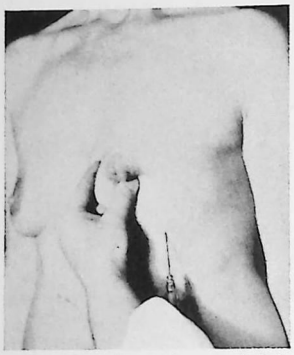


Fig. 1184. Conservative removal of the breast. The block anesthesia is begun by submammary infiltration of the anesthetic solution.

SINGLE CYSTS

Here the steps are similar to the preceding. The cyst walls often offer difficulties during enucleation, and the cyst is almost invariably broken. For that reason, it is best to excise a wedge-shaped segment of breast tissue carrying the cyst.

MULTIPLE CYSTS (POLYCYSTIC DISEASE)

The entire breast may be excised. Where conservative removal of the whole breast is contemplated, block anesthesia may be used. (Fig. 1184.)

Step 1. Make a Gaillard-Thomas incision as before.
Step 2. Dissect the breast free from the pectoral fascia and from the overlying skin. Divide the ducts as they enter the nipple.
Step 3. Insure hemostasis. Allow the superimposed skin to fall back over the large wound resulting from the removal of the breast. Suture the skin into place, after cutting away redundancy.
Step 4. Drain where indicated. Dress.

PLASTIC OPERATIONS ON THE BREASTS

PENDULOUS BREASTS (MASTOPTOSIS)

Unfortunately, the term "plastic surgery" was forced by quacks into disrepute in the ranks of ethical surgeons, for a number of decades. The thought is



Fig. 1185. Virginal hypertrophy of the breasts.

stimulating, however, that on the European continent, serious-minded surgeons through an education campaign, encouraged research and enlightenment in this direction. In this country, the Society of Plastic and Reconstructive Surgery and the creation of chairs for the teaching of plastic surgery in various universities have done much to develop this branch of surgical endeavor.

A bird's-eye view of the history of this phase of surgical work may not be amiss in this connection.

Durston, in 1669, was first to describe the clinical entity now known as hypertrophy of the breast and mastoptosis. Nearly a century of silence prevailed in the literature until Velpeau in 1857 and Labarque contemporaneously studied

the subject anew. In 1898 Michel and Pousson excised the upper half of the breast, making a half-moon shaped excision, beginning at the axilla and extending to the sternum in a case of double hypertrophy of the breast in a young woman. Verchère followed suit in 1898 but excised a lateral triangular section of the breast.

In April, 1921, I reported my experiences and results in free transplantation of the nipple and areola supplemented by resection of the hypertrophied breast, before the North Shore branch of the Chicago Medical Society and published a paper on the subject in November of 1922.[1] In 1923 Lotsch reported that he elevated and resected the breasts through a longitudinal "slit incision" above and below the mammilla. In 1924, Holländer combined the methods of Pousson and Verchère. In 1925 (March 11) Passot, and on the 25th of March of the same year, Dufourmentel reported on the subcutaneous transposition of the nipple. In 1925 Joseph published his case of mastomiopexy which he performed in 1922 by double wedge-shaped excisions of the breast with the retention of a bridge of skin to insure nutrition to the nipple. In the same year Lexer and Kraske, and in 1926 Axhausen described plastic resections of the hypertrophied breast.

In 1927 Joseph described his two-stage, and later in the same year, his three-stage operation. In 1928 Biesenberger published his plastic operation with surgical torsion of the breast and in 1930 Schwarzman elaborated on the Joseph technic.

Erna Glässmer of Heidelberg resected, in 1930, lateral and supramammary sections of skin and breast tissue and thus endeavored to diminish the size of the breast and accomplish its elevation.

Dartigues and others added refinements of technic of some type or another.

Patients seek relief from these disabling conditions because they interfere with their earning a livelihood: some even develop psychoses from brooding over their disability. In others where the condition is less pronounced, esthetic and vocational reasons force the patients to seek surgical relief (Fig. 1185).

Careful individualization and planning of the operation are necessary to obtain anticipated results although a great deal depends on the experience and skill of the surgeon as well as the cooperation of the patient in the pre- and postoperative care. While many successful cases are reported at the hands of the experienced operator, numerous unrecorded failures are attributed to the inexpert in plastic procedures. Lack of knowledge of the subject, improperly selected cases, inadequate pre- and postoperative care may result in sloughing, abscess formation and even loss of life.

The great multiplicity of operations suggested for the correction of hyperplastic breasts has thus far failed to yield a standard technic. Complicated procedures such as transpositions of the nipple, two, three, and even four stage operations, partial resection with axial torsion of the remaining mammary substance and numerous other complicated procedures, capable of yielding good results in the hands of the originators of the respective method, create a chaotic situation, eventuating in perplexity to the surgeon who asks, "Which is the simplest method giving uniformly good results?"

After a number of years of experience with most of the methods advocated, I have concluded that good results are obtainable and depend upon the simplest

[1] New York Med. J. S. Record, 116:572, 1922.

possible technic, absolute asepsis, a thorough knowledge of anatomy and assiduous attention to detail.

Distressing effects of hypertrophy of the breasts may be grouped as follows:

1. Physical manifestations.
2. Vocational incapacity.
3. Esthetic drawbacks.
4. Psychic influences.

Physical Manifestations. The excessive size of the breast may cause a considerable degree of discomfort (pulling, dragging sensations intensified at the menstrual period) referred to as mastodynia by Girard. Circulatory disturbances have been described by Velpeau and in our times by Kraske (edema, discoloration, even ulcerations). Intertriginous eczema is not infrequently encountered particularly in hot weather (crustation); excessively pendulous breasts are followed by untoward influences on the heart and lungs. The dragging breasts cause alterations in the vertebral column which may, in aggravated cases, lead to a greater or lesser degree of kyphosis.

Vocational Incapacity. In this group belong dancers, public speakers and people of the stage, manikin models (so important a vocation in modern times), and those engaged in swimming, tennis, etc. (Figs. 1186-1187.)

Esthetic Drawbacks. Women of refined esthetic tastes are superconscious of pendulous breasts.

Psychic Influences. Inferiority complexes, neuroses and psychoses may develop. Tendencies to suicide and actual attempts at self-destruction have been reported (Axhausen).

A rather exhaustive study of the more or less complicated methods of Lotsch, Eckstein, Weinhold, Kausch, Lexer-Kraske, Holländer, Joseph and particularly that of Biesenberger has convinced me it is best to abandon any procedure which is difficult to perform and offers greater possibilities of failure than the simple method of resection of the breast with free transplantation of the nipple which I have devised.

Summary. 1. Patients often seek relief from excessively hypertrophied breasts and the train of symptoms accompanying the condition.

2. Surgeons desiring to relieve these patients should acquaint themselves thoroughly with the anatomicopathologic factors underlying the abnormality and the methods for their relief.

3. Good results usually follow properly executed operations but it must be remembered that amateur attempts at breast plastics have been followed by necrosis of the nipple, necrosis of the breast tissue and suppurative conditions and their sequelae.

4. The more exact the technic the better the results.

5. Patients should be told that the transplantation, though not transposition, of the nipple precludes lactation.

6. When the pendulosity is moderate a transposition operation may be carried out successfully.

Principally, the operative procedures for reconstruction of pendulous breasts may be divided into:

Operations with transposition of the nipple.

The author's operation of resection of the breast with transplantation of the nipple.

Resection of the Breast and Transposition of the Nipple

Step 1. Circumincise the nipple. Make an incision above the nipple as shown in Fig. 1188. (1) A retromammary incision supplements the latter.

Step 2. At a higher level, cut out an oval area to receive the transposed nipple. Dissect away the skin. (Fig. 1188 [2].)



Fig. 1186



Fig. 1187

Fig. 1186. Vocational disability (mask) the result of mastoptosis.
Fig. 1187. Same patient three weeks after operation (mastopexy).

Step 3. Undermine the skin overlying the superior segment of the breast. (Fig. 1188 [3].)

Step 4. Introduce a long forceps through the circular opening made. Grasp the nipple and pull it into its new site. (Fig. 1188 [4].) Suture it in place.

Step 5. Resect the redundant part of the breast. (Fig. 1188 [5].)

Step 6. Suture the flaps of skin together as shown in Fig. 1188 (6).

Author's Operation of Resection of the Breast and Transplantation of the Nipple

Step 1. Make a supra areolar convex incision anteriorly over the hypertrophied and pendulous gland with a second, similarly directed incision beneath the global mass.

Step 2. Between these two incisions remove as much of glandular and adipose tissue as is deemed necessary to obtain the desired size and contour.

Step 3. Detach the nipple and areola completely through a free, circular incision. The subdermal tissues of the nipple must be treated with utmost gentleness.

Step 4. Transplant the dissected nipple into a circular bed prepared at the site previously selected.

Surgical artistry and special technical skill are requisite for these procedures if one's aim is to obtain a well-formed new breast-contour and to avoid unsightly lumps and disfiguring scars. .

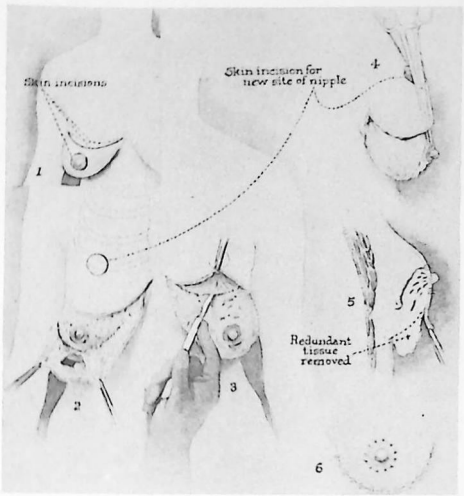


Fig. 1188. Transposition of nipple with resection of the breast. Two-stage operation.

In the great majority of my cases thus treated there was clinical evidence of good cosmetic result and there was no doubt regarding the viability of the freely transplanted tissue. However, it was not until recently that I had the opportunity of obtaining complete histological verification of this statement.

In 1930, a woman on whom I had performed a plastic operation on the breasts, including nipple transplantation, again came under my care two months later. With the patient's consent a small section of the transplanted nipple was removed for biopsy (Fig. 1189). The epithelium was found intact; the corium contained round cells with a few polymorphonuclears and some plasma cells. There was an isolated islet of epithelial cells. In all probability this was due to implantation, the result of pinching off some of these cells during the process of operative transplantation.

Following the acute reactionary process, this stage passes to the subacute phase as is evidenced by some of the polymorphonuclear and a more extensive

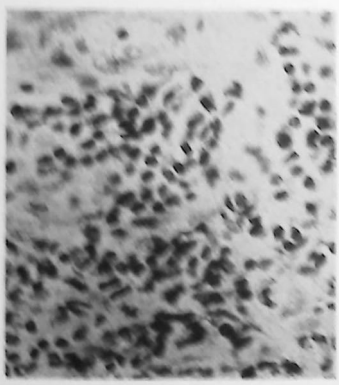


Fig. 1189. Transplantation of the nipple. High power magnification; the cells are intact in the skin of the nipple as are those in immediate continuity. Round cells, a few polymorphonuclears and some plasma cells are seen.



Fig. 1190



Fig. 1191

Fig. 1190. Pendulous hypertrophic breasts before operation.
Fig. 1191. Same as preceding—about one month after author's operation.

round cell infiltration. When this area is examined under high power, the epithelial strata are found intact and immediately below this area, in the corium,

there are some round cells, plasma cells and some scattered polymorphonuclear leukocytes. This is seen to even greater advantage when a higher magnification of the corium is examined. Here the cellular elements and the capillaries in the corium may be closely studied.

From these findings, it is quite evident that the transplanted nipple and areola have become vascularized and incorporated in the new site, as normal, living tissue. They further show that the operation of resection of superfluous tissue in hypertrophied pendulous female breasts, with free transplantation of the nipple and areola, is a practical one, and that, when carried out with proper technic, the result will not only give relief of the patient's disability, but also be satisfactory from the esthetic point of view. (Figs. 1190-1191.) The transplanted



Fig. 1192

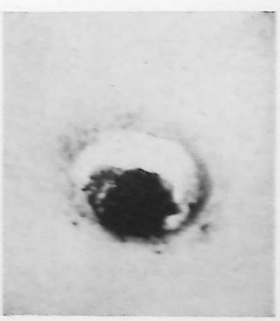


Fig. 1193

Fig. 1192. Beginning separation of the superficial layers of the skin revealing the healed nipple underneath.
Fig. 1193. Close-up of transplanted nipple five weeks after operation showing stratum corneum separating, leaving the healed nipple structure united to the breast.

nipple does not become absorbed or die, but continues as normal, vascularized, living tissue in the vast majority of cases.

In a properly performed operation, as I have outlined, the surgeon must not concede failure if the surface of the nipple appears dark to even black in color a few days following transplantation. This does not signify failure of the nipple to take; on the contrary, in most, if not all, of the cases where the technic has been faultless and the postoperative care proper, the superficial, discolored layer, representing only the stratum corneum, exfoliates, while the cutis vera goes on healing by primary intention (Figs. 1192-1193-1194). It may take from 4 to 7 weeks for the stratum corneum to separate. This, however, does not hinder the patient from pursuing her usual vocation. The keynote to the postoperative treatment consists of dry asepsis (desiccating powder and sterile supportive dressings).

Operations with transposition of the nipple.

The author's operation of resection of the breast with transplantation of the nipple.

Resection of the Breast and Transposition of the Nipple

Step 1. Circumincise the nipple. Make an incision above the nipple as shown in Fig. 1188. (1) A retromammary incision supplements the latter.

Step 2. At a higher level, cut out an oval area to receive the transposed nipple. Dissect away the skin. (Fig. 1188 [2].)





Fig. 1186 Fig. 1187

Fig. 1186. Vocational disability (model) the result of mastoptosis.
Fig. 1187. Same patient three weeks after operation (mastopexy).

Step 3. Undermine the skin overlying the superior segment of the breast. (Fig. 1188 [3].)

Step 4. Introduce a long forceps through the circular opening made. Grasp the nipple and pull it into its new site. (Fig. 1188 [4].) Suture it in place.

Step 5. Resect the redundant part of the breast. (Fig. 1188 [5].)

Step 6. Suture the flaps of skin together as shown in Fig. 1188 (6).

Author's Operation of Resection of the Breast and Transplantation of the Nipple

Step 1. Make a supra-areolar convex incision anteriorly over the hypertrophied and pendulous gland with a second, similarly directed incision beneath the global mass.

Step 2. Between these two incisions remove as much of glandular and adipose tissue as is deemed necessary to obtain the desired size and contour.

Step 3. Detach the nipple and areola completely through a free, circular incision. The subdermal tissues of the nipple must be treated with utmost gentleness.

Step 4. Transplant the dissected nipple into a circular bed prepared at the site previously selected.

Surgical artistry and special technical skill are requisite for these procedures if one's aim is to obtain a well-formed new breast-contour and to avoid unsightly lumps and disfiguring scars.

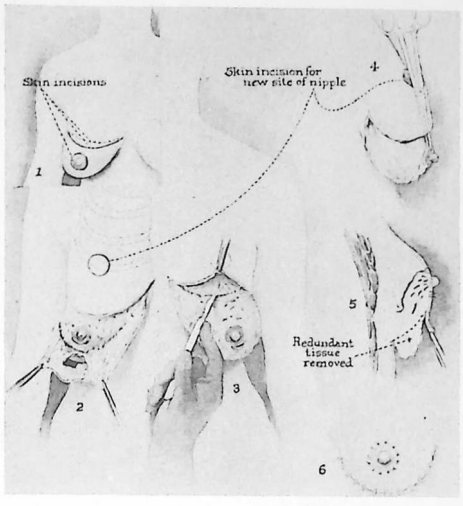


Fig. 1188. Transposition of nipple with resection of the breast. Two-stage operation.

In the great majority of my cases thus treated there was clinical evidence of good cosmetic result and there was no doubt regarding the viability of the freely transplanted tissue. However, it was not until recently that I had the opportunity of obtaining complete histological verification of this statement.

In 1930, a woman on whom I had performed a plastic operation on the breasts, including nipple transplantation, again came under my care two months later. With the patient's consent a small section of the transplanted nipple was removed for biopsy (Fig. 1189). The epithelium was found intact; the corium contained round cells with a few polymorphonuclears and some plasma cells. There was an isolated islet of epithelial cells. In all probability this was due to implantation, the result of pinching off some of these cells during the process of operative transplantation.

Following the acute reactionary process, this stage passes to the subacute phase as is evidenced by some of the polymorphonuclear and a more extensive round cell infiltration. When this area is examined under high power, the epithelial strata are found intact and immediately below this area, in the corium,

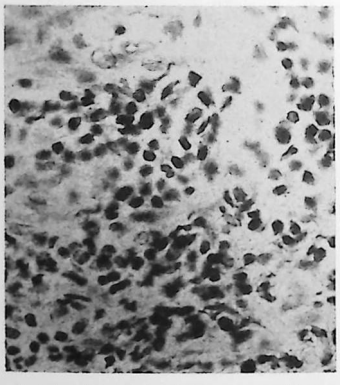


Fig. 1189. Transplantation of the nipple. High power magnification: the cells are intact in the skin of the nipple as are those in immediate contiguity. Round cells, a few polymorphonuclears and some plasma cells are seen.



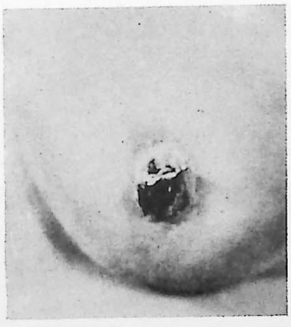


Fig. 1190 Fig. 1191

Fig. 1190. Pendulous hypertrophic breasts before operation.
Fig. 1191. Same as preceding—about one month after author's operation.

there are some round cells, plasma cells and some scattered polymorphonuclear leukocytes. This is seen to even greater advantage when a higher magnification of the corium is examined. Here the cellular elements and the capillaries in the corium may be closely studied.

From these findings, it is quite evident that the transplanted nipple and areola have become vascularized and incorporated in the new site, as normal, living tissue. They further show that the operation of resection of superfluous tissue in hypertrophied pendulous female breasts, with free transplantation of the nipple and areola, is a practical one, and that, when carried out with proper technic, the result will not only give relief of the patient's disability, but also be satisfactory from the esthetic point of view. (Figs. 1190-1191.) The transplanted nipple does not become absorbed or die, but continues as normal, vascularized, living tissue in the vast majority of cases.



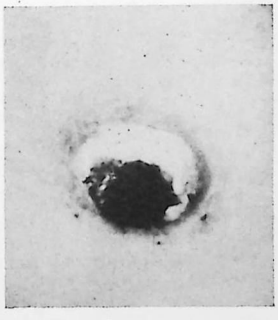


Fig. 1192 Fig. 1193

Fig. 1192. Beginning separation of the superficial layers of the skin revealing the healed nipple underneath.
Fig. 1193. Close-up of transplanted nipple five weeks after operation showing stratum corneum separating, leaving the healed nipple structure united to the breast.

In a properly performed operation, as I have outlined, the surgeon must not concede failure if the surface of the nipple appears dark to even black in color a few days following transplantation. This does not signify failure of the nipple to take; on the contrary, in most, if not all, of the cases where the technic has been faultless and the postoperative care proper, the superficial, discolored layer, representing only the stratum corneum, exfoliates, while the cutis vera goes on healing by primary intention (Figs. 1192-1193-1194). It may take from 4 to 7 weeks for the stratum corneum to separate. This, however, does not hinder the patient from pursuing her usual vocation. The keynote to the postoperative treatment consists of dry asepsis (desiccating powder and sterile supportive dressings).

INVERTED NIPPLE

(Sellheim's Operation)

Figures 1195-1196 depict the condition and the principles underlying this procedure. Careful outlining of the proposed procedure prior to operation and careful operating are essential.

Step 1. Measurements are made of the component parts of the area as outlined (A and B).



Fig. 1194. Same as preceding case. Observe completely healed nipple after separation of superficial layers of skin. (Stratum corneum.)

Step 2. Three small incisions above and three below the nipple and two larger, lateral incisions are made (C).

Step 3. A ligature of silk pulls the inverted nipple out. The flaps are dissected as shown in the illustration D.

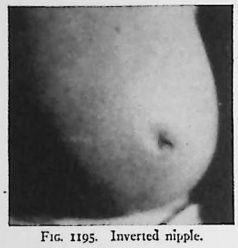


Fig. 1195. Inverted nipple.

Step 4. (E.) Triangular flaps are snipped away at the site of the smaller incisions.

Step 5. (F-H.) The triangular areas are united with fine, interrupted silk sutures.

Step 6. Michel clips finish the procedure (I).

OPERATIONS FOR CARCINOMA OF THE BREAST

Historical Notes. Antyllus operated for carcinoma of the breast as early as the third century. The breast was grasped with a crude pair of forceps, ablated with the sweep of a large sharp knife and the surface resulting seared with the cautery. Benjamin Bell (1804) insisted on thorough removal of the axillary glands and pectoralis muscle. Sir Astley Cooper pointed out the importance of wide removal of the skin and lymph channels, whether involved or free. Charles Moore (1867) insisted on block resection of the entire breast (skin, fat, pectoral fascia,

muscles and lymph nodes). Sir Mitchell Banks (1882) taught the removal of axillary glands whether they be palpable or not. Volkmann (1882) removed the fascia of the pectoralis major, in every case. Halsted (1888) practised the routine removal of the pectoralis major as advocated by Sir Mitchell Banks in 1867. Willy Meyer (1894) removed both pectoral muscles. Handley (1904) was a strong advocate of removing the fascia covering the inner border of the opposite pectoral muscle, the upper portions of the rectus muscles, external oblique and latissimus dorsi. Modern methods include the beneficial effects of early diagnosis, deep radiation and radium.

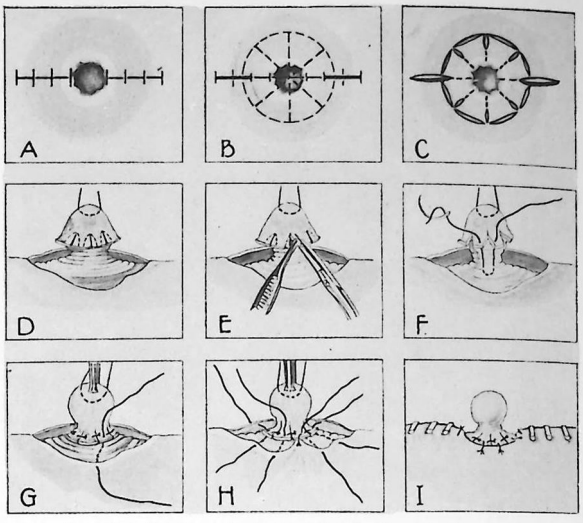


Fig. 1196. Sellheim's operation for inverted nipple. For explanation see text.

The modern aim of the operation consists of the removal of:

1. A sufficiently large skin area including the nipple and teguments overlying the tumor.
2. Sufficient subcutaneous tissue covering the chest wall and the tumor mass forming the center of the subcutaneous tissues removed.
3. Both pectoral muscles except a small part of the larger muscle (see below).
4. The fascial structures of the lateral chest and upper abdominal regions.
5. The lymph structures concerned.

OPERATION

Preparation of the Patient. When carcinoma is suspected, do not delay operating in order to "build up" the patient. The area to be operated on must

be prepared thoroughly with soap and water, the axilla shaved and a mild antiseptic applied overnight. Immediately before the operation the surface should be painted with iodine, the arm draped and placed in proper position (Fig. 1197).

Do not neglect to have x-rays made of the mediastinum, vertebral column and other suspicious zones. In some cases these sites are affected by early metastases, and if such be the case no operation should be undertaken.

Anesthetic. This depends upon the condition of the patient and the preference of the surgeon. Nitrous oxide oxygen when given by an expert is the anesthetic of choice. Ether, when no contraindications exist, serves well. When electrosurgery is used for the removal of the breast, caution should be observed with ether and ethylene should never be used.

Incision. Numerous skin incisions have been advocated. The incision shown in Fig. 1198 a will suffice for all intents and purposes; it may be extended and amplified to meet the special needs of a given case. Ample exposure and thorough anatomic dissections are essentials. (Fig. 1198 b.)

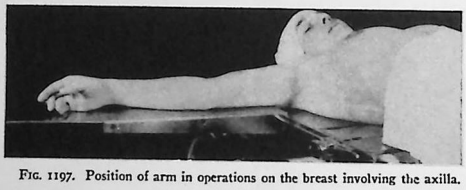


Fig. 1197. Position of arm in operations on the breast involving the axilla.

Position of the Patient. Dorsal decubitus with a pillow between the shoulders. The arm, with the elbow flexed upward, should be placed at right angles with the body. Avoid pressure on the musculo-spiral nerve. Do not abduct the arm too forcibly; this causes a displacement of the axillary vein exposing it to injury.

Step 1. The skin along the entire margin of the incision is dissected up from the underlying tissues to an extent shown in Fig. 1198 b, viz.: the flaps extend as far as the sternum in the midline and to the posterior axillary fold laterally. Expose the pectoral fascia in the line of the upper incision. Lift the skin and fat off the muscle until the furrow is reached that marks the dividing line between the sternocostal and clavicular portions of the pectoralis major muscle.

Step 2. With the back of the scalpel separate the muscular fibers of the greater pectoral muscle almost as far as its humeral attachment. Retract the area thoroughly. Divide the muscle at its humeral insertion. Now separate the muscle with the fasciae lying above and below it from its attachments and connections with the chest wall. The perforating branches of the internal mammary artery are now cut through. Ligate them. The entire mass (sterno-costal part of the pectoralis major muscle and mammary gland) is dissected away from the ribs and intercostal muscles and displaced laterally

(Fig. 1198 c). In this dissection set the knife flat thus avoiding injury to the intercostal muscles and pleura during the detachment of the mass.

The costo-coracoid membrane, the pectoralis minor muscle and the upper portion of the axilla are now fully exposed.

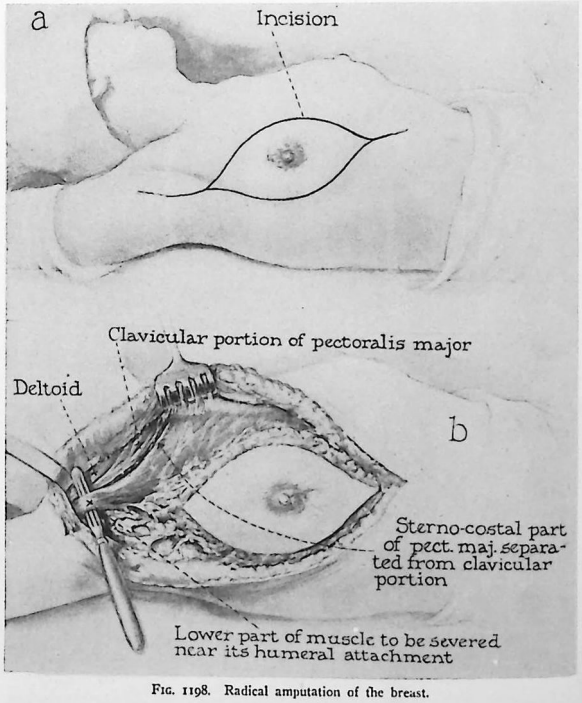


Fig. 1198. Radical amputation of the breast.

Step 3. The pectoralis minor, it will be remembered, is inserted into the coracoid process of the scapula. Expose the outer edge of the pectoralis minor in its entirety. In advanced cases of carcinoma the small pectoral muscle must also be removed (Fig. 1198 d). Expose the free edge of the latissimus dorsi muscle. Lift the gland off the interdigitations of the serratus magnus.

The gland and major pectoral muscle are now attached by connective tissue and axillary fat only.

Step 4. Cleaning out the axilla. Expose the axillary vein (Figs. 1200-1202). It is seen shining through the fascia. Do not tear through the fascia; rather, incise the clavicoraco-axillary fascia along the line of the coraco-brachialis

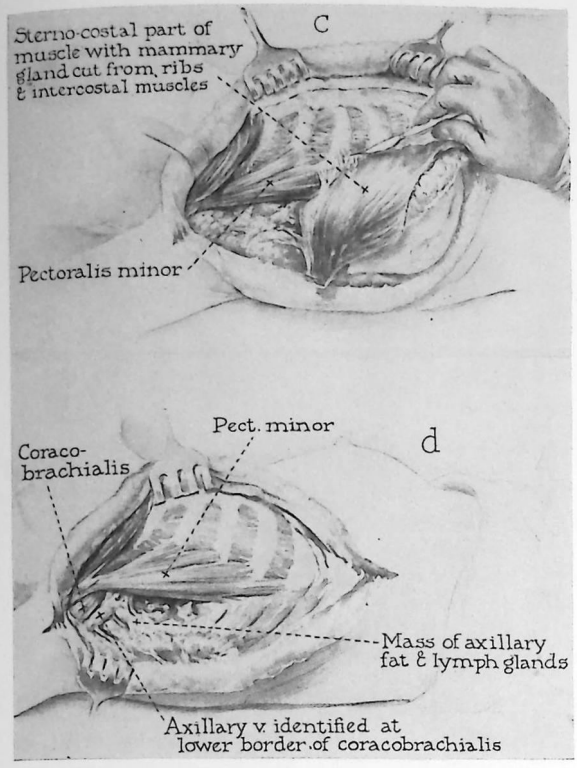


Fig. 1198 (*continued*). Radical amputation of the breast.

muscle up to the insertion of the pectoralis minor muscle. Hook a finger under this muscle and divide it, or the muscle may be retracted laterally if it is decided to leave it behind (Fig. 1203). Catch the fascia with an artery forceps and retract it toward the chest. Strip the fascia inward across the

axillary vessels. The upper edge of the clavicoraco-axillary fascia is thus loosened and the vessels thoroughly exposed. The axillary vein is usually a large single trunk but often found as two branches (Figs. 1204-1205). The

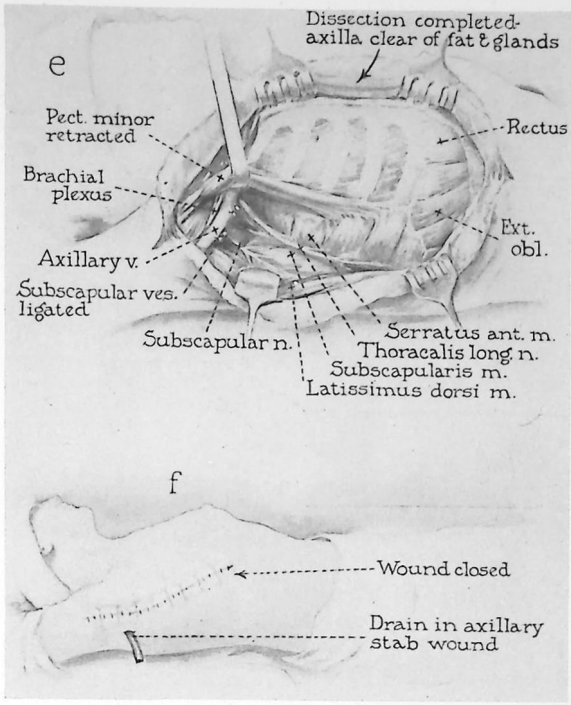


Fig. 1198 (*continued*). Radical amputation of the breast.

vein is superficial to the nerves and other vessels of the axilla. The nerves of the brachial plexus surround the axillary vein. A number of tributary veins enter it from the axillary fat. The largest and most important of these is the subscapular vein. This accompanies the subscapular artery.

Ligate and divide all tributary vessels in this locality; this is to go hand in hand with the removal of all fat, lymph nodes and other cellular elements.

This must be accomplished with care and exactitude. Blunt and sharp dissection carefully carried out accomplishes this. The axillary fascia should be separated from the brachial fascia. This permits the reflection inward of the anterior fascial wall of the axilla. Incise the fascia on the under surface of the latissimus dorsi; free it from the anterior border and then from the anterior surface of the muscle up to the anterior border of the subscapularis. The subscapular fascia is now freed (Fig. 1206).

If at all possible, preserve the important nerves springing from the brachial plexus. Respect the subscapularis and long thoracic nerves. The latter is also known as the respiratory nerve of Bell (Fig. 1198 e). The subscapular nerve is found in the proximity of the subscapular vein and supplies the subscapularis, teres major and latissimus dorsi muscles. The thoracalis longus (Bell's nerve) emerging from under the pectoralis minor muscle runs longitudinally along the wall of the thorax and supplies the serratus magnus muscle.

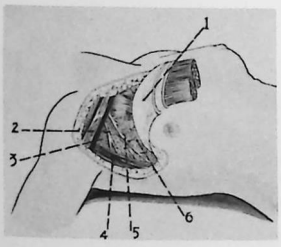


Fig. 1199. Radical amputation of the breast. Freeing of the long thoracic nerve, completing fascial dissection of the axilla, retracting the axillary flap inward and removal of pectorals begun. Operation from above outward. 1. Axillary fascia, pectoral muscle and breast reflected en masse. 2. Long subscapular nerve. 3. Subscapularis muscle. 4. Latissimus muscle. 5. Long thoracic nerve. 6. Serratus muscle. (After Lyle.)

A thorough cleaning out of the axillary space should leave it absolutely clean, nothing remaining behind but the bare muscle, the subscapularis and long thoracic nerves.

Some begin the dissection of the axilla from above downward and vice versa.

When the malignant mass involves the lower and outer margin of the breast implicating the subscapular chain of glands, the subscapular nerve will have to be sacrificed. Gauze dissection is often effective in cleaning out the axillary space when not extensively involved. The nearer the primary tumor approaches the axillary margin of the breast, the further back it becomes necessary to remove the fat and fascia, beyond the edge of the latissimus dorsi. Whether the pectoralis minor is to be sacrificed or not, depends, as already stated, upon the extent of the disease.

Step 5. Close the wound. Introduce a rubber or cigarette drain through a stab wound (Figs. 1198 f-1212).

Smith's Two-Flap Incision for Cancer of the Breast

In order to improve the postoperative results, as far as mobility of the arm is concerned following amputation of the breast for carcinoma, Richard R. Smith[1] devised an incision which permits of the removal of an ample amount of skin and underlying tissue at the same time leaving the arm unhampered by scar, thus conducing to freedom of mobility, an important consideration for the patient. This incision is adaptable to almost every case of carcinoma of the breast subjected to radical operation. (See Figs. 1207-1208-1209, p. 1053.)

[1] S. G. O. July, 1926.

Step 1. Make an incision at a point below the middle of the clavicle, extending downward and outward to the edge of the pectoralis major muscle. Continue this incision along the edge of the pectoral muscle to a point near the breast, then continue toward the midline and around the inner side of the breast whence the incision proceeds straight downward parallel with the sternum to a point over the edge of the ribs and the upper part of the rectus muscle. Make an abrupt right angle horizontally and proceed for several inches to a point which permits plenty of mobilization of the lower

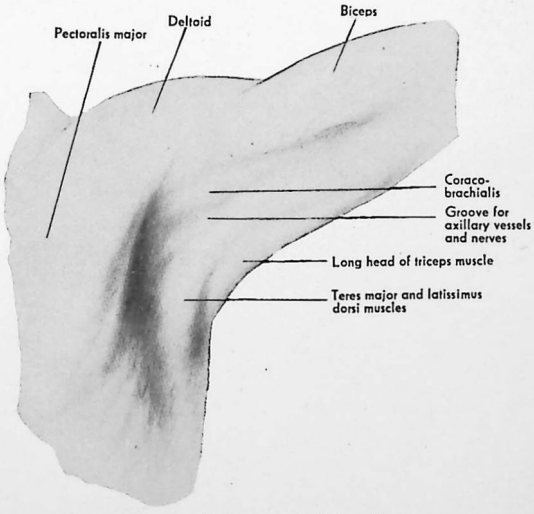


Fig. 1200. Surface anatomy of the axilla.

flap (Fig. 1207). The incision should be directed slightly downward, not upward as first described.

Step 2. Make a second incision around the breast beginning at the edge of the pectoralis major and proceeding around the outer side of the breast, then toward the median line to meet the first one.

Step 3. Raise the flaps consisting of skin and all underlying fat; undermine the edges of the incision and remove the breast with all of the fascia, muscle and axillary contents in the usual way (Fig. 1208).

Step 4. In closing (Fig. 1209), the lower edge, near the axilla, which has been made movable by a wide removal of the tissues underneath, is brought up into the angle between the upper flap and upper edge of the first incision at

its beginning. The right angle at the lower end of the incision over the rectus is closed and then the two flaps are fitted together and sutured in place. Silkwormgut may be used where there is any tension, but a running suture of catgut, or interlocked stitch if preferred, may be used to close those parts of the wound which fall easily together. One should be careful not to create sharp angles, for troublesome sloughing is apt to occur at such points.

Comment: The size and shape of the flaps will vary considerably according to the location of the growth and the elasticity of the tissues. If the edges have been sufficiently undermined and the flaps well mobilized, there will rarely, if ever, be any difficulty in covering the area with the flaps. It is better, however, to leave a gap or two in the incision to close in by granulation, than to have undue tension. It is well to bear in mind that the line from the shoulder to the middle of the sternum may be snug, but without undue tension, for upon it will depend to a degree the future freedom of motion of the arm. One must be careful to see that the lower flap, which is ordinarily the much larger one, has a very wide base or pedicle, as generally speaking, its blood supply is not as good as that of the upper flap.

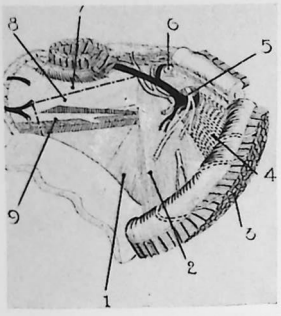


Fig. 1201. Radical amputation of the breast. Clavicoraco-axillary fascia lying over axillary vessels. In fascial dissection of the axilla, the first incision is shown by the dotted line. 1. Suspensory ligament of Gerdy. 2. Fascia over pectoralis minor. 3. Pectoralis major muscle. 4. Costocorocoid ligament. 5. Anterior thoracic nerve. 6. Cephalic gland. 7. Biceps. 8. Coracobrachialis. 9. Axillary vessels showing through fascia. (After Lyle.)

By making a smaller upper and a correspondingly larger lower flap, or vice versa, one may use this incision for growths situated in almost any part of the breast.

Hemostasis must be perfect. The skin should be closed with interrupted sutures. A stab wound lateral to the axilla is used for drainage (Fig. 1198 f). Complete closure of the wound is not always possible. Plastic operations and Thiersch grafts must frequently be resorted to. Apply voluminous dressings, firmly. Allow the arm on the affected side to rest against the chest wall supported by a triangular sling bandage.

Avoid too long immobilization of the arm. Encourage the patient to move it somewhat after four or five days. Dress the wound and remove the drainage tube after 48 hours.

The axillary fasciae must be completely removed if the operation is to prove successful. These fasciae are three in number, viz.: (1) The costocoracoid or suspensory ligament which envelops the subclavius muscle and is fastened by means of a double root to the clavicle. As it proceeds downward, it separates into two parts, surrounding the pectoralis minor, then reunites and merges with

the subcutaneous tissue. The ligament of Gerdy emerges from its under surface and passes under the axillary vessels. (2) The deep axillary fasciae which cover the muscles also form the back and outer walls of the axilla; the serratus magnus is covered by a deep, internal fascia; and the largest part of the anterior axillary wall is formed by the deep anterior fascia which is fastened above the clavicle and covers the posterior surface of the pectoralis major. (3) The lower part of the axilla is covered by fascia which reaches from the fascia over the serratus

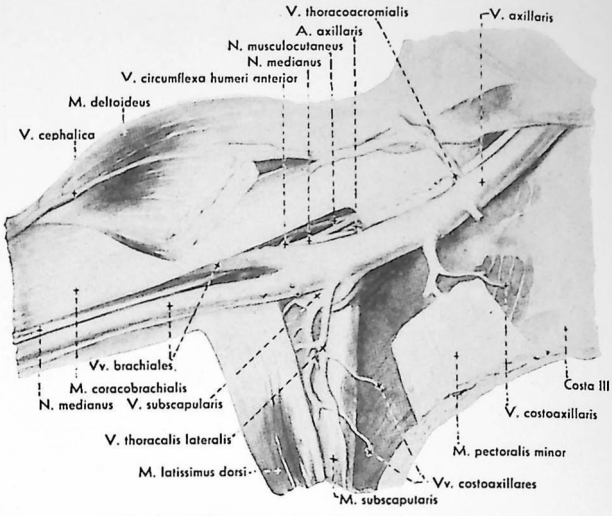


Fig. 1202. Veins of the right axilla, viewed from in front.

magnus to the fascia of the arm. It has an oval-shaped opening, the external border of which is referred to as the arm-arch (Armbogen), and the internal border as the axillary-arch (Achselbogen).

In a study on the swelling of the arm following radical mammectomy (Fig. 1210) J. R. Veal[1] concludes that:

1. Edema of the arm following radical removal of the breast may be due to lymphatic obstruction, to venous obstruction, or to a combination of the two factors. The present small series of twenty cases indicates that venous obstruction is the most common cause.

2. Obstruction of the axillary vein is due to various causes, the chief of which are the pressure of the malignant growth itself in its primary or secondary manifestations, scar formation, and the impingement of fat folds.

[1] J.A.M.A. 108; 1236, 1937.

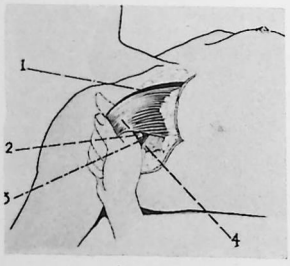


Fig. 1203

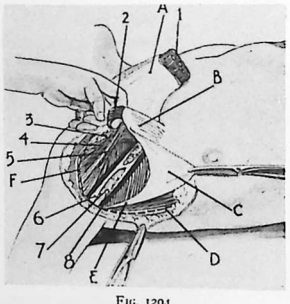


Fig. 1204

Fig. 1203. Radical amputation of the breast. Pectoralis muscle held on index finger after the axillary flap has been freed and turned inward. (After Lyle.) 1. Cephalic vein, 2. axillary artery, 3. axillary vein, 4. pectoralis major.

Fig. 1204. Radical amputation of the breast. The insertion of the pectoralis major has been divided and the muscle and its fascia reflected over the chest wall. The clavicoraco-axillary fascia has been divided over the coracobrachialis muscle. The structure held by the index finger is the insertion of the pectoralis minor muscle. A. Fascia of 1. pectoralis major, 2. pectoralis minor, 3. deltoid, 4. tendon of biceps, 5. coracobrachialis, 6. median nerve, 7. axillary artery, 8. axillary vein, B. fascia, C. reflected fascia, D. line of fascial incision at border of latissimus, E. continuation of axillary fascia into brachial. (After Lyle.)

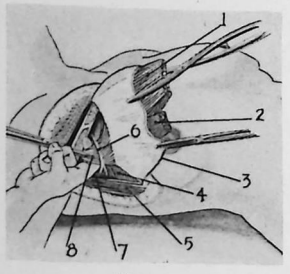


Fig. 1205

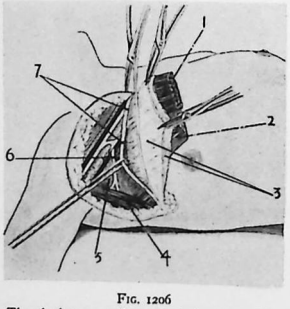


Fig. 1206

Fig. 1205. Radical amputation of the breast. The clavicoraco-axillary fascia has been dissected free exposing the subscapular fascia which is being isolated by the finger. 1. Pectoralis major, 2. pectoralis minor, 3. superior edge of clavicoraco-axillary fascia, 4. subscapularis, 5. latissimus, 6. long subscapular nerve, 7. teres major, 8. fascia over subscapularis.

Fig. 1206. Radical amputation of the breast. Freeing of clavicoraco-axillary, subscapular and latissimus dorsi fasciae intact and retraction inward shown. The long thoracic nerve is seen between the subscapular and serratus fascia. 1. Pectoralis major, 2. pectoralis minor, 3. reflected fascia, two layers, 4. latissimus, 5. subscapularis, 6. long subscapular nerve, 7. long thoracic nerve. (After Lyle.)

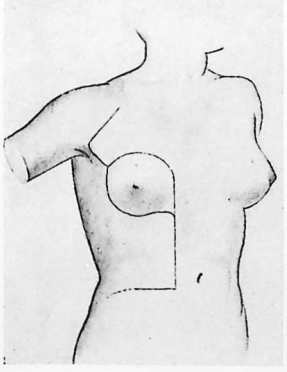


Fig. 1207

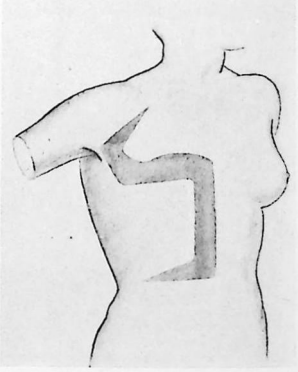


Fig. 1208

Fig. 1207. Richard R. Smith's incision for carcinoma of the breast. Shows lines of incision. Breast here portrayed as normal in size and position, though these will naturally vary considerably.

Fig. 1208. Diagrammatic. This gives the general idea of the relation of the flaps after the breast has been removed.

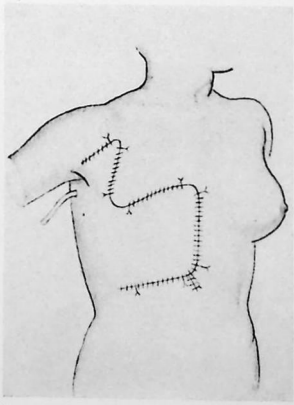


Fig. 1209. Closed incision showing usual position of silkwormgut sutures. (Courtesy, Dr. Richard R. Smith.)

3. Constriction may occur only when the arm is dependent and may disappear when the elevation of the arm restores the patency of the vein.

4. A collateral circulation may develop adequate to take care of the venous return.

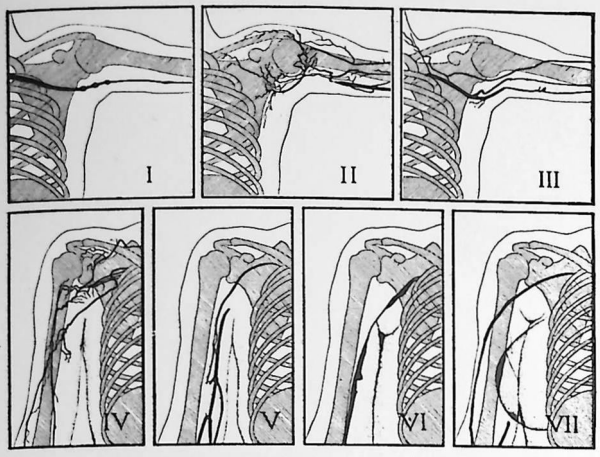


FIG. 1210. Types of axillary vein obstruction in a series of cases of edema of the arm following radical removal of the breast. Pen drawings from venographs. I. Normal axillary vein. Note position of valves and general contour of vein. II. Complete axillary vein obstruction with development of collateral circulation. III. Complete occlusion of the axillary vein from scar formation. Note the development of collaterals and the back-flow of opaque medium into the tributaries. IV. Complete axillary vein occlusion from invasion by carcinoma. Note development of collaterals. Edema subsided in this arm after the development of these collaterals. V. Axillary vein constriction with arm in dependent position. The constriction occurred at the site of recurrence of the carcinoma. The vein is patent when the arm is abducted. VI. Constriction of axillary vein by fat fold. Edema only when arm is dependent. Edema rapidly subsides when arm is elevated. Axillary vein is patent when arm is abducted. VII. Complete occlusion of axillary and brachial veins by pressure of large fat folds when arm is held against the side. Edema occurs only when arm is dependent, and subsides rapidly when arm is held away from side. (Courtesy, Dr. J. R. Veal and the Amer. Med. Asso., Chicago, Ill.)

5. Venography with stabilized thorium dioxide is of value in determining the cause of the edema, but no procedures have yet been devised to remedy it. The wisdom of prophylaxis is therefore obvious.

THE REMOVAL OF THE BREAST BY ELECTROSURGERY

In this procedure a knowledge of the currents used is essential. Briefly stated, of late, the high frequency current has been mustered into surgical use for cutting purposes. Kelly designates this form of surgical division of tissues as acusection. Krusen suggests the term of endosection. Other synonyms used for this form of tissue division are: electrothermic knife, Bowie knife, endotherm

knife, radioknife, etc. The use of this method allows of (a) division of tissues, (b) closure of capillaries and small size blood vessels as well as lymph vessels, (c)

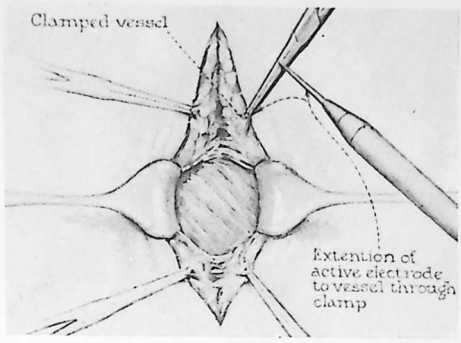


FIG. 1211. Indirect electrohemostasis of small vessel.



FIG. 1212. Amputation of the breast for carcinoma. Radical operation by electrosurgical means. All blood vessels treated by coagulation. Not a single ligature was used. Patient seven days after operation. Primary union.

sterilization of the field of operation, (d) and hemostasis, larger vessels being clamped, the clamp then touched with the endotherm knife and thus hemostasis secured (Fig. 1211). The clamp holding the vessel transmits the current promptly

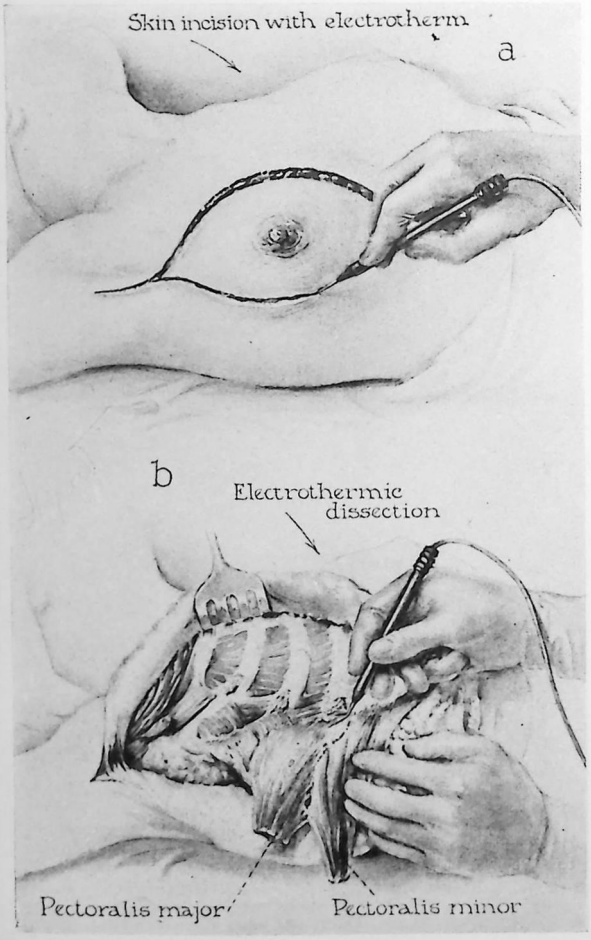


FIG. 1213. Electrosurgical removal of the breast.

to the bloodvessel which quickly coagulates. To a great extent this eliminates ligation of larger vessels (Fig. 1212).

Electrosurgery lends itself to simple and radical amputation of the breast. Howard Kelly and Grant Ward made valuable contributions in popularizing this procedure.

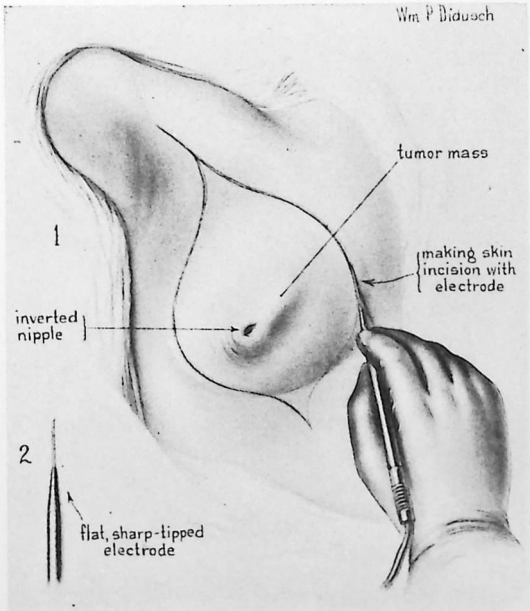


FIG. 1214. Electrosurgical amputation of the breast. Skin incision made with flat, sharp-tipped electrode, carrying fine, cutting current. (Kelly and Ward: Electrosurgery, Saunders; Courtesy of Dr. Grant Ward.)

The entire operation is conducted on the same lines as in the scalpel-scissors technic described in the preceding pages. The skin incision (Fig. 1213 a) and the dissection and ablation of the tissues concerned (Fig. 1213 b) are made with the endotherm knife. Instead of ligating the blood vessels they are electrocoagulated.

The heat that divides the tissues is not carried by the knife but is produced within the tissues themselves. Do not use pressure. Clamp all bleeding points. Allow the current to pass through the clamp by applying the endotherm knife.

Be cautious while working near the axillary vessels. The branches springing directly from the axillary vessels are better ligated.

Commenting on the treatment of malignant tumors of the breasts by electrosurgical means, Kelly and Ward[1] state: "In developing a radical

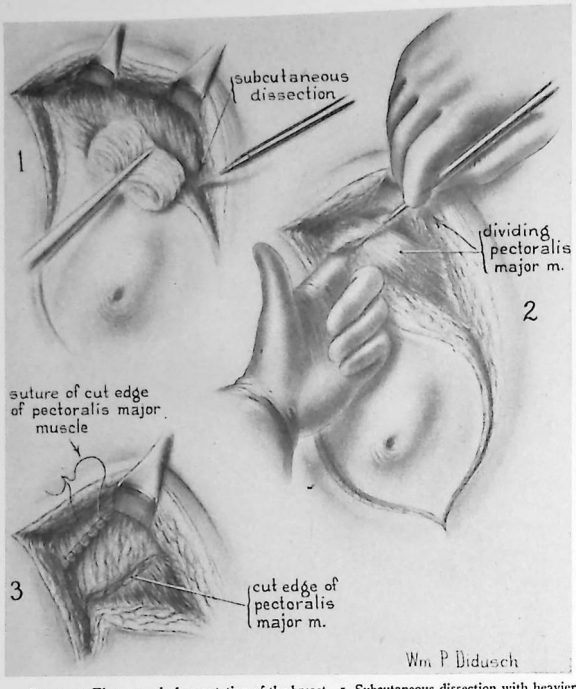


Fig. 1215. Electrosurgical amputation of the breast. 1. Subcutaneous dissection with heavier current, sealing many blood vessels, capillaries, and lymphatics. 2. In dividing muscles, cutting electrode must be placed in contact before turning on current to avoid excessive contractions. (Kelly and Ward: Electrosurgery, Saunders; Courtesy of Dr. Grant Ward.)

operation for the malignant breast, it is not likely that the Halsted-Willy Meyer procedure will be greatly altered. Changes in detail, however, are ever possible: those are especially welcome that shorten the operation, lessen the likelihood of infection, and reduce the chances of disseminating

[1] "Electrosurgery," W. B. Saunders, 1932.

tumor cells. Electrosurgery meets these requirements in this field and for this reason there will doubtless be a growing tendency to resort to it in

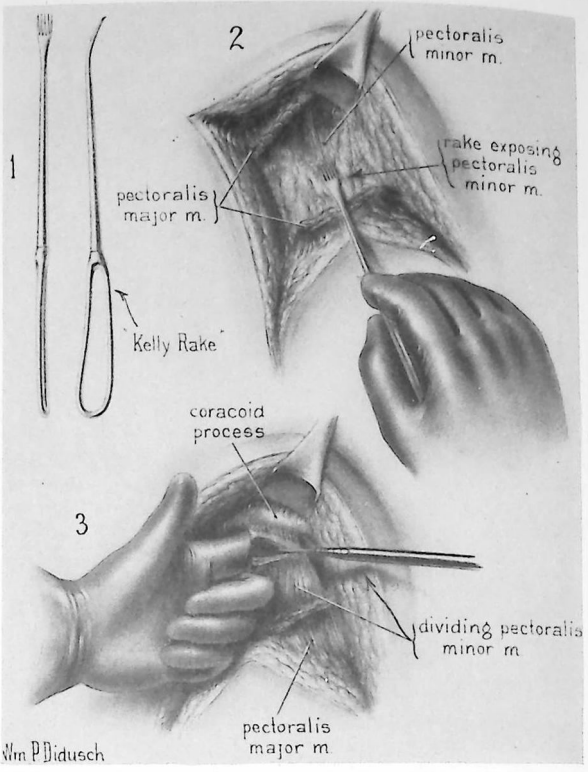


Fig. 1216. Electrosurgical amputation of the breast. Skeletonizing muscles with Kelly rake. 1, done with less trauma than with gauze and blunt dissection. (Kelly and Ward: Electrosurgery, Saunders; Courtesy of Dr. Grant Ward.)

radical extirpation. Anderson[1] comments that his results have been better than with the scalpel. He emphasizes the sealing of lymphatics and capil-

[1] Brit. Jour. Surg. xv, 1928.

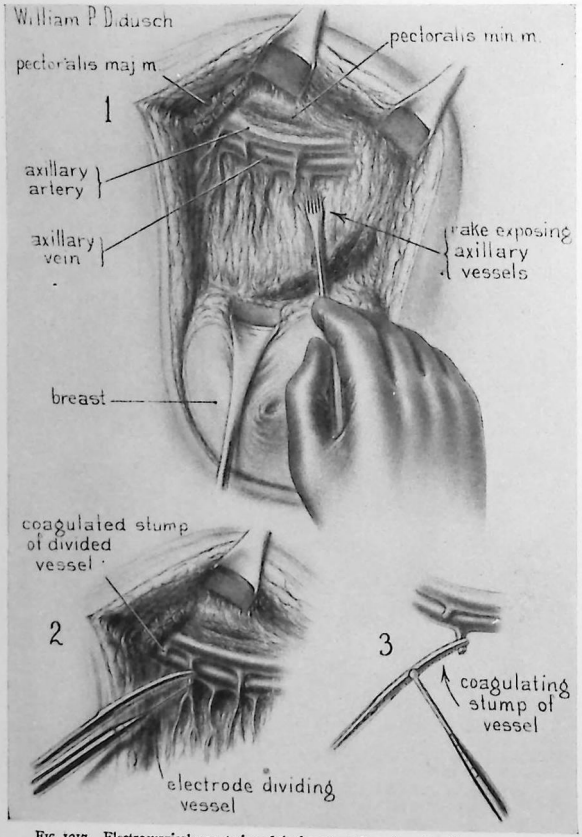


Fig. 1217. Electrosurgical amputation of the breast. 1. Branches of axillary vessels skeletonized with Kelly rake. 2. Vessels clamped and divided with cutting current. 3. Coagulation of vessel stump, possible only when vessels are severed far enough from main axillary trunks to prevent damage to larger vessels by current traveling up to them. (Kelly and Ward: Electrosurgery, Saunders; Courtesy of Dr. Grant Ward.)

laries and the lessened manipulations and loss of body fluids and urges keeping up the body heat by medical diathermy. Less catgut is left in the wound, as the average number of ligatures used is from six to ten. Healing in his series has been more satisfactory and recurrences less frequent.

"The special technic does not concern us beyond the suggestion that experience will doubtless lead to a greater readiness to make a wide ex-

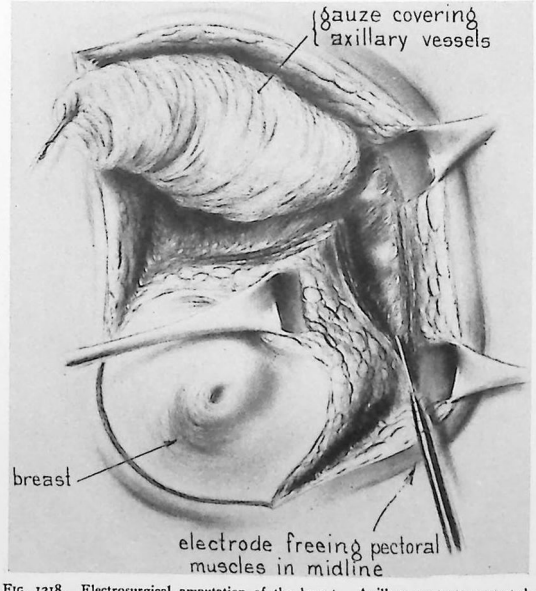


Fig. 1218. Electrosurgical amputation of the breast. Axillary contents protected with gauze while breast and muscles are dissected from chest wall. (Kelly and Ward: Electrosurgery, Saunders; Courtesy of Dr. Grant Ward.)

cision, sacrificing the hope of effecting an immediate complete closure. The skin incision is made with scalpel or acusector (Figs. 1214-1215) and the incision carried on through the fat with the heavier melting current. A low voltage and high frequency (smoother flow) tend to prevent excessive contractions when the muscles are reached. The axilla is carefully guarded with a hard rubber or wooden spatula while the pectoral muscles are divided near their insertion.

"Although it is practicable to make a complete dissection of the axilla with the current alone, without knife or scissors, this is not usually prac-

ticed because of the risk of injuring the axillary vessels. It is perhaps best for the present to dissect branches of the axillary vessels. A valuable aid in rapidly skeletonizing this region is found in Kelly's axillary rake

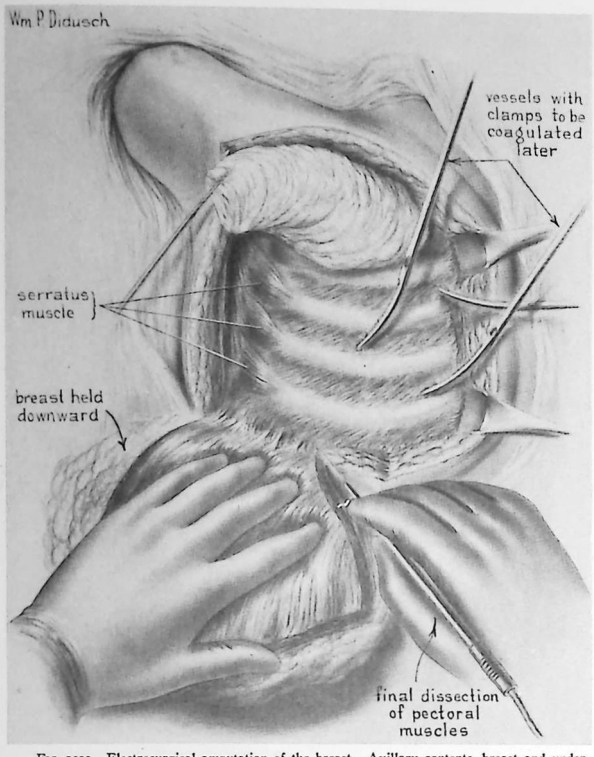


Fig. 1219. Electrosurgical amputation of the breast. Axillary contents, breast and underlying muscle removed en masse by cutting current. (Kelly and Ward: Electrosurgery, Saunders; Courtesy of Dr. Grant Ward.)

(Fig. 1216[1]) usable with greater safety and rapidity than a scalpel as with gentle traction it pulls down the investing fat and fascia and quickly skeletonizes the vessels, isolating them up to their origin at trunk-artery and -vein.

"After removal of the breast and axillary glands en masse (Figs. 1217-1218-1219-1220) with all bleeding vessels on the thorax caught in well-pointed clamps, complete hemostasis, without ligatures, is secured by hooking up the clamps one by one on the surgeon's left hand and holding them at right angles to the thorax, and coagulating as described. Or, the operator coagulates, while the assistant removes them, saving time.

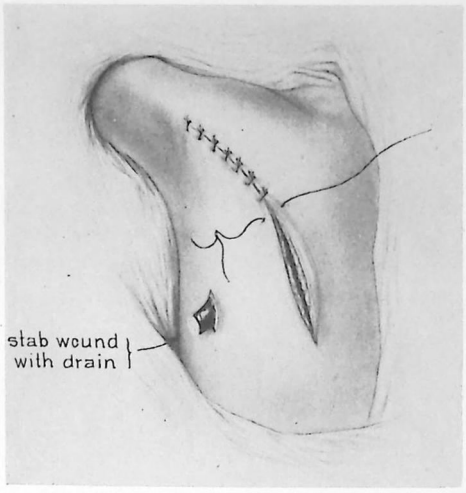


Fig. 1220. Electrosurgical amputation of the breast. Incision closed with interrupted silk; drain brought out through stab wound in posterior flap. (Kelly and Ward: Electrosurgery, Saunders; Courtesy of Dr. Grant Ward.)

"The measure for duration and amount of current is a slight hair-like coagulation ring at the end of the clamp. The time consumed is about one-fifth that of ligating the vessels. In this, more almost than in any other operation, we effect a great saving by keeping the foreign ligature material out of the wound. Beverly Chew Smith[1] states that approximately twenty to thirty minutes are saved routinely in mastectomy operations by using clamp coagulation hemostasis rather than ligatures."

SO-CALLED "INOPERABLE" TUMORS

Electrosurgery scores striking ameliorations in so-called "inoperable tumors" (Figs. 1221-1222-1223); some become operable, others are relieved and a few are cured. One does not see recurrences of the malignant growth in the line of in-

[1] New York Physiotherapy Society, January, 1931.

cision as is the case in Fig. 1224 which depicts skin metastases following amputation with the cold scalpel. Many patients to whom no hope is held out cer-

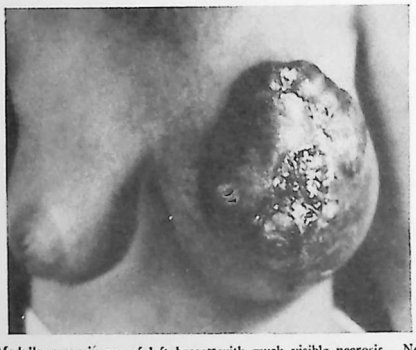


Fig. 1221. Medullary carcinoma of left breast with much visible necrosis. No lymph node involvement. Electrosurgical removal.



Fig. 1222



Fig. 1223

Fig. 1222. Advanced malignant disease of the breast in a young woman. "Too late" was the verdict. Radical removal and radium apparently halted the progress of the disease for some time.
Fig. 1223. Same patient seen in Fig. 1222. Some months after operation.

tainly are often benefited following electrocoagulation. I frequently supplement electrosurgical removal of the breast with radiation by deep x-ray or radium. A

combination of these procedures has served me well. Such patients find themselves relieved of pain and malodorous discharges. A feeling of *bien être* is often noticed.

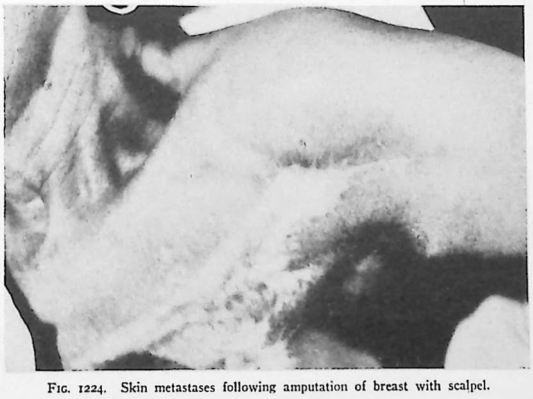


Fig. 1224. Skin metastases following amputation of breast with scalpel.

Many years of comfort often follow the removal of large tumors. After the coagulum separates, a healthy granulating base often develops which is receptive for skin grafting. Before grafting, however, fragments of such granulations should be examined microscopically to discover the presence or absence of malignancy. The periosteum, when involved, should also be submitted to destruction by electrocoagulation.

CHAPTER 26

SURGERY OF THE BRONCHI

BRONCHOSCOPY

This is usually done under local anesthesia using the technic that has been described for direct laryngoscopy (see p. 383).

The Chevalier Jackson laryngoscope is then introduced and held in the left hand. An assistant places the bronchoscope into the right hand of the operator who then introduces it through the laryngoscope. The surgeon now shifts his eye to the bronchoscope, and with the slanted portion of the instrument against the left vocal cord, passes it through the glottis. It should go through easily and very little pressure should be used. The air passages are then carefully examined, following the lumen of the tracheobronchial tree. Jackson states that only by thorough knowledge of the anatomy of the tracheobronchial tree and the experience of frequent bronchoscopy on a cadaver, will the operator always know where his tube-mouth is in the tracheobronchial tree.

FOREIGN BODIES IN THE TRACHEA

By inverting the patient, a foreign body may be expelled, provided that the foreign substance is not impacted. Léjars condemns this method.

Tracheoscopy or tracheobronchoscopy (Killian) (see chapter on Surgery of the Neck) per os or via the trachea often proves successful. Technical dexterity is essential to cope with these cases (Fig. 1225).

Removal of Foreign Bodies from a Bronchus by the Tracheal Route

Step 1. General anesthesia.

Step 2. After the trachea has been opened, place the patient in the dependent position.

Step 3. Retract the edges of the tracheal wound with retractors or sutures. Lift the foreign body with appropriate forceps (Fig. 1226). Coughing and inversion of the patient may bring a non-impacted body from the bronchus into the wound.

Step 4. Insert a tracheotomy tube for several days.

If the above means fail to give relief, Binnie suggests either suturing the edges of the tracheal wound to the skin or inserting a large cannula and allowing the patient to rest. After some hours, or next day, the wound is re-opened; if the object is not now coughed out, a small laryngeal mirror is introduced and the trachea is investigated by the aid of a strong light. If the foreign body is caught in the mucous membrane, cocaine should be sprayed in and laryngeal forceps or a wire loop used for its extraction; several sittings may be necessary before the object is removed.

Impacted Foreign Body in a Bronchus

Posterior bronchotomy may be resorted to or the formation of a pulmonary abscess awaited, when this may be opened and drained. The former is a formidable operation and the latter rather impractical (patients may die before or after solidification of the lung).

Posterior Bronchotomy (Schwartz's Operation)

The bronchi may be reached through the posterior mediastinum (see Lilienthal's technic of posterior mediastinotomy in this chapter).

Right Bronchotomy

Place the patient in the right lateroventral position on the edge of the table with the right arm hanging over the table (Fig. 1227).

Step 1. Make an incision from the point at the junction of the spine and median border of the scapula to a point about 1½ inches to the right of the

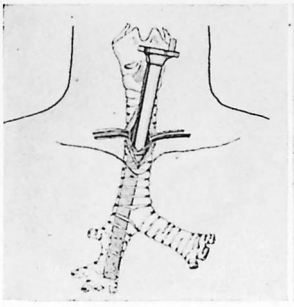


FIG. 1225

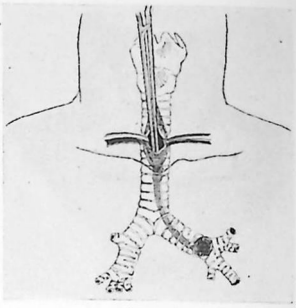


FIG. 1226

FIG. 1225. Bronchostomy. Direct endoscopy of the right bronchus through a tracheotomy incision. (After Doyen.)

FIG. 1226. Removal of a foreign body remotely lodged in the left bronchus with a curved forceps introduced through a tracheotomy incision. (After Doyen.)

spines of the thoracic vertebrae. Extend the incision downwards, parallel to the spinous processes of the vertebrae for a distance of about five inches and complete it in such a manner, just below the angle of the scapula, that when the flap is reflected it will expose the fifth, sixth, seventh and eighth ribs. J. D. Bryant fashions a flap with its pedicle towards the spine.

Step 2. Divide the spinal ends of the exposed ribs subperiosteally, just external to the transverse processes. Divide the ribs as far outward as possible. Separate the flap, consisting of ribs and intercostal muscles, from the subjacent structures. Divide the intercostal muscles along the paraspinal line in which the ribs were divided. Ligate the intercostal vessels. Divide the intercostal muscles parallel to and below the lowest rib to be mobilized. Similarly, cut through the intercostal muscles parallel to and above the highest rib to be mobilized. By gauze dissection, separate the parietal pleura from the flap of ribs and intercostal muscles. Reflect the flap outwards (Fig. 1228).

Step 3. Cautiously separate the pleura from the remnants of the ribs attached to the spine and from the side of the vertebrae. Displace the pleura and the lung outwards, away from the mediastinum (Fig. 1229). The azygos vein will be seen running vertically at the upper end of the wound arching for-

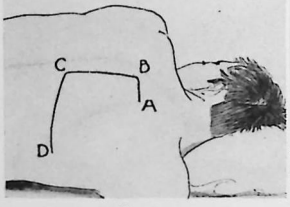


FIG. 1227



FIG. 1228

FIG. 1227. Bronchotomy. Schwartz operation showing lines of incision for creation of the osteoplastic flap.

FIG. 1228. Schwartz' operation showing exploration with the hand.

wards to reach the anterior mediastinum (Fig. 1229). Further separate the pleura under the arch of the azygos vein until the esophagus is exposed. The pneumogastric nerve lies external to the esophagus. Retract the pleura outwards.



FIG. 1229

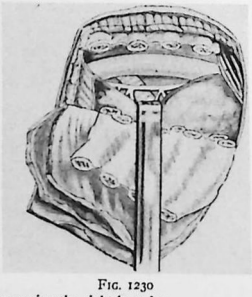


FIG. 1230

FIG. 1229. Schwartz' method of exposing the right bronchus.

FIG. 1230. Schwartz' method of exposing the left bronchus.

Step 4. Search for the posterior border of the cartilaginous rings of the bronchus in the concavity of the arch of the azygos vein. With the aid of a sharp hook, pick up the posterior wall of the bronchus and incise it. Remove the foreign body.

Step 5. Introduce a soft drain to the wounded bronchus. Hard drains may

cause dangerous pressure necrosis. Replace and suture the flap into place. The drain leaves the wound at a lower angle.

Left Bronchotomy

The patient is placed in the left latero-ventral position with the left arm hanging over the edge of the table.

Steps 1 and 2. Are the same as in performing right bronchotomy except that the operation is performed on the left side.

Step 3. Separate the parietal pleura from the remnants of ribs attached to the spine. On the side of the vertebrae, the aorta is encountered. The arch of the aorta passes towards the upper end of the wound. Separate the pleura under the arch of the aorta to a height of about 2 inches. The left pneumogastric nerve will be encountered. Displace the lung, which is covered by the intact pleura, outward with an appropriate retractor. Feel for the posterior prominent edges of the bronchial cartilages. The rest of the operation is the same as in right bronchotomy (Fig. 1230).

CHAPTER 27

SURGERY OF THE THORAX, PLEURAE AND LUNGS

Historical Notes. The history of surgery of the lungs is ancient. Hippocrates recommended opening of the pleura in cases of empyema. A lull is now noted until 1584 when Schenck suggested surgery in the treatment of abscess of the lung. Baglin and Bermann in 1696 followed suit. Debary (1726), Faje (1797), Jacques (1813) and Sharp in 1769 suggested opening of lung abscesses by incision, while Nasse, v. Herff and Kriner in 1830 and Stokes in 1845 entered the chest with a trocar. The names of König (1864), Jaszenko (1870), Russion and Koch (1874) are prominently connected with this phase of surgery. Later Garé, Quincke, Karewski, Gluck, Sauerbruch, Lilienthal, Graham, Jacobaeus Nissen, Churchill, Rienhoff, Jr., and others made notable contributions.

Anatomic Considerations. The Pleurae. The parietal pleura is divided into the costal, diaphragmatic, mediastinal and cervical portions. The cervical part is fortified by Sibson's fascia; this extends from the transverse processes of the lower cervical vertebrae to the apex of the pleural sac. The costal pleura is a substantial structure and is separated from the parietes by the endo-thoracic fascia; the diaphragmatic pleura is very thin and firmly connected with the underlying muscle. The visceral pleura surrounds every part of the lung except its root; it lines its fissures and is adherent to the pulmonary parenchyma. The ligamentum laterum pulmonis is a triangular fold of pleura which passes from the inner surface of the lung to the pericardium.

GENERAL CONSIDERATIONS

Methods of Maintaining Respiration When the Thorax Is Opened

Meltzer and Auer's Method. This is a method of artificial respiration brought about by intratracheal insufflation of air. A small tube is passed through the larynx into the trachea almost to its bifurcation. By means of a foot bellows or electric motor, air mixed with ether is blown continuously through the tube under pressure of about 15 to 20 mm. of mercury. The lungs are kept moderately distended, the blood is thus aerated and the excess air escapes alongside the tube.

Numerous apparatus are on the market to accomplish the desired results.

Sauerbruch was first to construct a cabinet by means of which the thorax could be freely opened and respiration kept up either under negative or positive pressure.

Negative Pressure Cabinet. In the use of this cabinet, the patient's body, the surgeon and assistants are on the inside of the cabinet. The head of the patient projects through an aperture at one end of the cabinet, his neck being surrounded by an air-tight collar. By means of an air pump, controlled by a manometer, the air pressure on the inside of the cabinet is sufficiently lowered to permit respirations to continue after the thorax is opened.

Positive Pressure Apparatus. The cabinet is the same as negative pressure cabinets with the difference that the patient's body is on the outside while his head and the anesthetist are on the inside of the cabinet. The pressure of the air on the inside of the cabinet is increased by means of an air pump.

minous dressing. Irrigation with saline or boric solution may be necessary in some cases.

Comment: The first case of thoracotomy under intratracheal insufflation anesthesia in the human being was done by Howard Lilienthal in 1903.[1]

THORACENTESIS

Object. Removal of fluid from the chest cavity. The procedure may be (a) exploratory or (b) therapeutic. In all operations here, the strictest asepsis must be maintained.

Instruments. Exploring trocars; aspirating or Dieulafoy trocars; Potain aspirator (Fig. 1232).

Without Admission of Air

This is much preferred in children and infants. Select the posterior axillary or scapular line; asepticize the skin thoroughly. Enter the trocar in the 5th, 6th or 7th intercostal space. Have the patient sit up wherever possible. Introduce the trocar at the upper border of the respective rib in order to avoid injuring the intercostal vessels. Permit the fluid to escape slowly; stop aspirating when about three-fourths of the fluid accumulation has been drained off. Should the patient complain of dyspnea, faintness, severe cough or dizziness, interrupt the paracentesis. If the condition seems extreme, inject half as much oil as fluid removed. When through put some collodion over the puncture made by the trocar.

With Admission of Air

This procedure offers a number of advantages over the preceding. The admission of air avoids negative pressure, which is responsible for such untoward symptoms as severe cough, dyspnea, pain and weakness which are often observed when the first method is practiced.

Procedure. Introduce the trocar at the most dependent part of the intrapleural accumulation, permitting some air to enter. When the latter has been removed, the opening created by the trocar is closed with collodion or a small square of zinc oxide adhesive plaster.

Comment: Avoid careless introduction of the trocar lest injury to the lung tissue, heart or intercostal vessels ensues. Avoid passing through the diaphragm thus invading the peritoneal cavity. Stay above the ninth rib posteriorly and the sixth rib anteriorly.

Rib Resection (Costectomy)

Practical Considerations. The removal of a portion of a rib is most commonly performed for the purpose of draining an empyema. Usually a portion of the sixth or seventh rib is removed in the midaxillary line. It is to be remembered that the second to the seventh ribs are covered posteriorly by the scapula. The ribs lying below the eighth are so closely related to the diaphragm that the latter may be injured during costectomy.

[1] Annals of Surgery, 1910.

BASIC OPERATIONS ON THE THORAX

The thoracic cavity is opened because of (a) empyema and for (b) exploration of the thoracic contents and (c) exploration of the mediastinum.

An empyema may be evacuated by thoracentesis (simple puncture and aspiration) or by thoracotomy (simple intercostal incision). For these procedures local or general anesthesia may be used. The former is all that is required in the majority of instances.

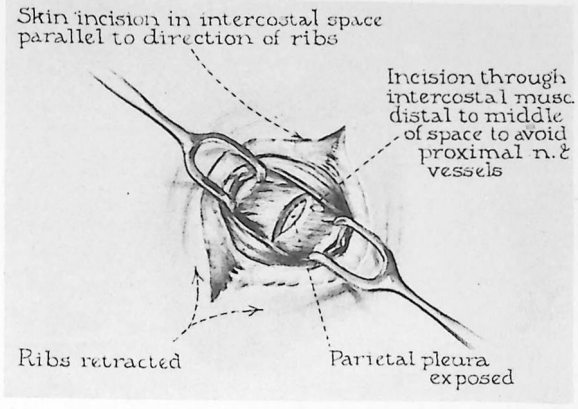


Fig. 1231. Thoracotomy.

THORACOTOMY

Step 1. An incision is made about two inches in length and running parallel with the ribs. It should begin just anterior to the latissimus dorsi muscle and correspond to the sixth, seventh or eighth intercostal spaces (Fig. 1231). Divide the intercostal muscles distal to the middle of the intercostal space, thus avoiding the intercostal vessels and nerves.

Step 2. Careful hemostasis. Make a small opening in the parietal pleura. Avoid too rapid evacuation of pus. Enlarge this opening with a pair of hemostats or the finger. Remove blood clots, shreds and fibrin. Leaving these behind causes delay in healing and they may obstruct the opening created for drainage.

Step 3. Insert a rigid rubber tube into the pleural cavity. Not much of the tube should project into the cavity and it should be kept from slipping by stitching or by attaching it to the skin with a safety pin. Apply a volu-

The removal of a segment of one or more ribs does no permanent harm.

Position of Patient. It is best to place the patient with the sound side uppermost, midway between the lateral and ventral position e.g., the patient lying half over the abdomen. The sound side must never be undermost, otherwise respiration will be interfered with. The illustration (Fig. 1233 a) shows how it should not be done.

Anesthesia. Local infiltration analgesia with novocaine, one-half of one

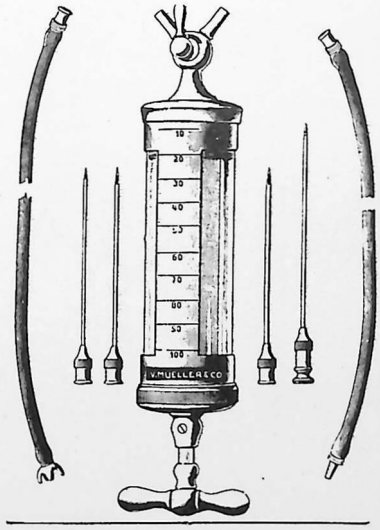


Fig. 1232. Dieulafoy's aspirator.

per cent, suffices in most instances (Fig. 1234). Infiltrate the solution along the lines of the proposed incision. The area to be blocked by the anesthetic should embrace about one intercostal space above and one below this line of infiltration.

Step 1. The incision should be two or three inches in length, along the long axis of the rib chosen for resection and halfway between its upper and lower borders. Divide the periosteum along the line of the incision with a curved periosteal elevator (Fig. 1233-b).

Step 2. The intercostal vessels are separated from the bone with the periosteum by means of a Doyen instrument (Fig. 1235). Avoid accidental opening of the pleura at this stage of the operation. Retract the parts thoroughly.

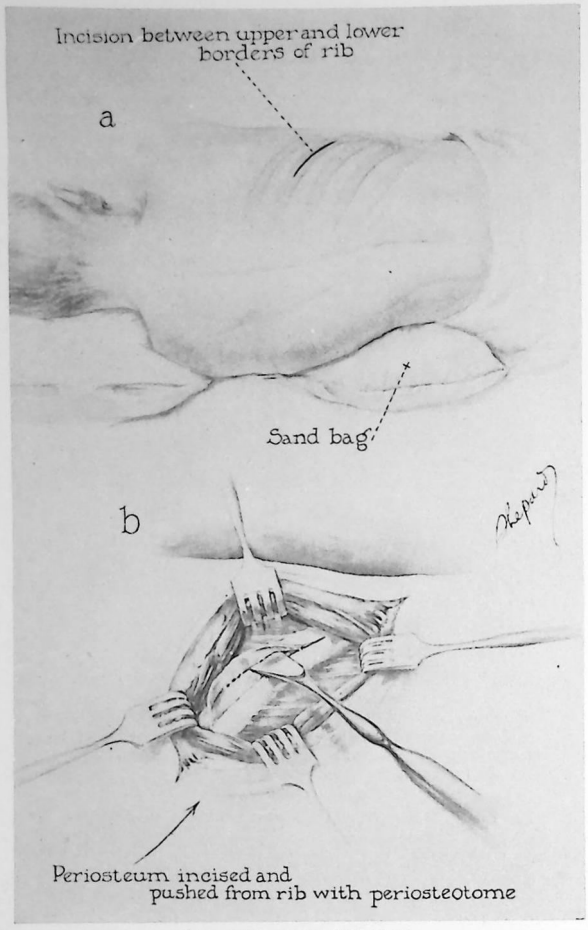


FIG. 1233. Rib resection (costectomy)

Divide the exposed portion of the rib with properly constructed rib shears (Fig. 1236). Remove about two inches of the ribs. Aspirate. (Fig. 1237 a.)

Step 3. Make a small incision along the aspirating needle dividing the posterior periosteum and parietal layer of the pleura. (Fig. 1237 b.) Allow pus to issue slowly; too rapid evacuation may cause pulmonary congestion and if not guarded against, fatal anemia of the brain.

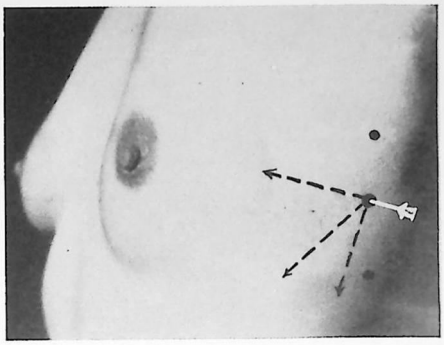


FIG. 1234. Block anesthesia in rib resection where one rib is to be resected; the fan-shaped area is infiltrated intradermally and subcutaneously and after the incision is made the exposed structures are similarly infiltrated.

WOUNDS OF THE LUNGS AND PLEURAE

These usually result from (a) stabs, (b) bullet wounds, (c) trauma, the result of fragments of fractured ribs and (d) surgical operations.

Dangers:

(1) Pneumothorax, (2) Pyothorax, (3) Hemothorax, (4) Pulmonary Collapse, (5) Shock, (6) Air Embolism.

TREATMENT OF PENETRATING WOUNDS OF THE CHEST

Determine the patient's vital capacity. This indicates the extent of surgery permissible in a given case.

1. Encourage the patient to lie on the affected side.
2. Exert steady pressure on the injured side of the chest (compression bandage).
3. Enlarge the wound; explore; remove foreign bodies; cleanse; asepticize: attend to hemostasis. See if the pleura is injured; if so, repair it. Explore for injury to the lungs; if wounded, suture the wound in the lung.
4. Pack loosely and partially close the external wound.
5. Dress. Apply dressing to immobilize the chest (adhesive tape).

6. If hemorrhage cannot be arrested by the measures suggested augment the existing pneumothorax.
7. Nonintervention has many advocates (Clement et al.).

SUTURE OF THE LUNGS

Step 1. Enlarge the original incision inflicted by the trauma, along an intercostal space or combine it with rib resection as indicated. Exposure must be ample at any cost.

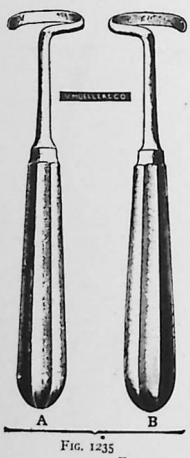


FIG. 1235



FIG. 1236

FIG. 1235. Doyen's costal raspatory.
FIG. 1236. Rib osteotome and laminectomy shears (Doyen).

Step 2. Using the hand or special forceps pull the lung into the wound just sufficiently for exposure, not too much, lest respiratory embarrassment ensue (reflex action) (Fig. 1238).

Step 3. Isolate the wound. Clamp it temporarily with proper elastic forceps that will not compress the lung excessively. Ablate ragged edges where present. Ligate larger vessels and bronchi with fine silk. If the injured parts are extensive, resect them. Alternatives: suturing of the injured lung into the cutaneous wound; tamponade and drainage.

Step 4. Suture. Use fine curved needles with silk. Catgut is not as pliable as silk or linen. Ligate carefully. Approximate, do not strangulate! Tiegel recommends touching the suture apertures with iron perchloride (Figs. 1239-1240).

Lung tissue is more resistant than is commonly supposed. Tension sutures are occasionally of value.

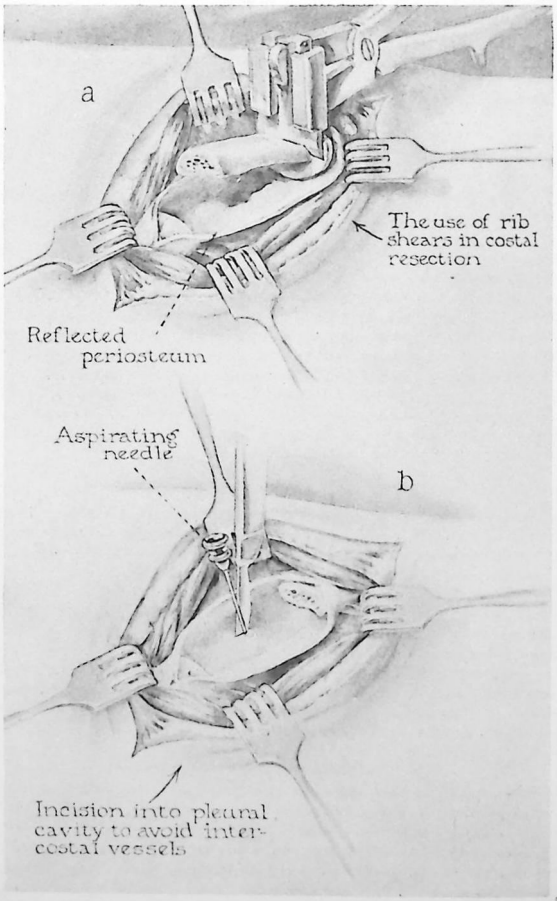


FIG. 1237. Rib resection. Costectomy.

Step 5. The pleura may or may not be sutured; proceed as indicated. If sutured, Lembert type inversion sutures are to be used (Fig. 1241).

Step 6. Close the wound. Usually drain.

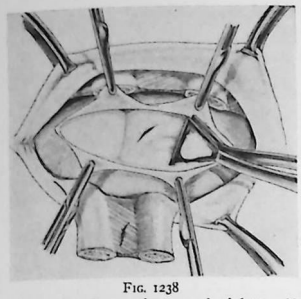


Fig. 1238

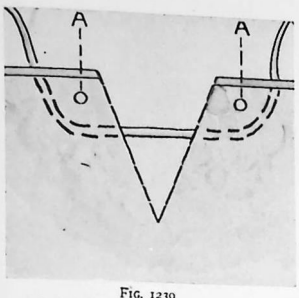


Fig. 1239

Fig. 1238. Penetrating wound of lung. Note opened pleura. Lung grasped and steadied preliminary to placing of coaptation suture.

Fig. 1239. Tiegel's method of suturing of the lung. Cross section.

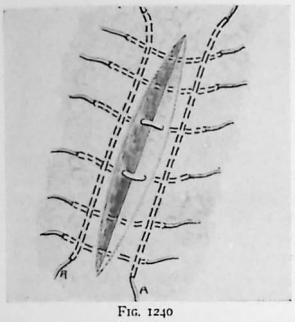


Fig. 1240

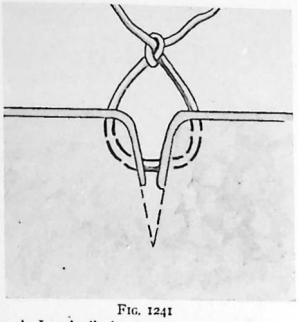


Fig. 1241

Fig. 1240. Tiegel's method of suture of the lung. A. Longitudinal suture acts as an efficient support for the transversely placed sutures. Fig. 1241. Inverted suture of the lung.

Hernia of the Lung

Nontraumatic hernia is the result of some congenital or acquired locus minoris resistentiae.

Treatment. Compression (pads).

Operation. Plastic closure of the hernial opening.

Trauma resulting in hernia of the lung is treated by reduction of the prolapsed lung; if not necrosed, this is followed by external compression; if the lung segment is affected ligation of its base and removal of the necrotic portion

with the electro- or thermocautery is resorted to, followed by repair of the cutaneous opening, if the wound is clean; if not, drain.

PNEUMOTHORAX

Pneumothorax, the result of fractured ribs, is characterized by (a) cyanosis and (b) embarrassed respiratory and heart action.

Treatment. Aspiration is usually followed by prompt relief. If the wound in the lung is closed, relief is permament; if open, distressing symptoms will continue and operative intervention becomes imperative.

Operation. (a) Do a costectomy (p. 1072) to gain access to the wound in the lung. (b) Treat the injury to the lung as described. (c) Compress.

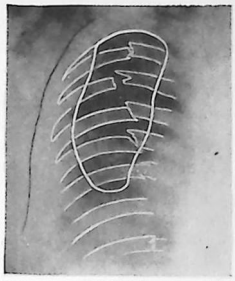


Fig. 1242. Multiple fracture of the ribs with resulting pneumothorax.

EMPHYSEMA

This condition often follows fractured ribs or stab wounds but may also occur subcutaneously if air reaches the cellular spaces through the tubes during the process of injecting saline solution. The seriousness of the case depends upon the quantity of air introduced and the nature of the injury.

If a fractured rib is responsible for the emphysema, strapping, morphin, ice bags and absolute rest is the treatment.

If a penetrating wound caused the emphysema, cleanse the wound and give antitetanic serum at once. Thoroughly immobilize the chest, keep the patient at absolute rest (mental and physical) and treat symptoms as they arise.

If a large area is involved and it seems to be spreading, the subcutaneous tissues should be incised and the air permitted to escape.

A cadet about 20 years of age was injured during a scholastic fencing meet. His opponent's foil broke and the broken end entered the right chest at the midaxillary line of the second interspace. The lung was penetrated and immediate hemoptysis resulted. The usual picture of a partial pneumothorax developed with associated dyspnea, cyanosis, cough and blood-streaked sputum (Figs. 1243-1244). A few hours following the injury a rather definite and rapidly spreading surgical emphysema developed which extended from the right costal region and upper right rectus zone up to the right supra- and infraclavicular fossae, this extending medially to about the midline. A definite sense of crepitation could be elicited upon palpation. However, the amount of air in the right infraclavicular fossa was so marked that a definite protruding and insufflated zone resulted. Adhesive strapping was applied from above downward to prevent the further ascent of the air into the neck thereby avoiding further respiratory embarrassment. Under a symptomatic régime associated with absolute bed-rest the lung re-expanded, the hemo-pneumothorax disappeared and the subcutaneous effusion was entirely absorbed.

Another case which came under my attention was that of an old nurse (89

years of age) who was seen in extremis (Fig. 1242). She sustained fractured ribs, a fragment of which penetrated the lung. Emphysema developed which rapidly extended into the neck and subcutaneous tissues. Embarrassed heart action and the rapidly spreading emphysema caused death.

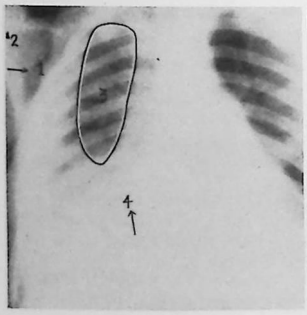


Fig. 1243

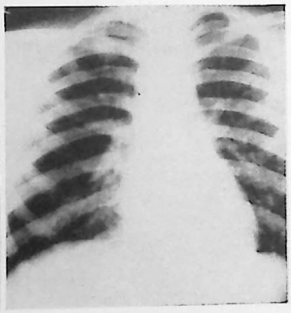


Fig. 1244

Fig. 1243. Traumatic pneumothorax and surgical emphysema. Partial collapse of the lung with hemothorax, the result of stab wounds. 1. Point of entrance of rapier; 2. subcutaneous tissues infiltrated upward over the right supraclavicular zone; 3. partially collapsed lung; 4. right costophrenic and cardiophrenic partially obliterated.

Fig. 1244. Surgical emphysema. Same patient. Complete expansion of the lung and apparent restitutio ad integrum.

Mediastinal Emphysema

An injured trachea, bronchus or esophagus which permits the constant escape of air into the mediastinum is the usual cause of mediastinal emphysema. This condition is life threatening and demands that immediate steps be taken for relief.

An incision is made on the anterior aspect of the infrathyroid region of the trachea down to the trachea. Secure hemostasis as the operation progresses. A suction apparatus is then improvised which will gradually withdraw the escaped air from the mediastinum. Continuous suction may at times be resorted to depending upon circumstances. Where the air issues from a wound in the trachea, the latter will have to be repaired by suturing the opening.

RÉSUMÉ OF TREATMENT OF INJURIES OF THE LUNG

Ambrose L. Lockwood's[1] recommendations for operation in injuries of the lung are summarized as follows:

"1. Operate on all patients with an open pneumothorax (traumatopnea).

[1] Surg., Gynec., and Obst., Feb., 1933.

"2. Operate on all patients with laceration of the diaphragm as well.

"3. Operate on all patients with a badly 'stove-in' chest, with overriding fragments and sharp spicules where the pleura is lacerated, even though there is no external wound.

"4. Operate on all patients where a jagged irregular missile has traversed the pleural cavity, whether lodged in (a) the chest wall, (b) the pleural cavity, (c) the lung, (d) the mediastinum, or (e) the heart or pericardium.

"5. Operate on all very acutely infected patients, even though the missile is not retained.

"6. Operate on all patients with a penetrating wound of the chest with progressive bleeding, hemoptysis and massive hemothorax.

"7. Operate on all patients with a massive pneumothorax and great displacement of the heart and mediastinum that cannot be controlled by aspiration.

"8. Operate on all patients in whom rupture of a main bronchus or artery at the hilus of the lung is suspected.

"Thoracotomy is rarely indicated for relief of the ordinary hemothorax or hematoma of the lung. Unfortunately, occasionally lung abscess or more rarely gangrene of the lung results from an extensive hematoma of the lung, but unless thoracotomy is necessary otherwise, we believe such patients should be treated expectantly.

"The modern gas oxygen machine with a snugly fitting mask applied to the well vaselined face affords all the positive pressure necessary for re-oxygenation and offsets the danger of a prolonged open pneumothorax. Intratracheal gas oxygen anesthesia in the hands of an experienced anesthetist should be employed for a prolonged thoracotomy.

"Paravertebral anesthesia for two or three spaces above and below the wound or the site of the incision, with local infiltration, to avoid delay, associated with gas oxygen analgesia, is the anesthetic of choice. Emergency cases that would never be fit for a general anesthetic can be safely operated upon with this type of anesthesia. A more extensive, deliberate, and protracted operation can be undertaken with the minimum of shock to the patient. Respirations are deeper and more regular than with a general anesthesia, and the movements of the lung, mediastinum, and diaphragm can be voluntarily controlled by the patient to an appreciable extent. The two stage operation, in which both sides of the thorax are opened, is possible only with this type of anesthesia. Postoperative restlessness, vomiting, retching, coughing and straining are avoided, and this plays no small part in the success of such operations, especially in bad risk patients.

"Operation. The complete intrathoracic operation must not be lightly undertaken. The preparations for operation, the anesthetic, and the technique of the operation are most exacting, although the manipulations themselves within the thorax do not require any exceptional dexterity. Speed is essential. Absolute asepsis must be maintained.

"For operation the patient should be placed with the injured side

dependent, usually in the half-sitting posture Primary union will not result without bold, thorough excision of the wound area.

"When the position of the wound will permit, resection of the fourth rib or preferably a long incision in the interspace immediately below it from the midclavicular to the posterior axillary line furnishes easiest access to the thoracic cavity. A powerful, snugly fitting rib retractor is necessary.

"The commonest source of bleeding is from a torn intercostal artery. If the artery cannot readily be picked up and ligated with a small periosteal needle, a suture can be passed around it or, failing that, around the rib itself.

"The lung can be freely handled, incised, or a wound excised as required. If the wound is of a gaping type in the lung, tags of intercostal fascia and muscle should be laid over the edges and sutures passed through them; this will relieve tension on friable lung tissue when the edges are approximated. Bronchial fistulae will invariably be avoided if the visceral surfaces are carefully apposed.

"Partial, or even complete lobectomy may be necessary, depending on the degree of laceration of the lung. In such a case preserve plenty of the visceral pleura.

"An open bronchus or alarming hemorrhage from the lung surface is rarely found at operation.

"The toilet of the pleura must be meticulous.

"The thoracotomy incision should be closed with a thick, moist towel, every moment that the hands of the operator are not within the thorax.

"Time should not be wasted in attempting to repair the parietal pleura.

"The chest must be hermetically closed with the first layer of muscles; otherwise, pocketing will occur, pleural effusion accumulate, the incision break down, and an empyema result.

"Careful approximation of the skin edges is necessary to insure early, absolute primary union.

"Drainage of the chest should never be employed in these primary operations.

"Gross injuries of the bony wall of the chest associated with injury to the lung require that all comminuted bone and sharp spicules be widely excised. If the intercostal nerves have been torn, employ alcohol injection proximally to offset pain during convalescence.

"Postoperative treatment. The postoperative treatment of chest wounds demands constant attention. The patient should be maintained in the position found to be most comfortable. Oxygen should be employed if the patient is cyanosed. Morphia should be freely used to combat restlessness.

"Aspiration should be carried out 18 hours after operation and as frequently as necessary to keep the pleural cavity relatively free of fluid. Early fluoroscopic examination or roentgenograms will help to determine the presence of a collection."

INFECTIONS OF THE LUNGS EXCLUSIVE OF TUBERCULOSIS

LUNG ABSCESS

Lilienthal[1] points out that the principles of the operations for lung abscess are always the same, namely:

1. The head of the patient should be lower than his hips.
2. Local anesthesia should be used if possible, if not, some extremely light form of so-called analgesia should be used so that the cough reflex may not be abolished and the danger of aspiration into the opposite lung may be reduced. Heavy narcotic dosage and anesthesia by avertin or other drugs should be avoided.
3. Evacuation should be by the most direct route avoiding free pleural involvement.
4. The drainage opening should be well above the lower limit of the abscess.
5. Manipulation of the cavity should be gentle so as to prevent dangerous hemorrhage.
6. One should refrain from the natural surgical tendency to simplify multiple abscess cavities at the time of operation.
7. The packings should never be so firm as to dislocate the mediastinum.
8. Whenever adhesions are feared rubber dam should be employed as a packing.
9. The wound pattern makes comparatively little difference but an opening which promises to enter the abscess by the most direct route should be employed with such preliminary or additional incisions as may be necessary for perfect exposure. As a rule, chest wall flaps should not be employed, even though they apparently permit of drainage at the lowest point, because frequent dressings will be necessary and the flap impedes complete exposure.

Comment: In lung abscess one may wait from six to eight weeks during which conservative treatment should be resorted to. A large majority of these cases heal spontaneously during this time. Particularly is this true in abscess which has perforated into a bronchus (abscess in the upper lobe and region of the hilus). The procedure of choice after an unsuccessful period of waiting with conservative management is pneumonotomy. Phrenicotomy should only be resorted to in the presence of cavities of the lower lobes. Nissen emphatically warns against the use of therapeutic pneumothorax in these cases and admonishes that aspiration of the abscessed cavity is even more dangerous. Bronchoscopic suction of pus is also deprecated as being of little value, if any. Where the condition of the patient is bad, the less interference, the better. The keynote to success is to put the affected lobe at rest wherever possible; even though one takes into the bargain a possible infection of the pleura artificial pneumothorax is advocated.

PNEUMONOTOMY

Pneumonotomy indicates the creation of an opening into the lung usually for abscess. The operation may be beset with difficulties. In cases of superficial abscess the suppurative focus is opened with either scalpel or thermo- or

[1] Surg., Gynec., and Obst., 1931.

electrocautery; its contents are evacuated and the resulting cavity drained. Hemorrhage is usually in proportion to the depth of the suppurating focus and proximity to the hilus of the lung. Exposure must be ample. If one of the larger vessels bleeds, ligation is called for. Often, with most careful search, a small abscess of the lung may be overlooked. An exposed lung may be explored with a stout aspirating needle or by palpation. Terrier, after rib resection, separates the parietal pleura from the inner surface of the chest wall and palpates the lung akin to extraperitoneal palpation of the abdominal viscera. Once the abscess cavity is widely opened, it should be thoroughly explored and drained. Do not curet; it may be followed by marked hemorrhage. Drainage is now accomplished by tamponade and rubber tube drain. Do not irrigate.

The treatment of acute abscess and gangrene of the lung is surgical. The foci are usually solitary in acute conditions; multiple in chronic. Procrastination may be permitted in the latter, prompt action in the former unless the arsenicals given intravenously are followed by prompt amelioration.

Avoid exploratory punctures unless you are prepared to operate at once. At any event resort to puncture only when the pleura has been exposed (costectomy). Operate under local anesthesia. In active hemorrhage in gangrenous processes the majority of surgeons incline to prompt interference (tamponade, exposure and ligation of the bleeding vessel).

In localized abscesses do a:

Step 1. Costectomy.
Step 2. Expose the involved area.
Step 3. In the absence of adhesions, outline the abscesses by circular suture in the same manner as described under transpleural approach to abscess of the liver (which see).
Step 4. Open and drain.

Thoracotomy with Tamponade

CONNOR'S METHOD

The most important contributions to the subject of pulmonary abscess, before Connor described his treatment by tamponade, were those of Mikulicz and Forlanini. Mikulicz advocated surgical intervention (thoracotomy) while Forlanini recommended artificial pneumothorax; this latter did not find much favor. The only technic adopted since was rubber tube drainage.

Connor, in 1926, described his method of tight tamponade. This he discovered by accident in using a tight tamponade to obtain hemostasis. When the pack was removed after three days, the floor of the pulmonary abscess was found dry and in the process of granulation. Ciacci lauds the method as perfectly meeting all requirements because pulmonary abscess is not amenable to any other than surgical intervention (rapid and complete drainage). The after-care is reduced in Connor's procedure to simple and short medications, not requiring tubes which may cause pleural irritation or costal osteomyelitis. Ciacci uses the procedure as a method of choice, if possible, in one step, and not before the sixth week of the disease and never later. He cites the following reasons: First, to effect an opportunity for spontaneous healing; this occurs in 10 per cent of the cases. Second, to permit formation of sufficient pleural adhesions and, third,

not to operate later than six weeks, because the patient's resistance might break down, and complications inherent to the long suppurative process develop.

Aspiration seems to be the most frequent determining cause; however, not all are exclusively due to aspiration of infectious material, but also to absorption via the lymph and blood vessels; a lacerated and infected tonsillar or dental bed may be etiologic factors. Chronic abscesses are usually large, and the surrounding fibrosis varies in degree and extension.

Anesthesia. Ether or avertin anesthesia. Administer physiologic salt solution by hypodermoclysis, beginning before and continuing throughout the operation. The position of the patient should be one which is most convenient for the opening of the abscess cavity.

Step 1. Make an incision 8 to 10 cm. in length along the rib crossing the center of the abscess. Resect about 5 cm. of rib subperiosteally. If the subjacent tissues are found indurated and devoid of respiratory movements (palpation and inspection), incise the abscess cautiously with a very sharp knife attacking the endothoracic fascia first.
Step 2. If the diagnosis is found to be correct, introduce iodoform gauze pending a second intervention about one week later. If the localization is exact, introduce the needle of an aspirating syringe into the abscess cavity allowing the pus to discharge, then introduce a grooved director.
Step 3. If the abscess cavity extends upward, resect a portion of the rib above. If it extends downward, remove part of the rib below. At all events obtain adequate drainage in every case.
Step 4. Suture the intercostal muscles with the intercostal vessels to the side of the wound. Remove the ribs where indicated. Break down adhesions between the multiple abscesses; convert them into one cavity. Dry the cavity with gauze sponges; tampon it rather tightly with iodoform gauze. Leave the cutaneous wound wide open. Cover its margins with gauze impregnated with vaseline. Place a dry dressing over the entire area.

Comment: If the unaffected pleural cavity is opened inadvertently during the operation, tampon the abscess cavity as usual with iodoform gauze, and the opened pleural cavity with simple gauze.

Give blood transfusions in case of collapse. Place the patient in a semi-sitting position after the operation; as soon as his condition permits, allow him to get out of bed. Remove the tampon between the third and fifth days, usually on the fourth. As a rule, the cavity will be found clean (the bronchial aperture visible). Tampon the cavity a second time, and from then on, every second day, but each time less tightly than the previous time, permitting the cavity to granulate from the bottom up. As soon as granulation is far enough advanced, the wound is allowed to heal up to about 2 cm. width. This opening is left patent for at least four months, or until recovery has ensued (x-ray; physical condition of patient).

EMPYEMA

Drainage of the Thoracic Spaces

"The principle of treating acute empyema as an acute abscess by prompt evacuation should be abandoned" (Nissen).

According to Lilienthal, drainage of the thoracic spaces may be undertaken according to the four distinct forms of the disorder: (1) peripheral empyema; (2) mesial empyema (often miscalled mediastinal), and (3) the collection of pus between the diaphragm and the lung which Lilienthal has called supraphrenic empyema. The latter has a tendency to extend mesially and upward. It is sometimes necessary to differentiate between supraphrenic empyema and subphrenic abscess. This can easily be done when the disease is on the right—the more usual site—by introducing a little oxygen into the peritoneal cavity through a needle and then making an x-ray film with the patient upright. On the left side a drink of carbonated water will produce a gastric bubble which will function in an x-ray film in the same manner as a pneumoperitoneum. Adjacent sacculated empyemas, it must be remembered, may coalesce. (4) The fourth

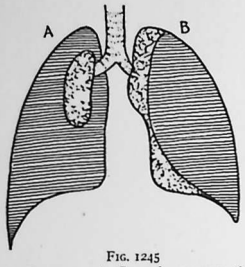


FIG. 1245

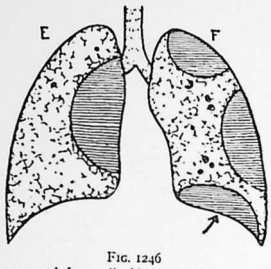


FIG. 1246

FIG. 1245. A. General empyema, the lung compressed from all sides upon its root. B. Large sacculated empyema wrongly called general empyema. (From Lilienthal, Thoracic Surgery, W. B. Saunders Co.)
FIG. 1246. Distribution of empyema. E. Mesial empyema. F. Three sacculated empyemas, the lower one supraphrenic. (From Lilienthal, Thoracic Surgery, W. B. Saunders Co.)

form is the interlobar empyema which results from infection by that part of the lung where one lobe touches another (Figs. 1245-1246-1247).

Interlobar Empyema. If this condition exists without adhesion of lung tissue to the chest wall, Lilienthal advises (1) exposure through a free intercostal incision; (2) production of adhesions with extrapleural packings around the proposed site of drainage over which a rib has been resected and (3) evacuation of the pus at a later stage. Lilienthal comments: "While this may seem to be an operation of considerable magnitude it does not, in reality, cause shock and it may prevent opening into a bronchus, always a serious affair because of the possibility of inducing a chronic condition; it will also probably prevent the development of a large complicating empyema. The interlobar disease is well suited to the form of drainage secured by packing with gauze immediately after it has been opened at the second stage. The latter method of treating empyema at a primary operation has been recently tested thoroughly in the service of Doctor John F. Connor.[1] Packing is, of course, one type of drainage and in some cases of empyema, especially in those of not too great size, is particularly suitable. Doctor Connors employs it even in extensive purulent pleuritis. It

[1] Ann. Surg., 1931, Vol. 94.

is necessary to resect enough ribs to get ample room for manipulation to break down adhesions when the cavity is anatomically complicated. The gauze must not be too firmly packed. It is removed on the second to the fourth day and as a rule need not be replaced. Coughing and straining are encouraged and the various complications of tube drainage are usually avoided. Manifestly, if the interlobar empyema has become adherent to the parietal pleura, this operation can be performed in one sitting.

Bilateral Empyema. Should both sides be operated upon at the same time? The side most affected should be drained and the other side simply aspirated to

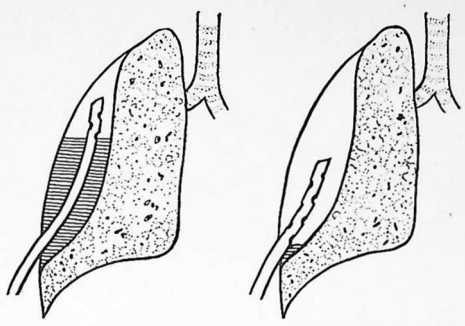


FIG. 1247. Incorrect manner of fenestrating a catheter or other tube; the openings are all so near the inner end that the empyema has to fill to the end of the tube before actual drainage occurs. The second picture illustrates the correct fenestration permitting almost complete emptying. (From Lilienthal, Thoracic Surgery, W. B. Saunders Co.)

be followed by repeated aspirations; treatment should be directed to either intercostal incision with closed drainage or rib resection with packing. In the small sacculated empyemas packing only should be resorted to.

SURGICAL TREATMENT OF CHRONIC EMPYEMAS

Estlander's Operation (1879)

If an empyema fails to heal after months and the etiology is not to be found in a removable cause, a plastic operation to obliterate the entire cavity is usually called for; this consists in immobilizing either the chest wall or the lung.

Ascertain the size of the cavity (x-ray; exploration; injection of bismuth paste). Resect subperiosteally the ribs overlying the empyema cavity, which should be covered by soft tissues only. The chest wall and pleura, it will be seen, are thus made to collapse and the former is brought into apposition with the lung, providing the pleura is not too thick. This may be an inch or more. The number of the ribs to be resected and the type of flap depend upon the extent of

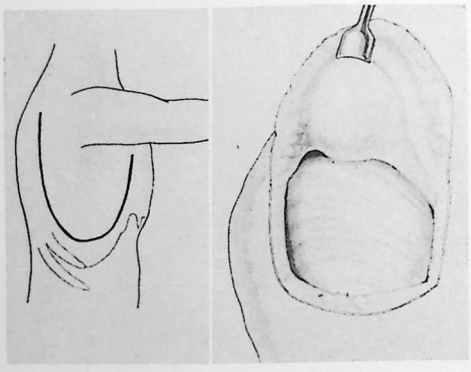


FIG. 1248

FIG. 1249

FIG. 1248. Schede's method of thoracoplasty. Extent of incision shown in heavy outline.
FIG. 1249. Formation of flap from soft tissues.

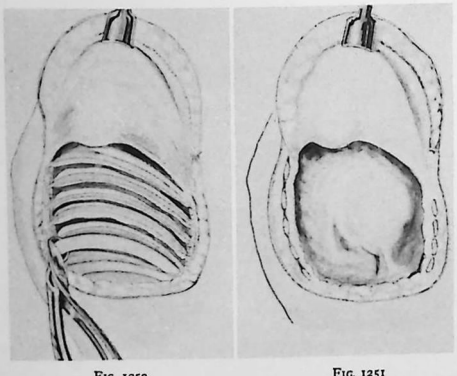


FIG. 1250

FIG. 1251

FIG. 1250. Schede's method of thoracoplasty for chronic empyema. Subperiosteal resection of the ribs.
FIG. 1251. The cavity resulting after removal of the soft parts including scar tissue.

the thickness of the pleural cavity. The incision may be a small semilunar cut or a small U-shaped flap, depending upon the area to be exposed.

Schede's Thoracoplasty (1890)

In those instances where there exists a single, large and collapsible cavity, Schede's extensive procedure may be resorted to (Figs. 1248-1249-1250-1251). It consists of removing not only the ribs but also all the soft tissues of the thoracic wall between the ribs and underneath them. Infiltration block anesthesia may be used (Fig. 1252).

Step 1. The incision begins in the upper part of the back, between the spinal column and the scapula, and descends to the lower border of the pleura, ascending again along the anterior axillary line and terminating under the border of the pectoralis major muscle. All the soft tissues of this extensive flap are dissected upwards, raising the scapula with it during the course of the dissection.

Step 2. All the ribs from the second down are resected together with their costal cartilages. After opening the pleura, the intercostal muscles and with them the thickened and infiltrated parietal pleura are removed. The visceral pleura which is much thickened in these cases is curetted with a Volkmann sharp spoon.

Step 3. Replace the skin flap. Introduce drainage tubes. It will be seen that the entire cavity thus becomes filled with the collapsible soft tissues of the chest wall which become adherent to the visceral pleura, thus obliterating the cavity.

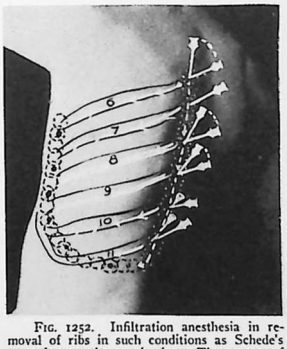


FIG. 1252. Infiltration anesthesia in removal of ribs in such conditions as Schede's operation or thoracoplasties. The extent of infiltration depends upon the number of ribs to be removed. The respective intercostal spaces are blocked in continuity at the angle of the ribs. Preliminary to blocking the nerves the line of proposed skin incision is infiltrated. The nerves are situated upon the parietal pleura. About 2 cc. of the anesthetic solution is deposited at the points of injection.

Depage recommended a similar incision. Reflecting the skin flap first, the ribs are divided in the course of the incision and the thoracic wall is turned upward in its entire thickness. The ribs are then resected subperiosteally by incisions on the pleural surface as far as desired and the skin flap is replaced.

Comment: The patient should be put in the best possible condition before undergoing this extensive operation. Shock is marked. Prerequisites: Blood transfusion, rapid operating and good hemostasis. In much debilitated patients who cannot be subjected to the formidable procedure outlined, a graded operation may be of value in the form of Sudeck's operation.

Sudeck's Operation

First Stage: Resect the eighth and ninth ribs. Make another incision a hand's breadth above the first, through which resect the sixth and seventh ribs subperiosteally.

Fasten the flap thus obtained into the thoracic cavity. Usually the flap fastens itself to the lower portion of the cavity; the secretions discharge above it. Tampon the entire cavity.

Second Stage: Attack the remaining upper part of the cavity by resecting the upper ribs and the lower half of the scapula. Utilize the scapular muscles and skin for plastic repair.

Robinson's Muscle Implantation Procedure

Robinson adopted Schede's procedure and advises muscle implantation, proceeding as follows:

Step 1. Make a U-shaped incision, beginning at the inferior angle of the scapula and extending downward to about the lower limits of the pleura and coursing upward anteriorly to terminate in the anterior axillary line at about the border of the pectoralis major muscle at the level of the nipple. The incision may be made to vary according to the location of the empyema cavity.

Step 2. Reflect skin and muscles upward. Cut the latissimus dorsi muscle between clamps. Resect the ribs subperiosteally. Ligate the intercostal vessels. Excise the thickened pleura. Dissect the latissimus dorsi muscle and displace it into the cavity. Replace the skin flap. Drain.

Comment: The entire attitude toward treatment of empyema is presently changing. It may be summarized in saying—use all means to prevent chronicity in empyema. Operate early to obviate the establishment of the abscess stage and conserve viability of the mediastinum. If the latter can be maintained with closed drainage, the healthy lung will fill up both thoracic spaces; not through empyematous expansion but through hypertrophy of lung tissue with tolerable displacement of the mediastinum.

Discussing the treatment of acute empyema, Evarts D. Graham recalls that "since the days of Hippocrates, empyema has been correctly regarded as an abscess of the pleural cavity which should be treated by drainage, for the same reason that drainage is employed for abscesses in other parts of the body. Nevertheless, the history of the treatment of this particular abscess is befogged by the advocacy of special methods to be used for the accomplishment of the drainage" and that the principles underlying the treatment of the disease are:

1. Drainage, but with careful avoidance of an open pneumothorax during the period of active pneumonia;
2. Early sterilization and obliteration of the cavity and
3. Maintenance of the nutrition of the patient.

Continuous drainage by a closed method (Fig. 1253) (viz.: one which does not permit the entrance of air into the pleural cavity) is, as Binnie

pointed out, an old method. He says: "In recent years it has been frequently rediscovered and modified in unessential details." One of its first champions was Cresswell Hewett who, in 1876, described his plan of "continuous aspiration."

"Theoretically," Graham argues, "the early establishment of continuous drainage with negative pressure should have the advantages of keeping the pleural cavity relatively free from liquid exudate and organisms, of aiding the expansion of the lungs as well as of avoiding an open pneumothorax with its attendant dangers. Practically, however, it seems doubtful if the results are appreciably better than with the method of repeated aspirations. There is also the risk, slight though it may be, that a delirious and unmanageable patient may, by interference with the apparatus or the drainage tube, allow air to enter his pleural cavity and may suffer from the effects of an open pneumothorax before it can be corrected.



Fig. 1253. So-called "closed drainage" of the pleural cavity through the seventh intercostal space. Patient suffering from empyema following six weeks' duration of pneumonia. (Surgical Service, Cook County Hospital.)

"There is still another danger if too much suction is used, the danger of tearing the lung. Not much suction is required to tear an edematous lung. In many cases this may result only in the creation of a small, temporary bronchial fistula, but in others hemorrhage may be produced. Other objections to most methods of closed drainage exist. One of these is the difficulty of keeping the tube and connections air-tight for more than a few days.

"Müller and others have also had difficulty in keeping it air-tight. As soon as the tube becomes loosened a little, pus begins to collect around it; and if rubber dam or some similar material has been used to seal over the wound, the pus spreads around under it and excoriates the skin. Still another objection is that with most forms of apparatus it is necessary for the patient to remain in bed. This is a distinct disadvantage because it is very desirable for all such patients to be up out of bed as soon as the heart and general conditions will permit. If, however, a valvular tube of some kind is used (with a soft rubber flap on the end, a slit finger of a rubber glove, etc.), or such device as that advocated by von Eberts, or if a Politzer bag is put on the tube as recommended by Bryant, then of course it will be possible for the patient to be out of bed. In spite of these remarks, however, in some cases continuous suction drainage seems to be of advantage. These are cases of empyema due to the rupture of a putrid lung abscess into the pleura, associated with severe intoxication

of the patient in whom, for reasons already stated, it would be dangerous to create an open drainage, and for whom repeated aspirations do not suffice in relieving the intoxication. Moreover, cases of bilateral empyema are sometimes treated advantageously by continuous closed drainage.

"Open Drainage. From what has already been said it has become apparent that open drainage should never be performed during the formative stage of an empyema unless it is known that adhesions already exist. On the other hand, open drainage after the pleural infection has become a true abscess offers the advantage of free and adequate drainage without the necessity of any complicated apparatus. Our own preference in most cases of acute empyema is to carry on repeated aspirations until such time as the exudate has become frank, creamy pus and then to drain openly, usually by the resection of about 2 cm. of one rib. In babies, smaller openings in general are more desirable than in older children or adults."

THE SO-CALLED CLOSED METHOD OF INTERCOSTAL DRAINAGE

This procedure is usually limited to children and to very asthenic and ill adults.

As a preliminary procedure to the operation, take a No. 16 or 18 catheter, a trocar and cannula; the latter should be of a size to permit the snug insertion of the catheter along its lumen. After this is accomplished, cut off the bulb end of the catheter. Make a second eye about one-half inch from the eye on the end of the catheter. Permit one and a quarter inches of the catheter to protrude from the cannula; this segment is to be introduced into the pleura. Mark this point so it will be plainly visible when necessary (Fig. 1254).

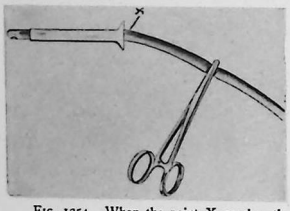


Fig. 1254. When the point X reaches the mouth of the cannula, 1¼ inches of the catheter should project from the distal end of the cannula. A secondary eye has been cut.

Step 1. Anesthetize the proper intercostal space.

Step 2. Make an incision a little longer than the diameter of the cannula and insert the trocar and cannula into the pleura for a short distance. Withdraw the trocar and place a finger over the mouth of the cannula.

Step 3. With a hemostat grasp the catheter and insert it in the cannula after removing the finger. When the marked point has been reached, withdraw the cannula.

Step 4. Place a second hemostat close to the cannula before removing the first one thus precluding the entrance of air into the pus-filled pleura.

Step 5. McEachern's method of closing the incision is the application of several layers of absorbent cotton which has been brushed with collodion until a collar one-half inch thick and five inches in diameter is built around the tube. The parts to which the dressing is applied are rendered clean

and dry by the use of ether. To drain the abscess cavity, the pleural tube is passed through the cork into a bottle containing some antiseptic solution. McEachern's method of irrigation with Dakin's solution is considered a superior method.

Block Pleurisy (Pleurisy Blocqué)

Occasionally, while the physical signs and symptoms point to fluid in the chest, the aspirating needle fails to find it. The explanation for this was offered by Dufour in 1905. He called attention to this behavior in recent acute pleurisies. The reason for the fluid's failure to issue is that in a cavity composed of rigid walls the tension of the fluid about equals that of the atmosphere. If the tension of the fluid is less than that of the atmosphere no fluid will escape. To overcome this pass a second hollow needle along the trocar; atmospheric air will be admitted into the cavity and satisfactory aspiration will result.

Operative Treatment of Suppuration of the Mediastinum

In a recent communication[1] Lilienthal says: "In reality the danger of the draining of the mediastinal spaces is not more than in drainage of the pleura. The operation is more complicated and more difficult, but this is no reason for delay.

"The anterior part of the mediastinum can be reached in three ways:

1. Through the suprasternal notch (superior mediastinum).
2. Through the sternum itself.
3. Parasternally according to the location of the infection.

"In acute suppuration of the superior space the spread is apt to be rapid and the safest thing is to make drainage through the suprasternal region. This is done through a median incision with or without the addition of a cross cut at its lower limit. The mediastinum should be entered by slow, careful dissection in order that neither great vessels nor pleurae be injured. Having entered the mediastinum it will be noted that with each strain or cough the pleural membranes will approximate and the fluid between them will be forced out. A multifenestrated soft tube should be inserted as far as required and permanent suction instituted.

"It may be necessary to split a greater part of the manubrium and gladiolus longitudinally with or without resection in order to gain perfect drainage (Milton's operation). One must be certain that the posterior periosteum has been divided. In any acute case the sudden audible snapping together of the pleurae when the patient strains or coughs is most striking as observed through the wound. As the wound granulates, the movements decrease and finally disappear.

"It sometimes happens that the main part of the anterior mediastinal abscess lies in such a location that it can be reached parasternally. A parasternal sagittal incision should be made (beware of mammary artery), costal cartilages removed and then careful blunt dissection performed into the infected part, always remembering that there is no certain way of telling whether the right

[1] New York State Jour. of Medicine, 1934.

anterior pleura may extend over to the left or the left anterior fold over to the right.

"Posterior mediastinitis may be drained by a major operation, although with less danger than that of draining the anterior space. The procedure is to incise just beyond the long spinal muscles, to divide the rhomboids if the upper part of the space must be reached and to continue downward as far as seems necessary, resecting enough ribs to afford wide access. Wounds of this kind may have to be revised, because there is a strong tendency for the ends of the resected ribs to approach each other. This can be avoided by cauterizing the ends with bi- or trichloracetic acid. In making a lower posterior mediastinotomy on the left side the right pleura which normally extends across the median line in this region is in danger unless great care is exercised. If this accident has occurred it will always announce itself by a characteristic sucking sound. Dissection must be careful and digital exploration to find the aorta must be made. It lies toward the left of the vertebral bodies. In right lower posterior mediastinotomy the pleura is always in the way and must be guarded. Having reached pus, the limits of the cavity should be explored if possible, and packed with gauze.

"It should be repeated here that the timidity already referred to in operating for the relief of infection of the mediastinum is entirely unwarranted. To wait for a sure diagnosis may mean the loss of the patient's life. At the same time it should be emphasized that one to whom these operations are a novelty would do well to avail himself of the assistance of a trained thoracic surgeon."

SURGICAL TREATMENT OF PULMONARY TUBERCULOSIS

Historical Notes. Early attempts to treat pulmonary tuberculosis by surgical measures failed. In the eighteenth century, E. Barry, Boerhaave, David, Poutau, Sharp and others tried to evacuate tuberculous cavities as they would other abscesses. Von Mosler, in the first half of the nineteenth century, tried to inject potassium permanganate, carbolic acid or tincture of iodine into tuberculous cavities. Later, Block, Doyen, Macewen and others tried extensive pulmonary resections. These procedures had to be abandoned because of the very high mortality. Freund proposed chondrotomy of the first rib without satisfactory results.

The keynote to success in the surgical treatment of pulmonary tuberculosis is collapse and immobilization of the affected lung to insure functional rest. This objective is reached by the following procedures:

1. Artificial pneumothorax (the introduction of a gas between the two layers of the pleura) (Figs. 1255-1256-1257-1258-1259-1260).
2. Pneumolysis—(1) external pneumolysis where the intervention is directed between the inner surface of the thoracic cage and the outer layer of the pleura and rarely (2) internal pneumolysis between the two layers of the pleura.
3. Extrapleural thoracoplasty—removal of part of the wall of the chest.
4. Operations on the phrenic nerve (crushing, division, resection, avulsion) to effect immobilization of the diaphragm, in an ascended position, compressing the lung.

Each of these methods has its special indications. Some may be combined.

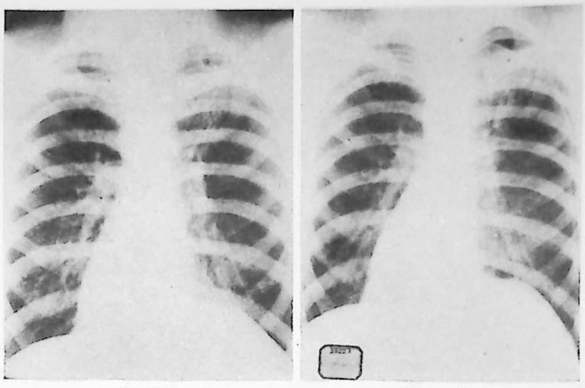


FIG. 1255 FIG. 1256

FIG. 1255. F. N. 8-20-31. Left apex cavity before pneumothorax.
FIG. 1256. Same as preceding after pneumothorax treatment. (Municipal Tuberculosis Sanitarium, Chicago.)

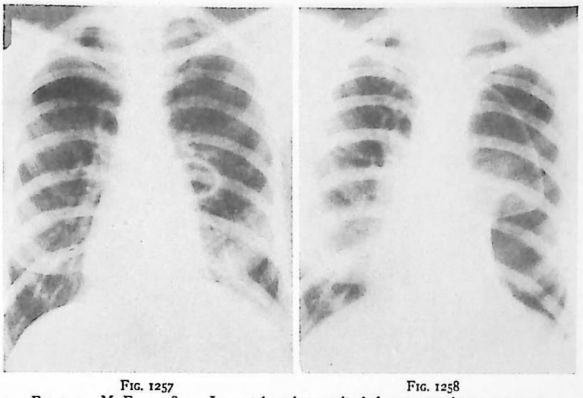


FIG. 1257 FIG. 1258

FIG. 1257. M. F. 10-28-32. Large tuberculous cavity before pneumothorax treatment.
FIG. 1258. M. F. 4-20-34. Same as preceding. Complete closure of cavity following pneumothorax treatment. (Municipal Tuberculosis Sanitarium, Chicago.)

All are to be resorted to in conjunction with recognized hygienic measures. Fit the methods to the patient and not the patient to a pet method.

Historical Notes. The first pneumothorax by incision (open), was induced by Carson in 1882, and the first closed one (by puncture) by Caley, in 1885. Forlanini suggested the method three years before. It was later championed in America by Murphy, Schell, Lemke and Kelly, in Denmark by Saugmann, and in Germany by Brauer. Küttner, Spengler, von Muralt, A. Schmidt, Ranke and Deneke elaborated and popularized the method.

Extrapleural thoracoplasty was conceived, independently of each other, by Quincke in 1881 and C. Spengler in 1890. It was sponsored in Germany especially by Brauer, who recognized that a pneumothorax is unfeasible in cases with extensive

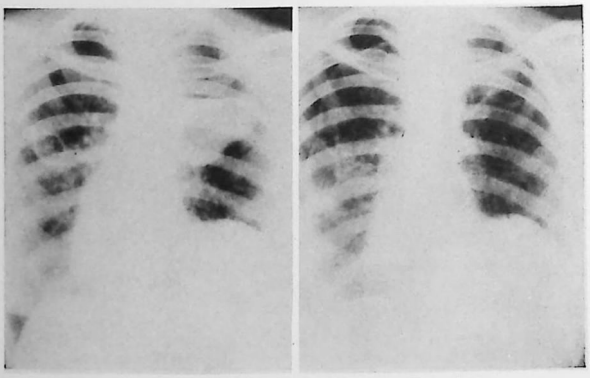


FIG. 1259 FIG. 1260

FIG. 1259. E. L. 7-25-33. Cavity in right middle lobe before pneumothorax.
FIG. 1260. Same as preceding, after pneumothorax treatment. (Municipal Tuberculosis Sanitarium, Chicago.)

pleural adhesions. In collaboration with Friedrich, he devised an operation in which the ribs, from the second to the tenth, are completely removed on one side, each one from the spinal column to the osteocartilaginous junction. To offset its danger Wilms proposed his columnar resection, by which only 3 to 4 cm. of the ribs were removed posteriorly and, if necessary, a similar small portion from the costal cartilages in front. To Sauerbruch belongs the credit for establishing the method on a comparatively safe basis. His method of paravertebral extrapleural thoracoplasty stands at a midpoint between the Brauer-Friedrich and Wilms procedure.

Extrapleural pneumolysis was first recommended by Tuffier, following a report by Schlange of a complete success of tamponade in a severe cavernous hemorrhage. Tuffier removed the calloused pleura from the internal surface of the thorax and tamponed the resulting wound cavity first temporarily, then permanently, with autoplastic fat and later, successively, with bismuth paste or paraffin. Paraffin plombage was devised by G. Baer.

Stuertz, in 1911, proposed and performed phrenicectomy or phrenicotomy; Oehlecker almost immediately followed suit. In 1913, Sauerbruch reported his first results in five cases. Goetze, in 1920 proposed phreniclasis, or crushing of the nerve.

Phrenicoexeresis, or avulsion of the phrenic nerve, was advised by Willy Felix who realized that none of the operations on the phrenic nerve take into consideration its anatomy especially the existence of the accessory phrenic nerves in 25 to 30 per cent of the cases. He suggests drawing out of at least 12 cm. of the nerve thus breaking all connections with the possibly present accessory phrenic nerve.

INDICATIONS FOR VARIOUS OPERATIVE PROCEDURES IN THE TREATMENT OF PULMONARY TUBERCULOSIS

Thoracoplasty

This is indicated in cases of:

(a) Chronic unilateral fibrosing tuberculosis with rigid mediastinum, good heart, good resistance and, preferably, in a patient running an afebrile course.

(b) Pyopneumothorax which has not responded to other treatment.

(c) Cavities which failed to close under pneumothorax or phrenicoexeresis or where these procedures were contraindicated on account of the danger of perforation.

(d) Severe recurrent hemorrhage where other treatment has failed.

(e) The positive sputum case which persists in spite of other compression measures.

(f) Bronchiectases where phrenicectomy has been of no value.

(g) In bilateral cases where there is evidence of regressive change in the healthier lung. If there is sufficient normal lung tissue in the lower lobes to maintain respiration, it is recommended by some to use partial upper thoracoplasty.

(h) It has been successfully used to prevent re-expansion after a prolonged pneumothorax.

(i) Pulmonary sclerosis with mechanical heart difficulties.

(j) Acute, rapidly progressing unilateral disease may be aided after all other forms of treatment have failed.

Thoracoscopy and Cauterization of Adhesions

Many authors maintain that thoracoscopy is not employed often enough as a means of diagnosis to indicate the pathologic changes present in the pleural cavity or to ascertain the cause and extent of adhesions which might interfere with pneumothorax treatment.

If pleural adhesions are suspected much time may be conserved by examining the surfaces of the pleura instead of instigating a long therapeutic test. It is essential that the surgeon be in possession of many facts concerning adhesions so that he will be in a position to judge whether or not pneumothorax will be beneficial.

Thoracoscopy may be useful in ascertaining the nearness of pleural symphysis in effusions which may occur during pneumothorax treatment. It is useful also in the diagnosis of nontuberculous pulmonary or pleural pathology.

Where adhesions interfere with the course of pneumothorax or oleothorax, cauterization or section is indicated. As a rule, cordlike adhesions are easily divided. Flat extensive adhesions involving a great deal of pleural membrane and whose appearance suggests their likelihood of containing extensions into the

parenchyma of the lung tissue or cavity should be divided very cautiously, if at all.

Multiple Intercostal Neurectomy

This procedure has the advantage of being comparatively free from operative dangers and is not followed by disfigurement. By injecting alcohol instead of cutting the nerve it may be made temporary. The chief objection to it lies in the fact that it immobilizes the ribs only and that it does not reduce appreciably intrapleural pressure or lead to collapse of the lung. The operation is indicated in a few rare cases where the lesion does not justify a thoracoplasty or when the patient's condition is too weak for it.

Apicolysis

This operation is indicated in the presence of large apical cavities which failed to close following other treatment, and where thoracoplasty is contraindicated. Bilateral apical cavitation where the lower part of the lungs is normal is a good example. The operation was originated by Schlange in 1907 and consists of extrapleural pressure applied directly over the cavity. The upper lobe is usually the operative site; approach is made through the anterior chest wall, through the third interspace. Some surgeons remove parts of the second and third ribs; others merely separate the ribs to gain access. This part of the lung is kept collapsed by stripping the pleura from the ribs and introducing packing between the ribs and pleura. The packing may consist of paraffin, gauze, fat muscle or rubber dam. The operation is more popular on the European continent than in this country. It has been successfully used as an adjunct to thoracoplasty with good success in closing cavities.

Anterolateral Costectomy

If cavities still persist after thoracoplasty has been employed, further sectioning of ribs will often result in additional reduction in the size of the hemithorax to accomplish the collapse.

Pneumothorax

The indications for pneumothorax in tuberculosis are taken up in detail under that section.

DIRECT DRAINAGE

The cavity to be drained is treated in the same manner as a nontuberculous lung abscess (p. 1083). Drainage is accomplished with more facility and safety when the cavity is close to the periphery of the lung with definite overlying adhesions to the wall of the thorax so that these adhesions cannot be divided (thus preventing an effective pneumothorax).

Cavities which are large and thin-walled respond satisfactorily to this type of treatment; in these cases a certain amount of collapse follows drainage which results in healing by granulation. Beneficial results follow drainage in cases which are characterized by large bilateral cavities which are too involved to allow any extensive collapse measures.

Thoracotomy (p. 1071) may be performed through an interspace or a small part of the rib may be removed. To prevent the escape of pus into the general pleural cavity, the parietal pleura should be sutured to the visceral pleura if they are not already adherent. A rubber or some other drain is inserted directly into the cavity.

THORACOSCOPY AND INTRAPLEURAL PNEUMOLYSIS

Thoracoscopy is a diagnostic procedure which was developed in connection with intrapleural pneumolysis or division of adhesions.

In 1913, Jacobaeus reported several cases where he had successfully changed an ineffective pneumothorax by the intrapleural division of the adhesions. Since then, the procedure has been used by a number of surgeons with modifications of apparatus and technic. At first it was used only in the Scandinavian countries; a little later Unverricht in Germany used it extensively and improved the apparatus; it is comparatively new in France. Exploration was accomplished using an endoscope by Jacobaeus. Following this, a cannula was introduced close to the adhesion through which access was obtained for the cautery.

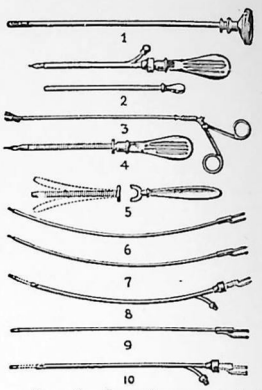


FIG. 1261. Laparothoracoscope after Jacobaeus-Unverricht for endoscopic exploration of the thoracic cavity and for severing, under guidance of the endoscope, pleural strand adhesions by means of cautery electrodes. The set of instruments consists of: 1. telescope, 2. trocar with cannula for introducing optical system and inflation tube, 3. forceps for excising specimen, 4. trocar with spiral flexible cannula for introducing curved cautery electrodes, 5. handle for attaching to flexible cannula, 6. cautery electrode with vertical curved blade, 7. cautery electrode with horizontal curved blade, 9. straight cautery electrode, 8. and 10. air escape tubes for cautery electrodes.

Indirect, right-angle vision is provided by a lens and mirror on Jacobaeus' thoracoscope (Figs. 1261-1262). The method had many objectionable characteristics; the right-angle vision is much less distinct than direct vision; the light on the thoracoscope is rather distant from the operative field resulting in the blurring of the lenses by blood and vapor; two instruments are rather hard to control. There have been many attempts to devise direct vision instruments through which cautery may be done.

In the direct vision thoracoscope, fumes, the result of cauterization, pass out immediately; the surgeon's coordination is better, resulting in section being efficiently done at any time. The movable light is an advantage.

The **number, type and location of the adhesions** are determined by the use of the fluoroscope and x-ray. The patient is prepared as for a minor surgical procedure. The thoracoscope should be introduced to one side of the adhesion to be divided so that the cautery may be brought into position at right angles to the adhesion; it may be inserted through a small incision or puncture between two ribs.

Diagnostic thoracoscopy is a simple procedure and practically free from danger. It is being used more and more. It is a valuable means of ascertaining whether or not pleural symphysis is taking place in a given case of pleurisy which is recovering. The presence of fine filaments in the fluid from visceral to parietal pleura calls for immediate pneumothorax or oleothorax. The sectioning of adhesions entails more technical considerations.

It is important for the surgeon to have a thorough knowledge of the anatomy and position of the adhesions. In 1930, Maurer classified adhesions into several main groups. Recently formed adhesions present no enlargement of either the thoracic or pulmonary insertion. Section is safe and easy, but on account of their tendency to stretch, the procedure is deceiving. Adhesions with enlarged thoracic insertions are rare. Adhesions with enlargement of the pulmonary insertion occur more frequently. Both varieties are indicative of old and tough-

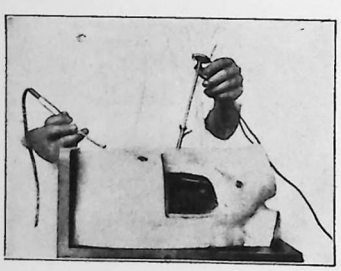


FIG. 1262. Phantom for practicing thoracocauterization, Kremer's. This is made of a plaster mixture and is so arranged that it shows a pneumothorax with adhesive strands. In places where trocars are generally inserted, perforated rubber pieces are incorporated, which permit of easy introduction and manipulation of operating instruments which may be observed through a window in the phantom.

ened adhesions. Great care must be exercised where the adhesions have the pulmonary insertion, as parts of the lung tissue are likely to be engulfed in the enlargement rendering them liable to injury. In some instances, lung tissue or a cavity extends into such an adhesion practically to the parietal pleura. This variety of adhesion is most common; empyema or hemorrhage following this operation is due to incising the adhesion too far from the wall of the thorax. In cordlike adhesions which are more than one-half centimeter in diameter care must be exercised as a large blood vessel may be coursing in it.

The broad membranous band type of adhesion presents the most difficulty to section. Their exact width and the structures contained are difficult to determine. A sound is used by some surgeons to ascertain the width; other surgeons do the sectioning in multiple stages.

A galvanocautery was used by Jacobaeus and others for dividing adhesions until recently. Many have since substituted the diatherm knife. Surgical cutting by means of the high frequency electrode was used very successfully by Maurer in France and Matson in America.

The high frequency cutting knife produces little coagulation necrosis, fumes or smoke. It penetrates the cellular structures so that spontaneous separation takes place. It should be done slowly and carefully; large blood vessels should be electrocoagulated. One should be thoroughly conversant with the action of the different kinds of coagulation and cutting currents.

Adhesions should be sectioned close to the wall of the thorax.

Maurer recommends dissecting the adhesions from the parietal pleura. His procedure necessitates the anesthetizing of the attachment of the adhesions on account of the sensitivity of the parietal pleura which is directly incised. A needle 25 cm. long together with a specially designed syringe is used for this purpose by Maurer. Care is exercised to avoid injury to an intercostal vessel.

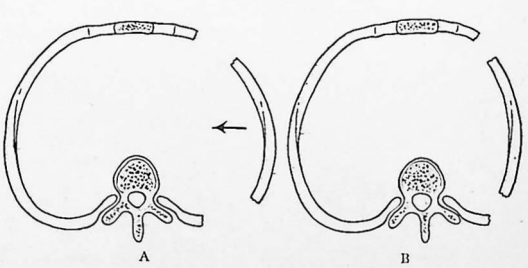


FIG. 1263. A, anterior and posterior rib resection. B, the capacity of the thorax is diminished by pushing the remaining sections of the resected ribs through the median line (Wilms). (Courtesy of Dr. Howard Lilienthal.)

Any number of adhesions may be sectioned in one sitting if the condition of the patient is good. When through, remove the thoracoscope; close the incision by sutures. Apply a tight dressing to prevent surgical emphysema. A day or so later a pneumothorax refill is given to prevent new adhesion formation.

EXTRAPLEURAL THORACOPLASTY

A number of operative procedures have been devised for the purpose of collapsing the lung. Wilms removed portions of many ribs posteriorly and anteriorly for the purpose of reducing the capacity of the thoracic cavity (Fig. 1263). A number of other methods have been employed to accomplish the same result. Sauerbruch's procedure in which many ribs, including the first, are shortened by paravertebral resection, is the most satisfactory. More important than the collapse is the immobilization which follows this procedure and which is aided by a bridge of bone which forms between the divided ribs uniting them into one rigid whole. If one adds to this the paralysis of the diaphragm by phrenic nerve resection or avulsion, the thorax is effectively placed at rest, a condition essential in the healing of tuberculosis. The operation is not a very difficult one and may be done by one not equipped with special knowledge of and experience in thoracic surgery.

The results of thoracoplasty, properly performed in selected cases, are ex-

cellent. The best age to perform total thoracoplasty is between 15 and 45 years (Nissen).

Phrenicotomy precedes the operation (about 2 months prior). The cavities are emptied by postural treatment. It is assumed that the patient is placed in an optimum condition to undergo the ordeal. Give morphine an hour before the operation.

Anesthesia. Local and regional nerve block (novocaine one-half per cent). This may be supplemented by ethylene-oxygen or cyclopropane. A competent

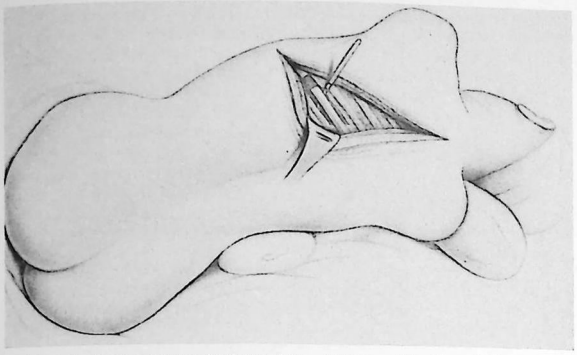


Fig. 1264. Position of patient for thoracoplasty. (Courtesy of Dr. Howard Lilienthal.)

anesthetist is a sine qua non in this form of surgery. Lilienthal does not consider that ether properly administered acts as a dangerous irritant in tuberculosis of the lung. Matson lauds sodium amytal preliminary to general anesthesia.

Step 1. Position on the Table. The patient is placed on the sound side. The operative area is drawn forward. The operation may be performed in a number of stages depending upon the exigencies of the case (Fig. 1264).

Incision. This is a paravertebral division of the tissues (Fig. 1265). The incision passes parallel downward as shown in the illustration; it is then deepened. The muscles are rapidly dissected from the thoracic wall with a sharp scalpel and displaced by means of retractors.

Step 2. The most prominent rib in the wound is selected for the first resection An incision with a scalpel or with a sharp periosteotome is made along the surface parallel with the line of the rib and by wiping strongly with gauze this part of the bone is cleared. Ten to 15 cm. segments of the lower ribs are resected, the resection being flush with the transverse process. The late Dr. Carl A. Hedblom advised this posterior resection in three stages—at intervals of seven to ten days.

Step 3. The nerves are identified and injected with a few drops of novocaine and then crushed. This eliminates postoperative pain.

Step 4. The remaining anterolateral segments are removed through a mid-axillary incision, in two stages. (Fig. 1266.) Separate the periosteum from

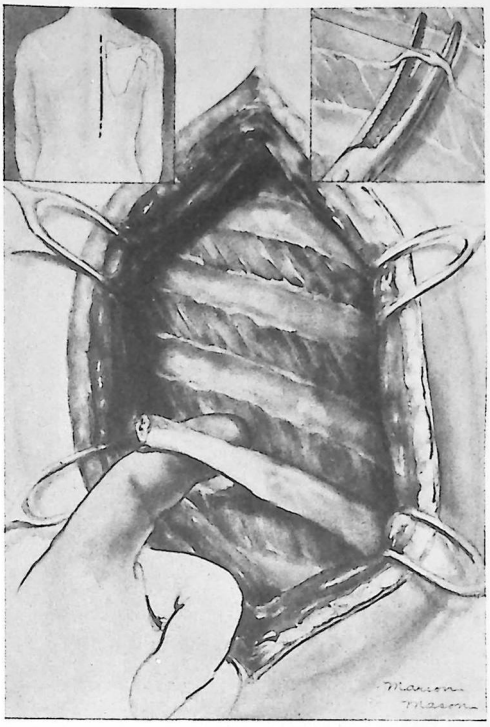


Fig. 1265. Posterior extrapleural thoracoplasty in three stages resecting posterior segments of the ribs. The erector spinae muscles are retracted. The scapula is lifted with the lateral wound edge for exposure of the portions of the ribs lying anterior to it. Note injection of isolated intercostal nerve near the spine. It is first injected with novocaine then crushed with a hemostatic forceps. (Hedblom in Lewis' Practice of Surgery.)

the anterior ends of the ribs. Section the ribs at the costochondral junctions. The mobilized anterior end of the rib is used as a lever (Fig. 1267); the

periosteum is separated from the rib in the portion lying underneath the posterior edge of the wound. For the removal of ribs Shoemaker's rib shears are excellent. Little difficulty is encountered in resecting the ribs until the second and first are reached. Even the second presents no particular obstacle.

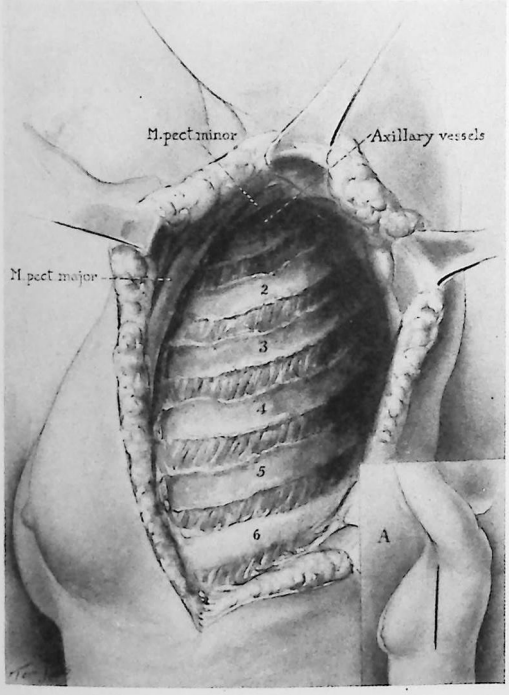


Fig. 1266. Extrapleural thoracoplasty. Anterolateral costotomy. Midaxillary line incision extending well up into axilla. Retraction of anterior and posterior axillary folds. Note good exposure to first rib. (Hedblom in Lewis' Practice of Surgery, W. F. Prior Co.)

The first rib is situated very deeply and far forward and the subclavian vessels are in close relation to it. The brachial plexus also is in close proximity.

Since the first rib is so deeply placed and difficult to approach from

behind, and believing that the screw guillotine principle will exhibit the greatest power in the steadiest manner, Lilienthal and Tiemann constructed an instrument after Lilienthal's drawings which proved of much value (Fig. 1268). The guillotine consists of a shaft with a right-angled bend at the ex-

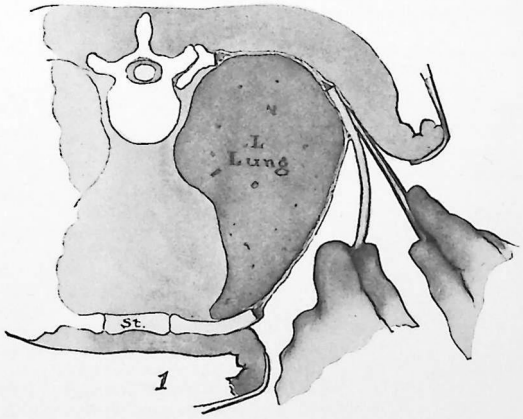


Fig. 1267. Extrapleural thoracoplasty. Showing technic of liberating the portions of the ribs lying under the soft tissue flap. When the periosteum has been separated the rib already resected posteriorly is easily removed by gentle traction. (Hedblom in Lewis' Practice of Surgery, W. F. Prior Co.)

tremity, to be passed behind the bared rib as a guard against injuring contiguous vessels and nerves. Toward this guard a powerful screw forces a long-beveled osteotome which is checked by a metal stop just before it reaches the guard and after it has passed through the rib. The slow and

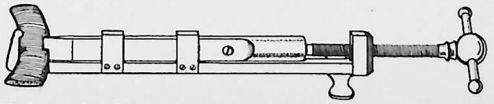


Fig. 1268. Lilienthal's guillotine for cutting the first rib. (Courtesy of Dr. Howard Lilienthal.)

steady screw action of the guillotine is much less disturbing to a patient being operated upon under local anesthesia than the application of forceps or shears worked by handles which of necessity must cause a jarring or other forced motion of the patient's bony frame.

Step 5. Having completed the multiple resections, introduce a drainage tube

with many fenestrae in the depths of the wound at about the level of the third rib, its lower extremity projecting from the inferior angle. Suture the muscles over the tube with chromicized catgut (interrupted). Approximate the fascia. A narrow packing of gauze is placed in the upper extremity of the wound down to the resected first rib, the end of the packing protruding from the upper wound angle. This gauze is put in as a safeguard in case of even the slightest infection.

Step 6. Approximate the skin edges with interrupted sutures or with metal clips and hold the dressings firmly in place with broad adhesive strips.

Sauerbruch's Paravertebral Extrapleural Thoracoplasty

Resection must comprise 10 to 11 ribs, including the first rib. The paravertebral stumps must be very short, not longer than the transverse processes of the

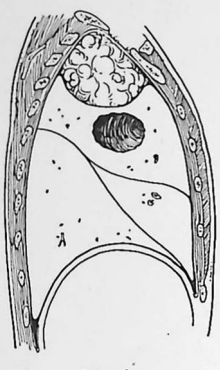


FIG. 1269

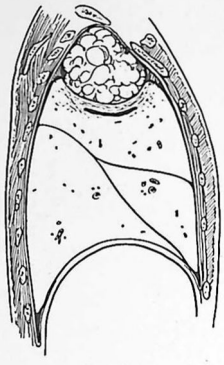


FIG. 1270

FIG. 1269. Apicolysis without adhesions of lung to chest wall. The cavity is but slightly collapsed and is pushed downward by the implant. It will collapse gradually by the elastic compression of the adjacent lung. (Note that the cavity was originally in the apex.)

FIG. 1270. Apicolysis. There are adhesions of upper lobe to chest wall, holding it in place, so that the implant makes good compression of the cavity. (Courtesy of Dr. Lilienthal, Thoracic Surgery, W. B. Saunders.)

vertebrae. The diameter of the thorax is not reduced, unless the operation begins in the middle of the axillary line, and it is materially reduced, when the posterior axillary line is reached. It should be performed in two steps, beginning with the eleventh or tenth rib to the sixth and continuing, about three weeks later, with the fifth to first rib.

Partial thoracoplasties may be used in conjunction with artificial pneumothorax, also partial.

According to W. Neumann, thoracoplasty should not be considered if the tuberculosis has lasted for more than two to four years. According to Sauer-

bruch, conservative treatment is given a fair chance if it is continued for one to two years. The preferred ages for operation are between 20 and 35 years; after the age of 50, a thoracoplasty should be considered only exceptionally.

EXTRAPLEURAL PNEUMOLYSIS

Lilienthal was first to point out the importance of saving healthy lung tissue in operations for tuberculosis. To afford a certain degree of pulmonary collapse, an attempt is made to free the normal connections between the parietal pleura and the rigid chest wall, with or without the endothoracic fascia. Lilienthal questions its usefulness in disease of the lower thorax. At the apex, the operation can be done with comparative facility and the superior portion of the upper lobe can be depressed extrapleurally, leaving a large space to be filled with some substance to prevent re-expansion.

Apicolysis is the term used to designate this form of pneumolysis; the lung is pressed downward and if there are no adhesions the infiltrated or cavitated apex may be, as it were, transported as a whole upon healthy lung, the latter being compressed far more than the diseased part. (Figs. 1269-1270). Subsequently, the compression of the apex increases because of the gradual elastic pressure of the healthy lung below. The full benefit of the apicolysis may not at once appear. When adhesions are present binding the lung below to the chest wall apicolysis will secure a much more thorough compression with good immediate obliteration of the apical cavities.

In a personal communication Dr. Howard Lilienthal writes: "My method of upper thoracoplasty combined with apicolysis is ordinarily preferred to the apicolysis which you have," referring to the procedure presently described.

Caforio's Modification of Proust, Maurer and Rolland's Apicolytic Thoracoplasty

In 1891 Tuffier used pleuro-parietal detachment in the treatment of tuberculosis of the lung; twenty years later, the same author performed compression of the apical cavities with transplantation of fat after first resorting to pleuro-parietal detachments. This opened a wide avenue for the progress of surgery of the tuberculous lung and formed the basis for what was later termed apicolysis. Normally, the respiratory mechanism represents a sort of functional antithesis—one side of the lung being permanently distended by negative intrapleural pressure and on the other side a motor apparatus represented by the thoracic cage and diaphragm engaged in alternating movements which act as a dynamic antagonism to the retractile tendencies of the lung. If the pulmonary tissue is affected by a tuberculous process this organic functional antithesis becomes a paradox because of the rest needed by the lung for recovery and thus the function of the thoraco-diaphragmatic motor system creates here a condition of real trauma with its maximum intensity at the inspiratory phase. The mechanical aids used in curing tuberculosis of the lung are in a general way directed to put an end to this organic functional antithesis and an endeavor is made to transform the pleural cavity into a sort of gas containing distensible and elastic cushion checking the functions of the thoraco-diaphragmatic motor system. To accomplish these results there are many avenues at our disposal, viz.: interruption of the motor innervation by phrenic exeresis, alcoholization or section of the

intercostal nerves (Leotta, Rindone); scalenotomy (Gregoire, Bile) or wide resection of the ribs (thoracoplasty). A pulmonary collapse thus results blocking the excursions of the thoracic wall; or, partial resection of the costal arches overlying the focus of infiltration in the lung may be resorted to causing local pulmonary detention (Proust, Maurer, Muralt). Two or more of the above methods may be combined. It must be remembered, however, that scar tissue formation in the lungs is dependent more often on the spontaneous retractility of the unaffected lung than upon the sole element of passive compression (Redaelli). Thus surgical intervention is indicated in cases where the pulmonary parenchyma shows particularly good retractile capacity. The crux of the situation is to obtain good immobilization of the affected lung by a thorough liberation of every factor that binds it in an abnormal position.

Step 1. Place the patient in ventral position with the head extending over the operating table and resting on a frontal support; this is preceded by local anesthesia of the skin and muscles with novocaine 1:200.

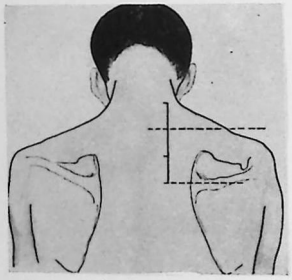


FIG. 1271. Line of incision (after Caforio).

Step 2. Make a longitudinal incision along the external margin of the long muscles of the spine. This incision must be made in such way that one-third of it is above and two-thirds below a horizontal line passing through the spinous process of the vertebra prominens. The lower end of the incision ends in an imaginary, horizontal line crossing the spine of the scapula (Fig. 1271). The skin, subcutaneous connective tissues and muscles are divided. The transverse processes of the vertebrae, the ribs and their intercostal muscles are well exposed.

Step 3. Regional infiltration anesthesia (novocaine) is now used around the posterior aspect of the transverse processes to be divided as well as in the immediate vicinity of the anterior and superior borders. On the anterior border of the 2nd, 3rd and 4th transverse processes we find a corresponding intercostal nerve. A good deal of attention should be paid in anesthetizing the first intercostal nerve running below the neck of the first rib as well as the intercostal spaces, particularly about the inferior margin of each rib.

Step 4. The injections here (intercostal spaces) should be thorough. When this procedure is completed, the periosteum of the posterior surfaces, borders and the anterior surfaces of the transverse processes is removed by means of a strong resection knife. By the aid of a chisel, the costotransverse process articulations at the posterior costal angle as well as the apophysis of the ribs are divided for a distance shown in the illustration. The neck of the respective rib is thus exposed. The subperiosteal removal of the rib is next completed. Costal resections must begin from below upward, from the fourth rib

upward to the first rib inclusive. The rib is disarticulated from its attachment to the vertebra or, if preferred, divided near the articulation. About 8 to 10 cm. of rib is removed (Fig. 1272). The resection of the first rib must re-

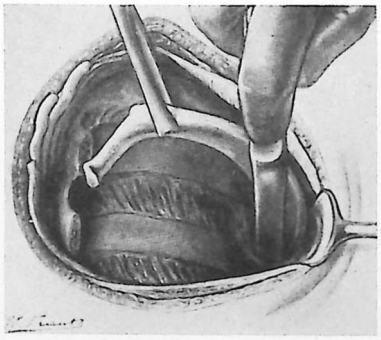


FIG. 1272. The rib disarticulated mesially. Its lateral detachment is shown. (Courtesy of Prof. Caforio, Naples.)

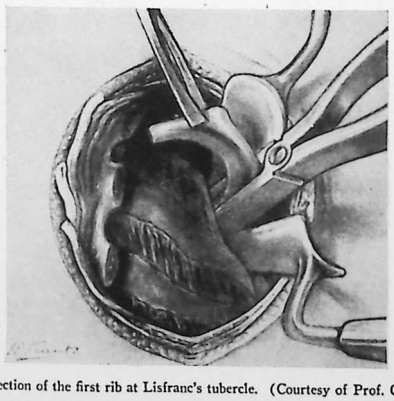


FIG. 1273. Resection of the first rib at Lisfranc's tubercle. (Courtesy of Prof. Caforio, Naples.)

ceive special attention. After having removed the lower ribs, the first rib presents and with its posterior border and its inferior surface seemingly forming a roof over the field of operation. Subperiosteal resection must be performed with great care. The arterio-cervico-intercostal trunk that crosses

the neck of the rib must be guarded as well as the dome of the pleura. Externally, we have the posterior scapular artery and still more externally and below, the cords of the brachial plexus and the subclavian artery and vein; these should be protected.

By displacing externally the field of operation and pushing the scapula laterally and forward we succeed in exposing the tubercle of Lisfranc. Resect about 12 cm. of the rib (Fig. 1273). The apex of the lung is now seen collapsed.

Step 5. The muscles and skin are now reunited leaving a drainage tube emerging at the inferior angle of the incision. The patient is returned to bed and placed in a reclining position and given 3 or 4 injections of camphor in oil daily and one injection of pantopon at night. The drainage tube is removed on the third day. Thus far the original operation of Proust, Maurer and Rolland has been described. This is rendered simpler by Caforio's modification[1] a description of which follows.

CAFORIO'S MODIFICATION A

Caforio has the patient sitting up in a high-back chair turned around so that his arms and head may rest on the back of the chair. The advantage of this position is that the patient does not get too tired, respiratory embarrassment due to thoracic compression does not supervene and the operative procedure is facilitated.

CAFORIO'S MODIFICATION B

This refers to the resection of the costal arches. Instead of disarticulating the rib from its attachment to the spine and resecting the rib laterally, Caforio prefers to excise the rib by dividing it into two segments—one short internal (vertebral) and one long external (scapular). The external fragment is resected first. This is grasped with a bone forceps and gradually retracted back laterally; while subperiosteal resection proceeds, an assistant retracts the lateral margin of the scapula externally. It is thus possible to proceed more laterally and to resect a total segment of the rib more than 12 cm. long; the short vertebral segment is taken care of later. Its removal is much easier because of the additional space now available and because the shortness of the segment allows greater ease of operative manipulation.

ARTIFICIAL PNEUMOTHORAX

The Concept of Selective Pneumothorax

Selective pneumothorax, according to the Italian school, was developed by Ascoli, in 1912; it was Parry Morgan, according to the English and American schools, who in 1913 first proved that in cases of incomplete collapse, the air tended to localize over and further collapse the diseased part of the lung.

The whole field of pneumothorax procedure was revolutionized by the proper concept of selective pneumothorax. Pneumothorax therapy was considered a specific measure, treatment capable of local application from which complete or nearly complete functional recovery might be anticipated. Mechanically, the old type of compressive pneumothorax was like thoracoplasty.

Limitations of Selective Collapse. This treatment, according to theory,

[1] Rivista di Chirurgia, No. 7, 1935.

should be ideal. However, in practice its success is rather limited, due to the presence of adhesions, lesions, fibrosis around cavities keeping them open, etc. Selective collapse should, therefore, be instituted early or not at all. It is indicated in localized lesions which do not reach the surface of the lung. In these cases the lesion is reduced to a small scar; hypertrophy and emphysema take care of any defects in the remaining lung tissue. Many early lesions treated in this manner are so completely cured that physical examination years later, as well as x-ray, reveals no scar or other evidence of pulmonary damage. On this basis pneumothorax is advocated early.

COMPRESSIVE PNEUMOTHORAX

Compressive pneumothorax consists in raising the intrapleural pressure above the zero level in the manometer, that is, above the atmospheric pressure. At the present time it is not applied to the entire lung. If it is definitely indicated, collapse should be brought about very gradually. The patient should be watched closely for any unfavorable symptoms. It may be necessary to add gomenol to oil, using it to induce mediastinal fixation during the course of this treatment.

BILATERAL PNEUMOTHORAX

There are two methods for applying bilateral pneumothorax. The method most commonly used is really an alternating pneumothorax and not really a bilateral pneumothorax. The lung most affected is treated first; when sufficient improvement is manifest, collapse may be reduced or withdrawn entirely and the other lung treated. If alternating collapse is resorted to, its type may be compressive, partial, selective, etc.

Initial collapse is never resorted to on both sides at once, but at different times, allowing a fairly long period between the treatment of one side and that of the other. Refills are also done at different times.

Contralateral collapse is never resorted to while there is complete collapse on one side except in extreme emergency, as a pleuro-pulmonary perforation is likely to result on the other side.

CONTRALATERAL PNEUMOTHORAX

Contralateral pneumothorax is used on rare occasions; it consists of inducing pneumothorax on the healthy side to cure a lesion on the opposite side. A flexible mediastinum is essential for its effectiveness; thus if there is a change in pressure in one pleural cavity, there will also ensue changed pressure conditions in the other. A partial mediastinal displacement causing a reduction in the negative pressure on the better side, results in a corresponding reduction in pressure on the affected side. In this way, it is possible to accomplish a partial collapse in the affected lung which may aid tissue repair.

Duration of Treatment. The duration of the treatment depends upon the extension of the lesion, the recession in activity, the social condition of the patient, the occupation, the availability of refill facilities, etc. If the case has not progressed too far a collapse of from 6 to 7 months to a year may be sufficient. If the case is well advanced, it should be maintained much longer. Dr. Frederick Tice believes that the early case with slight activity may be allowed to re-expand under given circumstances, in a period of six or seven months to a year, with good prospect of healing and even complete return to normal. This is particularly true

of the patient in good social circumstances, who can afford to lead a measured and careful existence. Usually, a collapse period of from two to five years is advocated. There are some cases in which pneumothorax has been maintained for a period of ten to fifteen years. This, however, is not advisable, because thoracoplasty should be resorted to in cases not yielding to pneumothorax. As a general proposition it may be stated that in any except an early case from six months to a year should be required to induce collapse which should be maintained from one to two years. Re-expansion should cover a period of from six months to a year. If, after conducting this treatment aided by supplementary measures over a period of six months, no improvement is noted, it should be discontinued.

The Technic of Re-expansion

This procedure requires considerable knowledge and skill. It should be carried out as carefully and painstakingly as collapse.

A diseased lung heals at the expense of considerable lung tissue resulting in a loss of this structure which corresponds to the extent of the lesion and degree of fibrosis. Obviously, it can never expand to fill the hemithorax, nor should it be permitted to expand its limit. The fixed mediastinum will not permit enough mediastinal displacement to assist in filling the defect.

It may be necessary, in some cases, to reduce the size of the hemithorax by means of phrenicectomy. In some instances hypertrophy may be depended upon to fill the hemithorax; if this seems likely watchful waiting is justified. The surgeon should watch carefully for any evidence of reactivation owing to the partially healed lesion opening, which should be an indication for phrenicoexeresis or thoracoplasty.

In severe cases, some surgeons contend the re-expansion period should cover one year. The amount of pneumothorax is gradually reduced during this time and the interval between injections is gradually lengthened. If it seems necessary to reduce the pneumothorax immediately, the surgeon should be able to decide whether the danger from collapse as indicated by activity in the contralateral lung is as great as the danger from rapid expansion.

Rationale of Pneumothorax

The successful use of artificial pneumothorax depends upon the absence of adhesions in the pleural space though a few minor adhesions do not form a contra-indication to its use. If the visceral and parietal pleurae in tuberculosis are not excessively adherent, the affected lung may be temporarily collapsed and put at rest by filling the pleural cavity with some non-irritating gas which resists too rapid absorption. To Carson belongs the credit of having first suggested this procedure in 1820. His work was forgotten, to be independently taken up at a later date by Forlanini (1888) and later by Murphy. Nitrogen gas was used by these observers. Brauer was an enthusiastic advocate of the method.

Definition. Introduction of air or gas by artificial means into the pleural cavity.

Object.

1. To collapse and promote healing of cavities.
2. To clear exudates and infiltrates by partial collapse, produce rest and relaxation and thereby promote absorption and prevent spreading.

3. To control pulmonary hemorrhages.
4. As a public health measure to convert positive sputum cases to negative and thereby prevent spreading of the disease.

Indications for Collapse Therapy

MOST IMPORTANT INDICATIONS

1. A unilateral lesion of greater than minimal extent, especially in the presence of cavitation and positive sputum.
2. A bilateral lesion of greater than minimal extent where the good side is relatively inactive or quiescent.
3. Early lesions and "infiltrates" especially where a stereo x-ray reveals cavitation. Sputum may or may not be positive.
4. Public Health Indications.

MOST IMPERATIVE INDICATIONS

1. Uncontrollable hemorrhage.
2. Repeated small hemorrhages.
3. Spontaneous pneumothorax.

UNUSUAL INDICATIONS

1. Diagnostic pneumothorax.
2. Pleurisy with effusion.
3. Bronchiectasis.
4. Lung abscess especially with hemorrhage.

DISCUSSION OF INDICATIONS

Unilateral, Incipient or Moderately Advanced. A unilateral exudative upper lobe lesion of greater than minimal extent, of short duration, sputum positive, with demonstrable cavitation by stereo-x-ray, temperature below 100° F. is the ideal type of case for pneumothorax treatment; early pneumothorax before any destruction has been done, before softening of infiltrates takes place with consequent cavity formation.

Unilateral, Advanced Cases. Cases of similar type where x-ray reveals more extensive cavitation, and the patient gives a history of hemorrhage, usually are successful and a good collapse is obtained.

Bilateral Cases. The same may be said of bilateral cases of short duration, where collapse may be done simultaneously. Satisfactory collapse and excellent results are usually obtained. The more actively involved lung should be collapsed first and when a satisfactory selective collapse is obtained, collapse of the contralateral lung is started.

Far Advanced Chronic Cases. Cases of longer duration, far advanced, where x-ray reveals unilateral and active multiple cavities, pneumothorax should be tried even though the contralateral better lung shows some involvement with chronic fibrosis. Good collapse may be obtained and the patient will do well.

Far Advanced Disease with Pneumothorax on Contralateral Better Lung. Pneumothorax on the contralateral better lung, to prepare for further radical surgery on the more extensively involved side has been done in a series of far advanced cases and excellent results obtained. By collapsing the one side for a period of one to two years, definite beneficial effects are often seen on the contralateral bad lung, though it has to carry the burden of respiration for the

time that the better lung is collapsed. Complete healing of small cavities and clearing of exudates in the re-expanded lung are seen and radical surgery may be done on the more advanced lung.

Far Advanced Bilateral Lower Lobe Lesions. In order to collapse a hilum or basal cavity where the wall is thickened and hard, the entire lung must be collapsed for a longer period of time, and therefore bilateral pneumothorax is not possible, at least not simultaneously. However, we do see lower lobe selective collapse and in such cases bilateral collapse may be successfully carried out.

Refills Following Spontaneous Pneumothorax. If tuberculosis is known to be present in the spontaneously collapsed lung, the patient is given the same routine as in artificial pneumothorax. However, where spontaneous collapse occurs in tuberculous people in far advanced cases only a partial collapse can be obtained, for there are usually numerous adhesions; and if the collapse is due to an injury to the lung, such as tearing of an adhesion as is often the cause of the accident, pleural exudate and empyema are likely to follow and, depending on the condition of the patient, more radical surgery is then the proper treatment.

Spontaneous collapse of a lung where no tuberculosis is known to exist and where tuberculosis cannot be demonstrated, occurs if the patient is in shock or very dyspneic. The pressure should be removed by inserting the pneumothorax needle and withdrawing air until the patient is comfortable. This may be repeated, in the course of a few weeks if no complications set in. This gives the lung a better chance to re-expand slowly.

Diagnostic Pneumothorax

This may be done to differentiate annular shadows, which may not be excavations, from cavities, and for differential diagnosis in cases where malignancy is suspected.

To determine whether any disease actually exists in a certain part of a lung, selective collapse proves that the lung has lost its expansibility and is diseased.

IN PLEURISY WITH EFFUSION

When fluid is withdrawn it may be partly replaced by air. This, when repeated, gives the lung a better chance to re-expand slowly for study, in order to determine if the condition of the lung is such that pneumothorax is indicated.

IN BRONCHIECTASIS

This has been done, but very little, if any, beneficial effect has ever been found and we do not recommend it.

IN LUNG ABSCESS

This treatment has been attempted but few beneficial results obtained.

If the abscess is open and draining by way of the bronchi it may be possible to obtain some collapse but a better result is obtained by more radical procedures such as surgical drainage and thoracoplasty.

Preparation of Patient

No special preparation is necessary. The patient should be assured that there is no pain and little, if any, danger in the operation. Pneumothorax should not be done immediately after a full meal.

The patient is placed on the table: stripped to the waist; lying on the better

side (i.e., with the side of the chest to be collapsed up); the foot end of the table elevated; the patient with both arms stretched upward over the head; a pad or pillow under the chest, not under the shoulder but below the shoulder; and the head down.

The site of operation depends on the type and location of the pathologic process in the diseased lung. The needle should be inserted over the part of the lung which shows the least evidence of pathologic changes and never over an area showing an exudative process, over a cavity, nor over an area showing thickened pleura, for we are more likely to encounter adhesions over the diseased part and here there is more danger of entering the lung. The fifth to seventh intercostal space in the posterior or midaxillary line is usually the favorable site to insert the needle.

Anesthesia. The skin and deep tissues are injected by a one inch 25-gauge hypodermic needle using ½ to 1 per cent novocaine. This will reach the parietal pleura in most cases. If not, a longer needle should be used. It is important to anesthetize the parietal pleura when a blunt needle is used to induce the pneumothorax to avoid pleural shock. The skin and superficial tissue are now punctured with a sharp instrument, an iridectomy knife or sharp needle of the same size, to prepare for the insertion of the blunt needle.



Fig. 1274. Types of needle. No. 1. This type of needle should not be used; it is a dangerous instrument. No. 2. Refill needle. No. 3. Proper pattern of pneumothorax needles used in artificial pneumothorax. (Courtesy of Dr. Allen J. Hruby and Dr. K. J. Henrichsen.)

Initial Inflation

NEEDLE USED

This is an ordinary two-inch, 18-gauge needle. The sharp point has been taken off, the opening at the point closed and a slit 4 mm. long made on the side. The needle is blunt and if the lung is free there is no danger of puncturing the visceral pleura, and injuring the lung (Fig. 1274).

To determine when the needle has penetrated the parietal pleura and entered the thoracic cavity remember that there is no air or gas in the thoracic cavity and consequently no air can be drawn back into the syringe. There is a vacuum and suction, when the syringe is removed from the needle. If the needle is filled with some of the fluid from the syringe, this will be seen to disappear into the thoracic cavity if the parietal pleura has been punctured.

On connecting the manometer, free fluctuation will usually be found. A small amount of air is then allowed to pass into the thorax under frequent manometric readings, until the desired amount is given. If the needle strikes an adhesion or thickened pleura and no free space can be found, a trial must be made again at some other place, this to be repeated until one has been successful or is satisfied that there is no free space.

If the needle has been inserted too deep into the adherent lung and entered the lung tissue, air and often blood will be drawn back into the syringe. the manometer may show fluctuation, and it will be noticed that if the patient holds

his breath in deep inspiration the manometer will show a negative pressure of 6-7 mg. Hg., but this will drop slowly even when the patient is not breathing. On the contrary, if the needle has entered the pleural space and not the lung, the negative pressure as shown by the manometer will remain at the same point on deep inspiration. In cases where phrenicotomy has been done or where there may be a rise of the diaphragm for other reasons, care must be taken not to insert the needle below the diaphragm. Pneumoperitoneum is not good treatment in pulmonary tuberculosis. If the needle has entered the peritoneal or abdominal cavity, the manometer will show positive pressure on inspiration and vice versa in contrast to the intrathoracic pressure which is negative on inspiration. These points are of importance and should be carefully observed before any air is allowed to flow into the chest cavity.

If the needle has punctured the lung, the patient will usually start coughing and it will be seen that blood and air or a slightly blood-tinged froth can be drawn back into the syringe. The needle must be immediately withdrawn and no air allowed to enter. If air enters the pulmonary circulation, embolism is likely to result.

AMOUNT OF AIR TO BE GIVEN

No air must ever be given unless there is free fluctuation and a minus manometer reading remaining at the same point when the patient holds his breath in deep inspiration.

How much air should be given at the initial treatment? This depends on the type and extent of the lung lesion, and the reading of the manometer. Positive pressure should never be reached, but a free fluctuation from about 2 or 3 to 4 or 5 minus.

This is usually obtained after giving 2-300 cc. of air. The first refill is given within 24 hours and about the same amount of air is given. The intervals are slowly lengthened from one to two, three and four days until weekly intervals are reached. Then the patient is kept on weekly intervals for several weeks. This, however, depends upon the condition of the patient, and on the type and extent of the involvement of the diseased lung.

When pneumothorax has been established and a satisfactory collapse obtained, the symptoms subside, the sputum becomes negative, and the patient gains in weight, the intervals may be lengthened from ten days to two weeks and later to three or four weeks or more, depending on what the collapsed lung will do: whether it remains in a state of collapse or has a tendency to re-expand. This must be carefully observed by fluoroscope or x-ray.

If the lung shows a tendency to re-expand on longer intervals between refills, more frequent refills must be given, since the lung must not be allowed to re-expand to the point where it touches the chest wall. Pleuritic adhesions are very likely to form and cause a successful case to be a failure.

COMPLICATIONS IN PNEUMOTHORAX

1. Air Embolism.
2. Pleural Shock.
3. Intrapleural adhesions.
4. Pleural Exudate.
5. Spontaneous Pneumothorax.

6. Empyema.
7. Emphysema.
8. Skin or Superficial Infection.

Air embolism may occur following puncture of the lung whether air has been permitted to enter or not. If the pulmonary tissue has been punctured, air from the lung may be sucked or drawn from the alveoli or bronchioles into the venous circulation, whence it goes to the left ventricle of the heart and then to the general circulation. The symptoms depend on what part of the brain is affected.

Death may occur almost instantly or within a few minutes.

Pleural shock has been discussed by various authorities; some insist that it does occur, others that it does not and that all so-called pleural shock cases are air embolism. No doubt most cases of shock in pneumothorax are embolism. However, we have seen cases going into shock on refills where the compressed lung could not possibly be reached by the needle, and also cases where shock occurred before the parietal pleura had been penetrated. The symptom is that of syncope which may last from a few to 10 or 15 minutes; the patient recovers suffering from no after effect. In embolism, on the contrary, if the patient recovers, there are some after effects such as partial paralysis of arm or leg or disturbed vision of one or both eyes, lasting for some time.

Intrapleural adhesions are encountered in a number of cases, usually in those of long duration and in cases giving a history of chronic pleurisy.

This may involve an entire lobe or more and it may be only a few thin stringlike bands. They may not interfere in obtaining a satisfactory collapse and yet one or two tiny bands may prevent the collapse of cavities (hanging cavities) or an important part of the lung so that it becomes necessary to cut these adhesions.

Pleural Exudate. In cases where a satisfactory collapse has been obtained and a small amount of pleural exudate develops, it may be found by fluoroscopy or x-ray. These small amounts are usually absorbed and do no harm. If the fluid increases and persists to a point where it becomes annoying to the patient it is removed gradually. It is nearly always clear, straw colored and sterile, although acid fast bacilli may be found in culture. Great care must be used to prevent carrying infection into this fluid. If it becomes infected, whether from within or without, we have one of our most serious complications in pneumothorax, empyema. The intrathoracic pressure is usually increased when an exudate develops, and it may even be necessary to remove fluid without doing any inflation with air. It seems that high intrathoracic pressure has a tendency to invite the formation of exudate and therefore the intrathoracic pressure should never be raised equal to the atmospheric pressure; only in rare cases when there is some definite indication such as a need to collapse a persistent thick walled cavity, or to stretch a string of adhesions.

Sanguinous exudate or hemothorax is rarely found in pneumothorax; if it is found, unless it can be accounted for by puncturing the lung, intercostal blood vessels or tearing of adhesions, or malignancy should be suspected.

Spontaneous Pneumothorax. This occurs, not infrequently in pneumothorax treatment, usually early and most commonly is caused by puncturing the lung at the initial inflation or at some later refill, where the lung is close to the

chest wall, not actually adherent, yet sticking to the parietal pleura so much that a sharp pointed needle will penetrate the visceral with the parietal pleura and therefore a blunt needle should be used, as stated in the article on technic, until the lung is entirely free and separated from the chest wall. The use of this needle will prevent such an accident unless we strike into an adhesion and puncture the lung that way.

Tearing of a small adhesion or rupture of a small bleb or bulla, which may form under the visceral pleura, is another cause of spontaneous pneumothorax. The exact cause in any case can hardly ever be determined, as the patient nearly always recovers.

Treatment of spontaneous pneumothorax where artificial collapse has been started in unilateral cases consists in keeping the intrathoracic pressure down to a point where the patient is comfortable; this is done by inserting the pneumothorax needle and drawing out air until the desired pressure is reached, repeating when necessary and keeping under close observation by x-ray and fluoroscopy.

In cases where there is a large tear and a valvelike action which permits the air from the lung to enter the pleural cavity, but by closing prevents its escape and the chest fills up rapidly when the patient becomes dyspneic in a short time, a needle should be inserted connected to a rubber tube leading into a water bottle placed under the bed. The needle and tube are then strapped to the patient's skin by adhesive tape and to the frame of the bed so that the tube reaches down into the water for about 1 cm.; this permits the air to escape through the tube when the intra-thoracic pressure reaches a certain point; air bubbles will be seen coming out through the water but no air can re-enter (Fig. 1275).

In bilateral cases particularly, this treatment has proven of great value; it is simple and can be carried out in the patient's room without any disturbance to the patient.

A puncture or small tear in the visceral pleura will heal in a short time and rarely do complications develop.

Empyema. Next to air embolism, empyema is the most serious complication in artificial pneumothorax, and goes hand in hand with or follows the simple pleural exudate or spontaneous pneumothorax. However, the number of cases developing empyema is very small.

When a patient under pneumothorax treatment develops a pleural exudate, this is a clear straw colored slightly greenish fluid, which is sterile, although tubercle bacilli may be demonstrated but no other organism can be found. If this exudate is not absorbed but increases and becomes infected, whether it is from within or from without, empyema is the result. The autogenous infection or infection from within no doubt is the more common. Infection from without can occur if a strict sterile technic is not used in refills.

Treatment of Empyema. The closed method of drainage and irrigation may be done but this nearly always results in a fistula and secondary infection, the condition becomes more serious while nothing has been accomplished. The case will go on to radical surgery. This must be done while the patient's condition is such that he can be considered a good risk and before amyloidosis of other organs such as the liver and kidney develops and the condition becomes hopeless.

Subcutaneous Emphysema. This condition occurs, but is rarely seen when

a small needle is used in refills. If an 18 gauge needle is used the small puncture to the pleura does not permit any air to escape into the tissues outside the chest wall.

Treatment. A small area of emphysema needs no treatment. If a large part of the thorax and neck becomes involved tight strapping will prevent spreading and absorption takes place. Serious complications are rarely encountered.

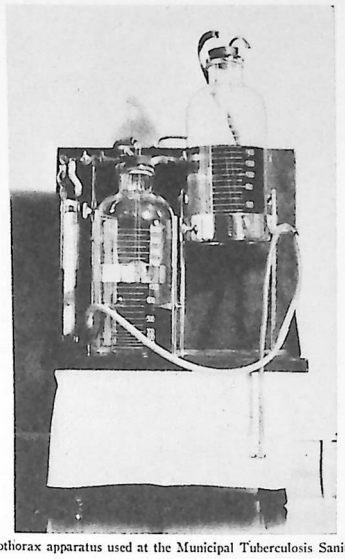


FIG. 1275. Pneumothorax apparatus used at the Municipal Tuberculosis Sanitarium of Chicago.

Skin Infection. It is not uncommon to find skin infections as acne or pustules. Such conditions are often overlooked and disregarded, however care must be used not to select such an area for inserting the pneumothorax needle. Infection can easily be carried into the pleural cavity and result in empyema.

CONTRAINDICATIONS

1. Uncontrollable activity on the opposite side.
2. Unusually large cavities.
3. Patients over 50 years of age.
4. Extreme emaciation.
5. Cardiac decompensation or myocarditis.
6. Marked diminution in vital capacity.

FAVORABLE FACTORS	UNFAVORABLE FACTORS
1. Unilateral lesions.	1. Bilateral lesions.
2. Thin-walled cavities.	2. Thick-walled cavities.
3. Cavities of moderate size.	3. Unusually large cavities.
4. Absence of serious tuberculous complications.	4. Presence of serious tuberculous complications.
5. Absence of adhesions.	5. Presence of adhesions or thickened pleura.
6. Inactivity of the process on the good side.	6. Activity of the process on the good side.
7. Young adults under 40.	7. Elderly patients over 45 or 50.
8. Maintenance of vital capacity.	8. Marked diminution of vital capacity.
9. Normal heart function.	9. Organic heart disease.
10. Good nutrition.	10. Extreme emaciation.
11. Resistant races.	11. Aboriginal races.
12. Low grade or no fever.	12. High fever.
13. Absence of other lung pathology.	13. Presence of asthma, emphysema or silicosis.
14. Some tendency to healing.	14. Very acute processes or pneumonic lesions.

Uncontrollable Activity on the Opposite Side. Bilateral extensive exudative disease where half or more of each lung shows involvement, temperature over 101° F., rapid pulse and rapid loss of weight.

Bilateral cases where an entire lung is involved with an acute exudative process with high temperature, should not be treated until the acute symptoms subside.

The foregoing material is quoted and is the routine method of procedure at the Municipal Tuberculosis Sanitarium of Chicago (Direction of Drs. Allen J. Hruby and K. J. Henrichsen).

Comment: Under "New Portable Pneumothorax Machine,"[1] Dr. J. J. Singer, St. Louis, describes this apparatus on which he comments as follows (Fig. 1276):

"This machine is presented because it embodies many desirable features which will be enumerated.

"It is made almost entirely of metal sufficiently heavy to withstand accidental tipping or breakage. The transparencies are made of heavy break-resisting glass and the gauge is made of hard glass. The apparatus consists essentially of two chambers, an upper and a lower. The new type manometer consists of a bellows, enclosed in a metal case, which opens and closes with the variations of the air pressures within. The needle on the dial shows these variations of pressures in cubic centimeters of water. It is mounted on fine jeweled bearings. Air can be put into or withdrawn from the chest through the commutator valve in the center of the instrument. Pleural pressure readings may also be obtained by changing the handle of this valve. We use 1000 cc. of mineral oil instead of water as

[1] Journal of Thoracic Surgery, June, 1932, Vol. 1, No. 5, pp. 562-563.

this does not corrode any of the metal parts. Tubing to which is attached a needle with a valve is inserted into the uppermost opening, and with the commutator valve placed in the proper position it is ready for use in pneumothorax work or aspirating air from the chest. A small test tube

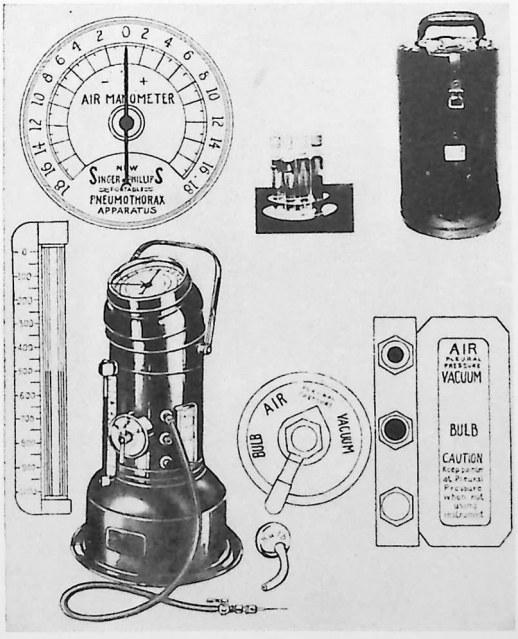


FIG. 1276. Singer's portable pneumothorax machine. (Graham, Singer and Ballon. Surgical Diseases of the Chest, Lea & Febiger.)

rack may be attached to a clip on the back of the machine which is not visible in the photograph. The apparatus as illustrated weighs ten pounds.

OLEOTHORAX

This was first described and performed by Bernou in 1921.

Indications for oleothorax: (a) compression; (b) prevention of adhesions (antisymphyseal) and (c) antisepsis.

Children tolerate this procedure well. It may be combined with pneumothorax where there is a tendency to adhesions between the pleural layers. It is useful as a treatment for pleurisy, particularly recurrent tuberculous pleurisies which do not readily respond to other treatment; tuberculous empyema; and secondarily infected non-tuberculous pleurisies. It is quite effective in treating small perforations which result from tearing the adhesions but if the perforations are large it is better to use oleothorax preparatory to doing a thoracoplasty. It is also useful in the valvular type of perforation where there is an effusion and in cases where more pressure is indicated over a part of the lung than can be obtained by pneumothorax.

In some instances oleothorax has been substituted for pneumothorax as a matter of convenience. A thicker, tougher pleura results from its use. It should be used only under trained supervision. In many instances it is more effective and consistent in its accomplishments than pneumothorax. It furnishes a means of applying antiseptics directly to the pleural surface and of replacing septic fluid with antiseptic oil. Liquid paraffin and olive oil are the oils generally used. Olive oil is more widely used and is more soothing and readily absorbed than liquid paraffin which is easier to prepare but has a tendency to produce pleural intolerance. The latter is indicated where a more or less permanent collapse is desired with few refills. Oils used must be absolutely pure, neutralized and sterilized at a high temperature. The antiseptic is added after the oil is sterilized. It is convenient to pour the oil into 100- to 250-cc. glass ampoules which are placed in warm water, so that the oil is at body temperature at the time of injection, and connected to the tubing of the injection apparatus.

Gomenol is the antiseptic of choice—2 to 8 per cent, usually 4 per cent.

Oleothorax is often a more difficult and complicated procedure than pneumothorax for the following reasons:

1. In comparison with air, the oil is non-compressible; decided changes in pressure result from the increase or decrease of a few cubic centimeters.
2. Because of the viscosity of the oil, as compared with air, no accurate device is available for ascertaining the intrapleural pressure.
3. Some pleurae are highly sensitive to oil resulting in frequent effusions which may prove serious due to the increase in pressure.

Patients in whom oleothorax has been done should be observed for sudden high temperatures, evidence of perforation, oil in the sputum or in the vomitus.

The chief obstacle with which the manufacturer of an oleothorax machine is concerned is the viscosity of the oil which necessitates a great deal of pressure to force it through the needle so that it is impossible to directly determine the oil pressure within the pleura. Bernou's oleomanometer is used for this purpose.

Where this treatment is used in place of pneumothorax, or to substitute for the fluid of an effusion or empyema, the apparatus must be able to displace accurately the amount of air and fluid with oil.

The patient is prepared the same as for pneumothorax. Not more than 10 cc. of oil should be given at the first treatment and the patient watched for several days following for signs of pleural sensitivity. A number of injections are sometimes required to produce an oleothorax of 100 to 200 cc. Sometimes effusions are replaced first by air and later by oil.

In treating empyema large amounts of oil are injected at one time. The pleural cavity may be washed out with saline solution first. The oil must be changed often in these cases. Oil which is not infected will remain fresh for an indefinite period in the pleural cavity.

FAT IMPLANTATION AND PLOMBAGE

Filling the space between the parietal pleura and the chest wall may be accomplished by the transplantation of fat from the patient's own fat layer from the abdomen or buttocks (Tuffier). Plombage of cavities in the upper lobes is a method of expediency which is only to be considered where a thoracoplasty is fraught with danger to the patient as in cases of advanced age or marked emphysema or in threatened hemorrhage from cavities; provided, however, that pneumothorax cannot be done (Nissen).

Lilienthal's Technic of Fat Implantation

Approach the apex either from the anterior axillary region or from behind by the route taken to reach the posterior portion of the superior mediastinum.

When operating from behind one finds it comparatively easy to push the parietal pleura away from the chest wall. In operating from the front or in the axilla, it is seldom necessary to resect more than one rib because the intercostal spaces in front are much wider than those in the back. In the approach through the anterior region make an incision over the second rib from the midaxillary line forward for about six inches. Remove subperiosteally about four inches of the rib. Separate the tissues between the endothoracic fascia and the chest wall very carefully beginning from behind with the fingers, holding their dorsal surfaces close to the chest wall. The fingers gradually creep upward toward the apex, making as little pressure as possible upon the pleura, separating the pleura from the thoracic wall. The fingers reach the dome of the pleura which may lie above the first rib, or, in old fibrotic cases, the pleura may have been drawn downward to a plane lower than the first rib. Tuffier refers to the "ligament of the summit of the pleura" described by Sebileau, which is a fibrous band attached to the anterior part of the seventh cervical vertebra. It may require a little additional force to loosen this band and the manipulation must be carried out with very great care lest the pleura be torn.

When the parietal and visceral layers are adherent this maneuver will be easier, but there again is the added danger of entering a tuberculous cavity. Having reached the dome of the pleura, pressure is made downward with the fingers (Fig. 1277). Separate the posterior portion of the pleura from the chest wall. A vacant space results. Fat from the abdomen or buttocks removed simultaneously by an assistant should be immediately crowded into the cavity which must be filled completely (Fig. 1278).

Draw the intercostal structures toward each other with a few chromicized catgut sutures. The skin and overlying muscles are approximated over all (Fig. 1279). If the operation has been carried out without accident or infection primary union will follow. If there has been an accidental perforation into a pulmonary cavity with or without hemorrhage the opening into the lung should at once be enlarged with the fingers, and after cleansing the interior it should be

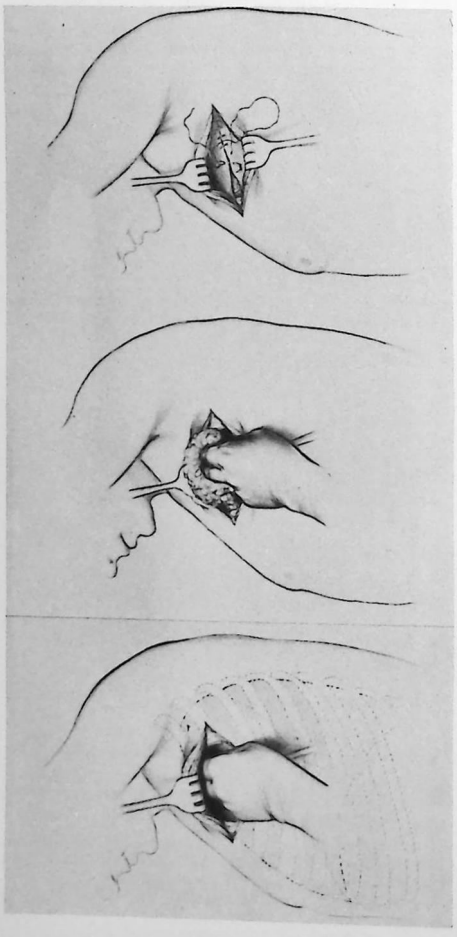


Fig. 1277. Apicolysis previous to fat implantation. Method of pushing down the apex of the lung to make an extrapleural space.
Fig. 1278. Apicolysis and fat implantation. The mass of fat from the abdominal wall is being forced into the dead space above the apex of the lung.
Fig. 1279. Apicolysis. The tissues are being sutured over the implanted fat. (Courtesy of Dr. Howard Lilienthal.)

packed with gauze, preferably vaselined, or with rubber dam, and most of the wound left open.

PHRENIC NERVE AVULSION

Phrenic Nerve Crushing, Phrenicectomy, Phrenic Exeresis, Phrenic Neurectomy

Anatomic Points. The phrenic nerve is formed by branches from the third, fourth, and fifth cervical nerves. It crosses the scalenus anticus muscle, goes behind the suprascapular and transversalis colli vessels, then over the subclavian artery and behind the subclavian vein. After passing in front of the internal mammary artery, it enters the superior mediastinum of the thorax. From here the nerve traverses the middle mediastinum, lying between the pericardium and the pleura and pierces the diaphragm. It breaks up on its under surface and has the following

Communications. The loop between the first and second gives off a branch to (a) the vagus, (b) the hypoglossal, and (c) the superior cervical ganglion of the sympathetic. The second and third send a branch to the descendens hypoglossi to form the ansa hypoglossi. The second, third, and fourth communicate with (a) the spinal accessory and (b) the superior cervical ganglion of the sympathetic.

While the operation has been performed by some surgeons on both sides for the relief of bilateral bronchilectasis, Brauer reports a case operated on by someone else where the patient died from respiratory failure, as a result of bilateral intervention.

Temporary or permanent interruption of the phrenic nerve may be obtained. In the former case simple crushing of the nerve with a hemostatic forceps is resorted to or a few drops of absolute alcohol is injected into the nerve. Following crushing or injection, the nerve regenerates and the function of the diaphragm returns in from about three to six months.

Step 1. Position of Patient: The patient lies flat on his back with a pillow or sandbag beneath the shoulders; the head is turned opposite to the side to be operated upon. Dress the head in an aseptic cap. Prepare the skin of the neck in the usual manner (iodine—alcohol—picric acid, etc.).

Anesthesia and Incision (Fig. 1280): Local infiltration anesthesia with ½ per cent novocain injected into the skin in a line just behind the border of the sternocleidomastoid muscle beginning at about the level of the top of the thyroid cartilage and extending downward to the upper border of the clavicle.

Step 2. After the skin incision has been made, the deeper parts are infiltrated. Infiltration should be thorough and no pain should be complained of by the patient. Precede the injection of the anesthetic with the subcutaneous administration of morphine gr. ¼ with atropine sulphate 1/150 gr. Nitrous oxide-oxygen anesthesia may also be used. In this event, however, the advantage of the pain as a guide that the phrenic nerve has been isolated is lost.

An incision about one or two inches in length is made parallel to the clavicle (Fig. 1280[1]). It is deepened, exposing the posterior border of the sternocleidomastoid muscle. The external jugular vein may be avoided but if the neck is short it is best to promptly clamp, ligate, and divide the vessel. Dissect the tissues carefully down.

Step 3. Retract the jugular vein, the location of which can be easily ascertained by its relations to the carotid, the pulsation of which should be felt

with the finger. Deeper dissection encounters the posterior belly of the omohyoid muscle which should not be divided. The scalenus anticus muscle is found directly behind the great vessels, its fibers running in a slightly oblique direction to the tubercle of the first rib (see scaleniotomy). In stout individuals it may be somewhat difficult to expose the scalenus; the fat tissue should then be cleared away. The phrenic nerve will be found descending on the anterior surface of the muscle under the fatty tissue. It is usually the thickness of the lead of a pencil. The scalenus anticus muscle, it must be remembered, runs downward to be inserted into the scalene tubercle of the first rib. Low down in front of it is the subclavian vein; behind the muscle is the subclavian artery. The course of the nerve is from above downward and is somewhat overlapped by the internal jugular vein. The nerve should not be confused with the cervical sympathetic which can be identified by tracing it upward or downward until a ganglion is reached; the course of the phrenic nerve is farther from the midline as compared with the sympathetic; the nerve is smoother and more cylindrical and somewhat larger than the cord of the sympathetic (Fig. 1280 [2]).

Step 4. After the phrenic nerve has been identified, inject it with a little of the anesthetic solution by means of a fine hypodermic needle. Free the nerve from the underlying tissues with fine dissecting scissors. Lilienthal throws a traction ligature around the nerve. "With the aid of this retracting ligature," says Lilienthal, "dissection downward of the nerve is extremely easy as far as the belly of the omohyoid beneath which it passes. This muscle should now be raised with a small blunt retractor and in obese individuals the fat in the triangle beneath carefully cleared away. Strong repeated traction upon the nerve above by means of the catgut ligature will tighten that part of the nerve which is below the omohyoid, drawing it upward so that it can be felt and seen beneath the overlying tissue."

The nerve should now be mobilized and divided. Traction upward on its lower portion will draw it out through the space below the omohyoid (Fig. 1280[3]). Considerable force will often be necessary to first draw the divided nerve out of its location. The free end of the nerve is drawn taut with a clamp and about 15 cm. of it should be twisted out from behind the clavicle; it is then divided with scissors (Fig. 1280[4]). Make certain that only the phrenic nerve is cut.

Step 5. Hemostasis must be perfect. Approximate the skin with fine sutures or metal clips. If much manipulation was done a small drain may be led out of the lower angle of the wound and removed in 24 hours (Fig. 1280[5]).

Comment. An accessory phrenic nerve occurs in from 20 to 30 per cent of subjects, but one may be reasonably certain that its connections with the main trunk have been severed if the length of the nerve indicated above is removed.

Where simple phrenicotomy is done, the nerve is cut across after being isolated (Fig. 1280[3]). During avulsion of the nerve the patient may complain of thoracic and abdominal pain. If this is severe it may be an indication of adhesions to tuberculous tissue, such as lymph-nodes and we must think of the danger of lighting up mediastinal infection. The nerve should then be cut off

without further traction. Cardiac irritation with tachycardia has also been observed after avulsion (Lilienthal). The choice between avulsion and resection

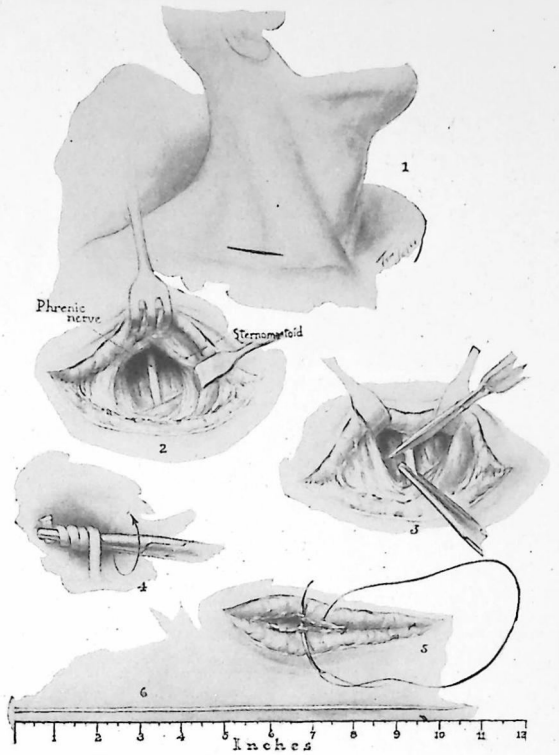


FIG. 1280. Phrenic nerve avulsion. Incision and technique. Exposure of the nerve is facilitated by mobilizing the external margin of the sternocleidomastoid muscle. The fatty tissue overlying the nerve which must be retracted is not shown in drawing. (Hedblom in Lewis' Practice of Surgery, W. F. Prior Co.)

rests with the judgment of the surgeon and the indications present in the case at hand.

Through an incision along the posterior border of the sternocleidomastoid muscle, the nerve may be identified with greater facility than through the transverse incision described. The exposure of the nerve is by no means as perfect nor the dissection as easy as it is through the longitudinal incision and there are the usual surgical objections to operating through what may turn out to be an insufficient exposure.

While resection or avulsion of the phrenic nerve has been considered almost free from danger, it must nevertheless be recalled that unexpected complications may occur during the operation. These are mainly due to difficulties in finding the nerve and to the limited experience of the surgeon.

Comment: Phrenic nerve avulsion is very much practiced nowadays. Nissen concludes from his vast experience that excessive enthusiasm prevails at present for this operation which is not justified. The operation has, of course, its indications, but also its pitfalls. In performing the operation, one must keep in mind that it is desired to paralyze the diaphragm either permanently or temporarily. In the first instance, the phrenic nerve is divided and in the latter it is crushed or injected with alcohol. "Theoretically," Nissen says, "such preconceived effects of paralysis of the diaphragm sound very beautiful but practically, it is very difficult to prognosticate under what circumstances paralysis of the diaphragm lasting 5 or 8 months will suffice. Alcoholization of the nerve, it is pointed out, is a great advantage because it is performed bloodlessly through a simple puncture. One should be warned against such advice.[1] In the first place, the diffusion of the alcohol does not always reach the phrenic nerve and when it does, it reaches other nerves and vascular structures. With no other collapse procedure are so many sins committed as with paralysis of the diaphragm," admonishes Nissen who further points out that, even if successful, the results obtained from phrenic nerve avulsion affect only the lower lobes of the lung which are not frequently the seat of chronic cavernous processes. In other words, a paralysis of the diaphragm has only little influence upon cavities in the apices and is only exceptionally sufficient to bring about such collapse. To be more specific, a healthy region is affected in nerve avulsion which better be left alone. Furthermore, if one depends on phrenicotomy as the only operative procedure to effect a cure, particularly if coupled with procrastination, valuable time is lost.

Experience has shown that partial thoracoplasties will accomplish most, particularly a combination of pneumolysis with subtotal removal of the first rib. This holds, of course, when the pathologic process is above the sixth rib; when below it, total thoracoplasty is indicated.

SCALENIOTOMY

The scalene muscles are accessory muscles of respiration. The cutting of these muscles as a method of treating pulmonary tuberculosis was suggested in 1930. The following names are prominently connected with the development of the procedure: Gale, Middleton, Kochs, Els, Junkersdorf, Rost, Loeschke.

Anatomic Considerations: The Scalenii Muscles are:

1. Scalenus anticus

[1] Nissen, Chir. Indicationen, Leiden, 1937—A. W. Sÿthoff's.

2. Scalenus medius.
3. Scalenus posticus.

Make an incision about 1-2 inches above the clavicle as in phrenicotomy (vide supra). Dissect bluntly until the scaleni muscles are exposed. Gale and Middleton recommend the injection of a small amount of solution of procaine hydrochloride when the insertions of the muscles are located. Separate the muscles from the surrounding structures so that a straight aneurysm needle can be hooked behind the detached muscles. Evarts Graham uses a special flat instrument made on the principle of a skid, protecting thereby the contiguous important structures (brachial plexus; subclavian vessels; transverse cervical and posterior scapular arteries; long thoracic nerve) while the muscles are being divided.

SURGICAL TREATMENT OF BRONCHIECTASIS

1. Pneumothorax and Phrenicoexeresis.
2. Pulmonary Decortication.
3. Ligation of the Pulmonary Artery (Sauerbruch).
4. Resection of the Affected Lobe.
5. Graham's Cautery Operation.

TUMORS OF THE LUNG

Briefly, tumors of the lung may be classified as

1. Metastatic.
2. Contiguous affection.
3. Primary.

The first is, of course, not amenable to surgical intervention. Those falling into groups 2 and 3 may be attacked surgically. While the outlook in benign growths is occasionally promising (removal of the tumor), malignant tumors, have until recently offered a gloomy outlook. Nevertheless, Wm. Francis Reinhoff, Jr., records a total mortality under 18 per cent and in his last series of seventeen cases there was no fatality. (Personal communication.)

ECHINOCOCCUS

Bolognesi described a case of echinococcic cyst of the lung operated upon by him following the method of Valdoni (extrapleural plumbage with Beer's paste) partly modified by substituting for Beer's paste partially iodoformized gauze for filling the cavity. The operation was done in two stages and was rapidly and completely successful.

DERMOID TUMORS

Harry Hyland Kerr and J. O. Warfield approached Intrathoracic Dermoids by a new method of thoracotomy.[1] The tumor was removed by the following technic.

Step 1. Under ethylene anesthesia a vertical incision is made over the middle of the sternum (Fig. 1281).

[1] Annals of Surgery, Vol. 88, p. 607, 1928.

Step 2. The manubrium sterni as well as the lower portion of the gladiolus sterni opposite the sixth interspace is trephined with a Doyen burr.

Step 3. The mediastinal contents are dissected away from the back of the sternum and a Gigli guide passed from one trephine hole to the other.

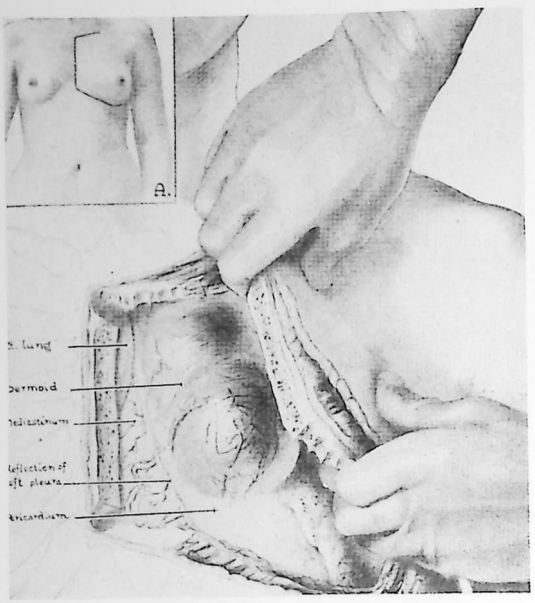


Fig. 1281. Kerr and Warfield's method of thoracotomy showing bevelled incision of the sternum and the first and sixth interspaces, allowing the left half of the sternum, with the ribs, to be sprung open in the form of a trap door which gives complete access to the entire hemithorax. The thoracotomy gives ideal exposure for any intrathoracic manipulation as it exposes the mediastinum, pericardium and hylus of the lung.

Step 4. The saw is passed and the sternum split longitudinally bevelling the saw-cut sharply to the right. The two trephine openings are then connected to the first and sixth left interspaces with a DeVilbiss bone-cutting forceps.

Step 5. The skin and intercostal muscles of the first and sixth interspaces are cut midway between the ribs. On elevating the flap the reflection of the pleura from the mediastinum to the anterior chest wall is exposed and divided. The trapdoor can then be sprung open exposing the entire left hemi-

thoracic cavity. The tumor can be seen presenting behind the pleura (Fig. 1281).

Step 6. The anterior mammary vessels are found, ligated and divided.

Step 7. The pleura is stripped from the tumor and the cyst is dissected with the finger and shelled out.

Step 8. The pedicle where the vessels supply the tumor is clamped and divided.

Step 9. The debris is sponged out of the pleural cavity and the lung expanded by increasing the oxygen pressure to 20 mg. of mercury.

Step 10. The osteoplastic trapdoor is closed and held in place by two kangaroo sutures passed around the sternum through the second and fifth interspaces. A No. 2 chromic suture is passed around the sixth and seventh ribs close to the sternum and another around the second and through a drill hole in the first rib. This effectually holds the bevelled incision of the sternum closed.

Step 11. The superficial fascia is closed with a continuous locked suture of No. 1 plain catgut. The skin is sutured with silkworm gut. Dressings are strapped to the left chest with adhesive plaster.

LOBECTOMY

This signifies the removal of a diseased segment or lobe of a lung. The knife or electrocautery may be used. Bleeding is controlled by compression of smaller vessels and ligation of larger ones. Open bronchial ends may lead to bronchial fistulae. Their mucous membrane should be removed for 1 to 2 cm. and the ends securely closed by ligature. Large elastic Doyen clamps (Fig. 1282) serve well for temporary hemostasis and are applied on either side of the section of the lung to be removed. When the resection is undertaken at the hilus, Sauerbruch advises the application of a temporary elastic constrictor. After ablation of the diseased segment, the stump of lung is sutured, preferably in sections (Garré). Where suture is not possible, tamponade should be resorted to.

In the hands of the experienced, lobectomy should have a mortality nowadays of from 10 to 20 per cent (Nissen). (Fig. 1283.)

Amputation of a Lobe of the Lung

The underlying principles of this operation are:

Step 1. Isolate and ligate the large blood vessels at the hilus of the lung separately (Friederich) without including the bronchi, because if this precaution be neglected the bronchi supplied by the ligated blood vessels would suffer. Where needed speed or inflammatory conditions prohibit to proceed as outlined, a rubber tube may be made to temporarily encircle the vessels and main bronchus akin to compression practiced in embolectomy of the pulmonary artery (which see).

Step 2. Division of the main bronchus supplying the respective lobe must be accomplished at some distance from the reflection of the pleura. In other words, the lobe of the lung must be resected in such a manner that the entire stem of the bronchus running through the hilus is retained. If this precaution is neglected mediastinal infections or emphysema may result from the retraction of the bronchus.

Step 3. Closure of the bronchus. Curet the mucous membrane of the bronchus

for a little distance. Ligate it beyond this area and reinforce it by another catgut ligature beyond the first one.

Step 4. Use tamponade from the operated region on to the surface of the wound.

Willy Meyer counseled (a) Crushing of the bronchus and ligating it; (b) Inversion like an appendix stump; (c) Covering the inverted bronchial stump with interrupted catgut sutures. (Fig. 1289.)

To Nissen belongs the credit of having successfully done the first pneumonectomy for bronchiectasis in 1931.[1] The operation is indicated in unilateral bronchiectasis. (Fig. 1283.) It is a major procedure demanding meticulous technic and painstaking preoperative as well as postoperative care. Infection of the pleural cavity should be guarded against. Mediastinal emphysema, suppurations and leakage from the stump are often inimical to success. The single-

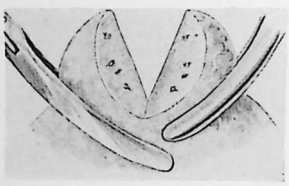


Fig. 1282. Application of lung clamps in partial resection of a lung. (After Sauerbruch and Schumacher.)

stage operation is apparently the simplest and consists of opening the chest, liberating the affected lobe and amputating it at the hilum. Multiple-stage operations are preferred by many.

Preliminary pneumothorax to ascertain the extent of pleural adhesions and to reduce shock when the chest is opened is counseled by some.

Anesthesia. Preliminary basal narcosis supplemented by overpressure inhalation is the anesthetic of choice.

One-Stage Operation

Step 1. Place the patient on the unaffected side with a firm pillow under the axilla arching the side to be operated upon. Deflect the head of the patient a little downward thus permitting secretions to be aspirated with a suction apparatus.

Step 2. Make a long incision along the line of the 6th or 7th interspace along the course of the rib (Fig. 1284). Attend to hemostasis. Open the chest in the exposed interspace for about ten inches. While dividing the pleura the lung slowly collapses. Enhance exposure by properly constructed rib spreaders. If deemed advisable, a portion of one or more ribs at their posterior end may be removed. (Fig. 1285.)

Step 3. With scissors separate any existing adhesions between the parietal and basal surfaces of the affected lung. Effect separation along the interlobar

[1] Rudolph Nissen, Zentralbl. f. Chir., 58:3003, 1931.

fissure. Divide the pulmonary ligament from below to the hilum. Crush the phrenic nerve on the pericardium if the respirations are jerky or if the lobe of the lung is enlarged.

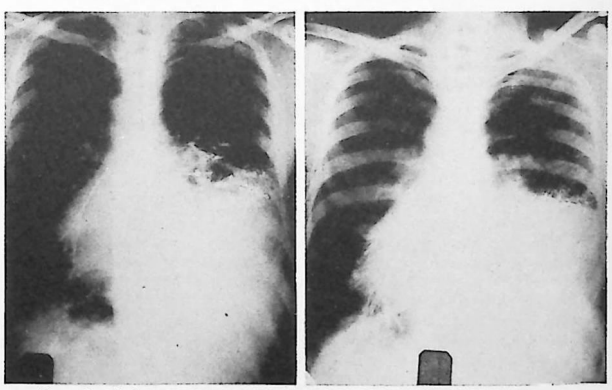


Fig. 1283. Left: x-ray following lipiodol, before operation, showing bronchiectatic sacs. Right: x-ray after operation. Lower lobe and eighth and ninth ribs removed. Case No. 1. E. S., age 37, foundry worker, developed symptoms of bronchiectasis following pneumonia and empyema in December, 1933. Expectoration 8 to 10 ounces of foul smelling sputum daily. Single-stage lobectomy performed June 2, 1936. Recovery was uneventful. Patient is now symptom free and clinically well. (Case of Dr. Richard Davison.)

Step 4. Free the lobe of the lung all the way around except where it is attached to the mediastinum. (Fig. 1286.) Apply rubber tubing around the

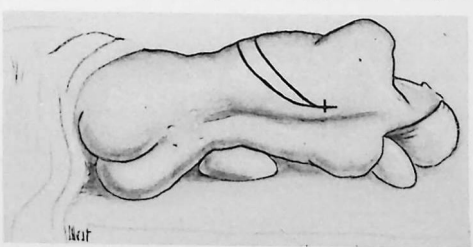


Fig. 1284. Position of patient on the table for lobectomy and cutaneous incision. The upper or lower transverse incision may be chosen. (After Howard Lilienthal.)

hilum or use a crushing clamp to occlude the blood vessels coursing to the lobe of the lung. (Fig. 1287.)

Step 5. Amputate the lung by a wedge-shaped incision in such a manner that the raw borders of the lung tissue may be united over the stump. Secure

the blood vessels by means of several mattress sutures through the stump. Crush and excise the protruding ends of bronchi. (Figs. 1288-1289.)

Step 6. Remove the clamp and inspect the stump for bleeding points. Secure the stump to the adjacent lobe of the lung. To completely remove the lobe, apply a heavy crushing clamp close to the mediastinum and tie the ligatures

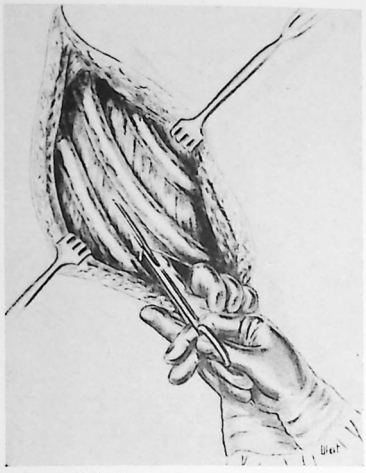


FIG. 1285. Lobectomy. Major intercostal thoracotomy. Incision through the soft parts down to the intercostal structures has been made. The pleura has been entered and with the finger as a guide the scissors are used to lengthen the wound in the intercostal structures and pleura. The ribs are shown plainer and the hands smaller than in life for purposes of illustration. (After Howard Lilienthal.)

deep to this. If a tourniquet is employed, leave some of the lobe tissue for suturing over the hilum.

Step 7. Make a stab wound in an intercostal space in the lowest part of the chest and insert a small tube through it. Unite the pleuro-intercostal structures with interrupted catgut sutures. Approximate the ribs by pericostal or percostal sutures (Fig. 1290).

Step 8. Unite the superficial muscles by a few interrupted catgut sutures. Suture the skin. Dress. Return the patient to bed. Give blood transfusions. If the drainage tube becomes blocked, tension pneumothorax may result.

Two-Stage Operation

SAUERBRUCH'S METHOD

Step 1. Make an incision along the length of the interlobar fissure being careful not to injure the parietal pleura. Create a space into which paraffin wax is inserted.

Step 2. Place the "plombe" over the full length of the septum. This will exert

pressure on the underlying visceral pleura causing adhesions to form. At the same time a stabilization of the mediastinum takes place.

Step 3. Permit two or three weeks to elapse: then remove the "plombe" and excise lengths of the fifth to seventh or the eighth ribs: expose the bronchiectatic lobe.

Step 4. By blunt dissection identify the interlobar fissure situated among the artificially produced adhesions and separate the affected lobe down to the hilum.



FIG. 1286. Lobectomy. The adhesions are being freed digitally, preparatory to dividing them. (After Lilienthal.)

Step 5. Ligate the main bronchus and vessels with a piece of rubber tubing. Natural separation of the lobe follows in from 7 to 17 days. Erosion of blood vessels may be prevented by tying the ligature loosely at first and gradually tightening it. The remaining space is obliterated by granulation tissue. In some cases a residual bronchial fistula requires closure.

ALEXANDER'S OPERATION

Efforts to produce satisfactory adhesions have not always met with success. The operation of John Alexander of Ann Arbor, Michigan, strives to induce traumatic inflammation of the pleural surfaces.

Step 1. Under positive pressure anesthesia, excise the sixth, seventh and eighth ribs. Vigorously rub the parietal pleura with gauze.

Step 2. Close the wound with the lung in full expansion. This treatment should produce adhesions as well as some exudation which may be aspirated if deemed necessary.

Step 3. Ten days later open the chest again and separate the adhesions around the affected lobe by blunt dissection.

Step 4. Transfix the hilum of the lung with stout silk ligatures; the lobe eventually sloughs away. Sometimes it is necessary to separate the cartilaginous bronchus with scissors.[1]

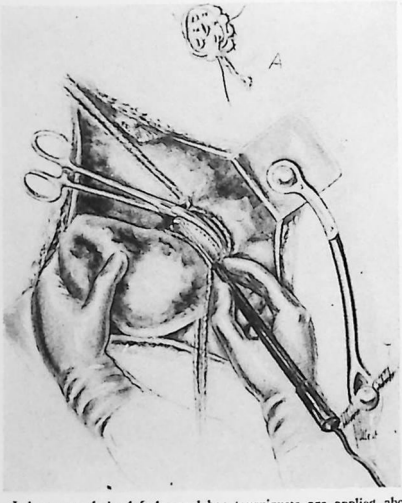


FIG. 1287. Lobectomy of the left lower lobe: tourniquets are applied above and below the line of section. Observe large clamp placed distal to upper tourniquet. Division of the tissues is accomplished with the diatherm knife. Insert "A" shows method of closing pulmonary stump by means of individual mattress sutures embracing individual components of the stump and an overall continuous catgut suture.

GRAHAM'S CAUTERY OPERATION

Cautery pneumonectomy is employed in selected cases with reported success by Evarts E. Graham. The method consists of isolating the affected lobe and causing it to adhere and then destroying the lung tissue with the actual cautery. (Fig. 1291.)

Step 1. Do a free posterior thoracotomy by excising the lengths of two or three ribs. Produce adhesions by packing against the pleura or by suture and a partly closed wound.

Step 2. After ten days the adherent lobe will be found to have decreased in size. The exposed surface is now cauterized with a soldering iron at dull

[1] Edward D. Churchill records a mortality of 6.1 per cent in a series of 49 patients; 5 per cent in another series and still another series of 38 patients with only 2.6 per cent mortality! (Personal communication.)

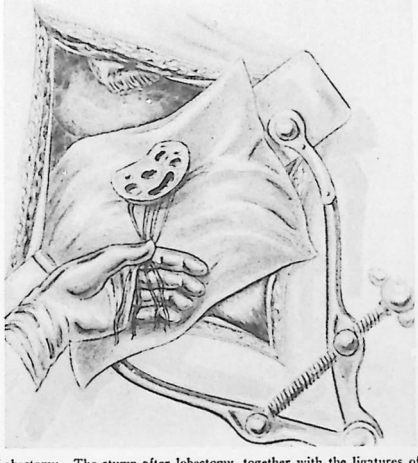


FIG. 1288. Lobectomy. The stump after lobectomy, together with the ligatures of the pedicle, drawn through an opening in a piece of rubber dam. (After Howard Lilienthal.)



FIG. 1289. Lobectomy. Method of closing a bronchus. (Willy Meyer.)

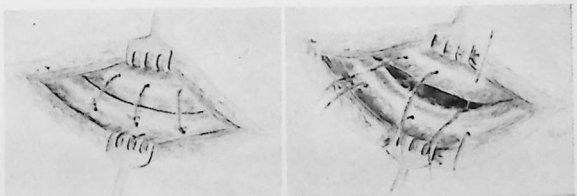


FIG. 1290. Lobectomy. Left, Pericostal suture; right, Percostal suture. (After Sauerbruch.)

red heat (Fig. 1291[2]). Hemostasis is effected by firm packing which is left in place for several days.

Step 3. After three weeks have elapsed, further destruction by the cautery is supplemented by drainage. Bronchial fistulae may form but this is not important.

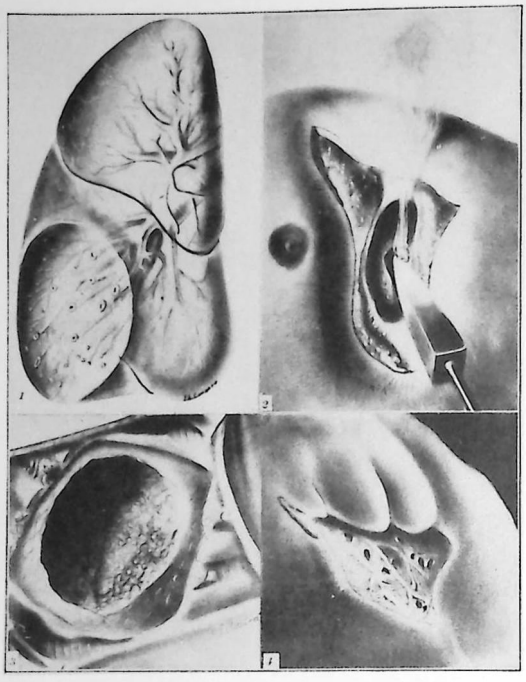


Fig. 1291. Graham's cautery operation of pneumonectomy. (Graham, Singer and Ballon: Surgical Diseases of the Chest, Courtesy of Lea & Febiger.)

The chief advantages of this procedure are that efficient drainage of the dilated bronchi may be instituted in desperately ill patients without having to remove the lobe entirely. Later on, if conditions permit, obliteration of the lobe may be taken into consideration. The chief disadvantage of the procedure is the length of time required for treatment.

RIENHOFF'S[1] TECHNIC OF TOTAL PNEUMONECTOMY

The preoperative preparation of the patient is of the greatest importance. This consists, first, if possible, in complete collapse of the lung by gradually induced pneumothorax. This diminishes the possibility of circulatory disturbance following the immediate ligation of the pulmonary artery on the affected side and seems to prevent the shock associated with the opening of the pleural cavity. For over two years, Rienhoff has produced an inflammation of the parietal and visceral pleura in order to incite a serofibrinous pleurisy followed by the formation of granulation tissue because it is much more difficult, if at all possible, to infect a granulating surface. As a result of this lining of granulation tissue, in the whole series of Rienhoff's fifty-two cases not one instance of generalized empyema or mediastinitis has occurred.

GENERAL TECHNIC

Step 1. A high anterior approach over the hilus, when total removal of the lung is contemplated, is very advantageous. Proper exposure of the lung can be obtained without resorting to the resection of ribs, and at the same time the length of the operation is shortened. In the entire series of thirty-five cases adequate exposure has been obtained by making an anterolateral incision in the third interspace (Fig. 1292) and then separating the ribs by means of a self-retaining retractor. This incision may be made below the line of the nipple and should be carried from the parasternal line in front to the anterior axillary line laterally; if more exposure is desired, it can be continued posteriorly.

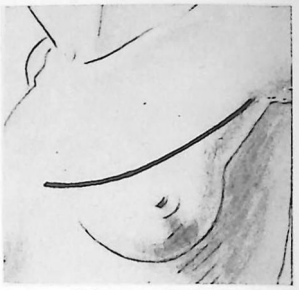


Fig. 1292. Lobectomy. Rienhoff's incision for total pneumonectomy.

Step 2. The fibers of the pectoralis major muscle are divided along their course. This entails no difficulty or impairment of the postoperative function of the muscle.

Step 3. Make an incision dividing the intercostal muscles midway between the third and fourth ribs; avoid the intercostal vessels.

Step 4. Open the pleural cavity as speedily as possible. (It is surprising how extensive an exposure of the entire pleural cavity can be obtained by mere retraction of the third and fourth ribs.) Occasionally, disarticulation of the third or fourth rib at the costochondral junction will occur, but this was not followed by bad results.

Step 5. The lung completely covers the hilus on its anterior and superior surfaces (Fig. 1293 B). The superior surfaces come in contact on both the right and the left sides with the mediastinal pleura. Free and retract this

[1] William Francis Rienhoff, Jr., Archives of Surgery, February, 1936, Vol. 32, pp. 218-231.

lappet which overlies both the right and the left pulmonary artery; the first anterior or ventral branches of the artery are thus exposed (Fig. 1293-C).

RESECTION OF THE LEFT LUNG

Step 1. On the left side the intrapleural portion of the pulmonary artery is very short. Three large anterior branches emerge to supply the upper, middle and lower portions of the superior lobe of the left lung (Fig. 1294

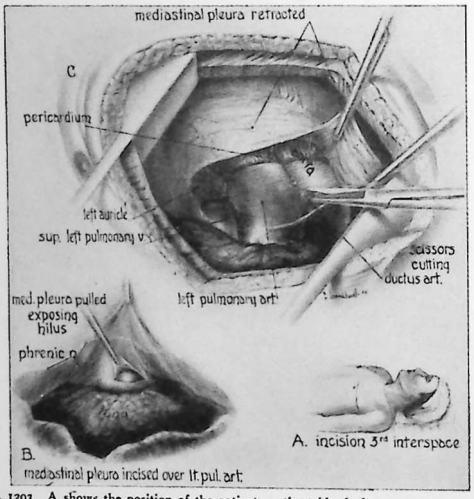


Fig. 1293. A shows the position of the patient on the table during pneumonectomy on the left side. An incision is made anteriorly in the third interspace. This position allows full expansion of the opposite lung. B shows exposure of the mediastinal surface of the upper lobe of the left lung. The anterior margin is laid back. The mediastinal pleura is incised, exposing the pulmonary artery. In C below the scissors may be seen the pleural mediastinal reflection. The pericardial reflection is shown as it blends with the mediastinal pleura after reflection off the systemic and pulmonary aortas. (Courtesy of Dr. W. F. Rienhoff, Jr.)

A and C), while coursing below and immediately behind the primary bronchus is the large posterior branch. This vessel is difficult to expose and because of its relatively thin wall is very easily and inadvertently torn. The artery fans out, as it were, so that its large posterior and smaller anterior branches intimately embrace the inferior, superior and posterior aspects of the primary bronchus. Its exceedingly short length between its emergence and departure of those branches gives the surgeon very little room to free the main artery. The main point of danger is the dissection of the posterior surface of the artery from the anterior aspect of the bronchus, for it is here that the large posterior descending branch may be torn.

Step 2. Control of hemorrhage is also more difficult here than at any other point "because," as Rienhoff says, "the vessels are literally entwined around the unyielding, stiff primary bronchus and can be clamped individually only by the greatest of good luck, the tip of the clamp usually grasping the rigid wall of the bronchus." Incise the mediastinal pleura. The areolar tissue

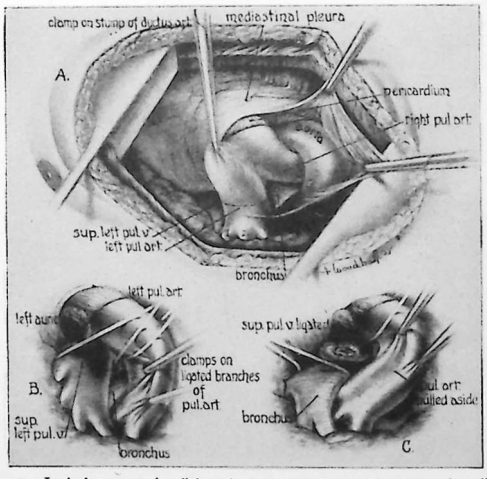


Fig. 1294. In A the suprapericardial mediastinal space described in the text is well defined by the arch of the aorta, reflection of the pericardium, the bronchus posteriorly and the superior left pulmonary vein. The dotted line shows the point of election for ligation of the artery. The intimate association of the two anterior and the large posterior branches of the left pulmonary artery with the bronchus is demonstrated. B shows the point of extrapericardial ligation of the superior left pulmonary vein and artery, indicated by the tapes. Clamps have been placed on the anterior branches (1 and 2), to demonstrate the distribution of the large posterior branch in its relation to the left primary bronchus. The departure of the first branch from the large posterior one is shown. C shows the superior pulmonary vein ligated, exposing the bronchus. The tape marks the level at which the bronchus should be divided. This point is within the extrapericardial mediastinal space. The pulmonary artery is further pulled aside, demonstrating the breaking up of the posterior branch into the first two smaller divisions. (Courtesy, Dr. W. F. Rienhoff, Jr.)

surrounding this portion of the pulmonary artery may be dissected away with ease (Fig. 1293 C). Between the aorta and the superior surface of the left pulmonary artery, a small bundle of white glistening tissue, the fibrous strands of the obliterated ductus arteriosus (Fig. 1293 C), are divided and clamped and used as a retractor (Fig. 1295 A and B). The posterior surface of the left artery is revealed for a distance of 2.5 cm. from the point at which the pulmonary artery divides into the right and left pulmonary arteries.

This space (the point of election at which to ligate the left pulmonary

artery) is extrapericardial and in the superior mediastinum. It is bounded above by the arch of the aorta, behind by the primary bronchus of the left lung and the portion of the pericardial sac covering the left auricle and below by the superior left pulmonary vein, and it is roofed over by a small portion of the redundancy of the superior reflection of the pericardial sac but in the main by the mediastinal pleura. The artery is easily separated from the surrounding areolar tissue lying between it and the left primary bronchus posteriorly and the pericardial sac inferiorly. Separate gently the

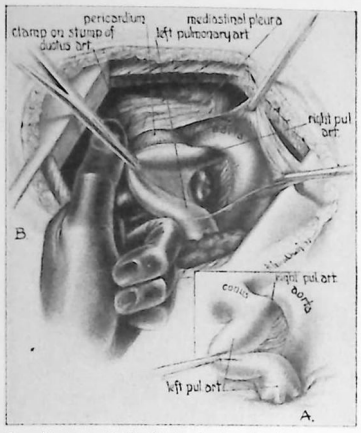


Fig. 1295. A is a diagrammatic sketch showing areolar tissue surrounding the posterior surface of the left pulmonary artery and the division of the pulmonary aorta into the right and left pulmonary arteries outside the pericardium. The first and second ventral branches of the left artery are also shown. B demonstrates reflection downward of the left pulmonary artery by gentle traction on the clamped stump of the ductus arteriosus. The point at which the obliterated strand is severed from the aorta can be seen as a small rough spot on the under surface of the aortic arch. The index finger is passed under the left pulmonary artery with ease. Reflection of the pericardium is also shown. (Courtesy, Dr. W. F. Rienhoff, Jr.)

areolar tissue between the artery and its surrounding structures (the aorta, bronchus and the superior posterior portion of the pericardial sac) (Fig. 1295-B).

Step 3. Ligate the pulmonary artery which divides just outside the pericardial sac about at the region of the stump of the obliterated ductus arteriosus. Close the mediastinal pleura.

Step 4. Ligate the superior and inferior pulmonary veins in the order named as they are within the pleural cavity.

Step 5. Expose the bronchus in the space on the left side and amputate it high. The posterior membranous portion of the bronchial wall is sutured to the anterior cartilaginous rings. These mattress sutures are placed between the

rings along the stump up to the trachea. Cauterization either with the actual cautery or with chemicals is not necessary. Closure is made with the epithelial surfaces abutting each other, just as in suturing the surfaces of the skin. (Fig. 1296.)

Step 6. There are numerous lymphatic glands which lie about the bronchus and can be removed only after an exploration of this space.

RESECTION OF THE RIGHT LUNG

In total pneumonectomy on the right side, the dissection is slightly different and somewhat more difficult than on the left side. The azygos vein is the best landmark for the beginning of dissection.

Step 1. Incise the mediastinal pleura.

Step 2. Dissect gently the areolar tissue, separating the right pulmonary artery from the azygos vein superiorly, the superior vena cava anteriorly and the superior pulmonary vein and the posterior wall of the left auricle inferiorly

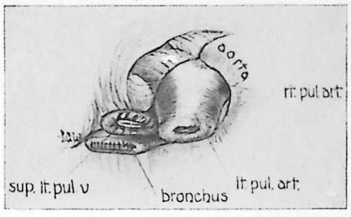


Fig. 1296. This diagrammatic sketch shows the stump of the hilus of the left lung, which has been dissected, with the vessels and the bronchus ligated individually. It will be noted that the bronchus is closed with interrupted silk sutures. This type of closure, with simple ligation of the artery and the vein, is considered the method of choice. (Courtesy, Dr. W. F. Rienhoff, Jr.)

(Fig. 1297-B). The disposition of the branches of the pulmonary artery on the right side differ to some extent from that on the left. Running alongside of the bronchus on the right side is the first ventral or anterior branch, while occasionally, a second anterior branch supplies the lower portion of the upper lobe of the right lung, after which comes the slightly more deeply situated branch to the middle lobe (Fig. 1297 C). The tributaries to the superior pulmonary vein overlie the latter branch as well as the large posterior division of the artery which is by far the largest of the four.

Step 3. Ligate the superior pulmonary vein intrapleurally. Expose the large posterior branch of the right pulmonary artery (Fig. 1297 C). The difficulty of making an intrapleural ligation of the right pulmonary artery is at once apparent, for the distance between the inferior margin of the descending branch and the superior margin of the first ventral branch is greater than the diameter of the main right pulmonary artery. However, with careful retraction of the superior vena cava (Fig. 1297 C) and gentle separation

of the inferior margin of the right pulmonary artery from the pulmonary vein and left auricle, the former may be mobilized proximal to its branches, and a ligature may be placed around it. The right pulmonary artery is, like the left, entirely extrapericardial, but it is longer than the latter. Remove the areolar and lymphadenoid tissue.

Step 4. Eradicate the mediastinal nodes and take care of the bronchus.

Step 5. Remove completely all the tissue of the lung together with the lymphatic vessels. While it may be possible in some instances to remove the lung by placing mass ligatures around the hilus without dissecting out the vessels,

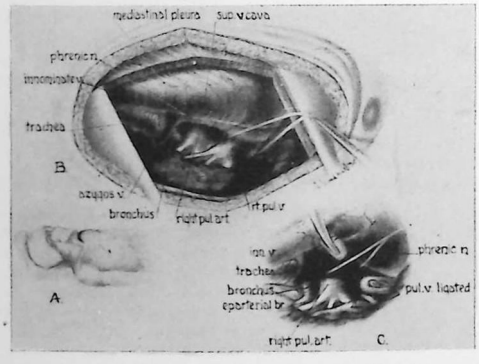


Fig. 1297. A demonstrates the position of the patient on the table during pneumonectomy on the right side. An incision is made anteriorly in the third interspace. B shows self-retaining retractors spreading the third and the fourth ribs apart. The mediastinal pleura has been incised, and the right pulmonary artery and the right superior pulmonary vein are exposed. The azygos vein is shown at the level of the bifurcation of the trachea. The right primary bronchus is seen just below the azygos vein. In C the superior pulmonary vein is ligated, exposing the first two ventral or anterior branches of the right pulmonary artery and the large descending posterior branch. The tape is around the artery at the point of election for ligation. Areolar tissue surrounding the pulmonary artery has been gently removed by blunt dissection, freeing the artery from the primary bronchus posteriorly, the azygos vein superiorly, the superior vena cava anteriorly and the pulmonary vein inferiorly. A Küttner dissector is shown freeing the superior vena cava from the right pulmonary artery. (Courtesy, Dr. W. F. Rienhoff, Jr.)

in many instances the tissue of the lung that is left in such an unsurgical procedure will already have been invaded by the malignant tumor, and a recurrence is certain.

Step 6. Closure of the wall of the chest should be simple. Three pericostal braided silk sutures are placed through the second and fourth interspaces and encircle the third and fourth ribs. The latter are then held together by a rib approximator while the sutures are tied.

Step 7. The overlying pectoral muscle and fascia are brought together with interrupted silk sutures. The skin is closed in a similar manner.

Step 8. Drainage of the thoracic cavity is not resorted to.

Comment: In all of Rienhoff's cases tribrom ethanol in amylene hydrate was used, the dosage being 80 mg. per kilogram of body weight, by rectum. This basal anesthetic was supplemented with nitrous oxide and oxygen, given, except in two cases, without an intratracheal tube. A high percentage of oxygen was used during the operation with a small percentage of nitrous oxide. The anesthesia was very light, and the movements of the diaphragm and mediastinum, after one had become accustomed to the rhythm, were of no great inconvenience. Rienhoff is against the use of a tracheal tube because of the trauma it inflicts and because of the possibility of infection.

The position of the patient in bed after operation is of prime importance in preventing respiratory complications. It is advisable to adopt the Trendelenburg position with the foot of the bed elevated for the twenty-four hours following the operation, thus producing free bronchial and tracheal drainage with the minimum effort on the part of the patient. Avoid tight bandages. After forty-eight hours, the patient can be put in a semi-sitting posture, but he should never be kept in one position throughout the twenty-four hours. The elevation of the bed and the position of the patient in the bed should be changed every two hours during the day and night.

CHAPTER 28

SURGERY OF THE PULMONARY ARTERY

Anatomic Considerations. The pulmonary aorta, often called the pulmonary artery, originates at the top of the conus arteriosus of the right ventricle. It is about 2 inches long and follows an upward, backward direction turning slightly toward the left. Under the aortic arch it separates into the right and left pulmonary arteries. It is invested throughout most of its length by the visceral layer of the pericardium which surrounds it and the basal part of the systemic aorta. At its source it is partly overlapped in front by the tip of the right auricular appendix and in back it is related to the base of the systemic aorta and the proximal part of the right coronary artery. It lies to the left of the systemic aorta, more distally, and rests upon the anterior surface of the left auricle.

In discussing the surgery of the pulmonary artery[1] Willy Meyer of New York stated:

"The trunk of the pulmonary artery is easily accessible: On longitudinal incision of the pericardium, to the outside of the plexus made up of the left phrenic nerve and vessels which run right on the surface of the sac, the first vessel encountered is the pulmonary artery. Its direction is obliquely upward and backward toward the left. The forefinger or a large curved sound introduced right below it in a backward and upward direction toward the right of the patient enters the transverse sinus of the pericardium and passes around the artery and ascending aorta which latter lies on the right side of the pulmonary artery. Both vessels are intimately connected by means of connective tissue and are surrounded by the same layer of the visceral pericardium; it is impossible to separate them. There is no defined sheath of the pulmonary vessel, a thin layer of subserous fat presents itself after the pericardium has been opened. The main trunk of the pulmonary artery lies almost entirely within the pericardium and is about five centimetres (two inches) long. At the concave border of the aortic arch the vessel divides into the right and left branches. The right, longer than the left, turns downward and backward around the ascending aorta, passes the superior vena cava, and divides into two branches, an upper and a lower one, at a level with and right above the right bronchus, before it enters the hilus of the lung. Further on, these two again divide, the pulmonary artery branch always running 'to the north' of the respective bronchus. This is an important anatomic point. The left (shorter) main branch of the pulmonary artery first continues in the original direction of the parent trunk but soon turns downward in front of the left bronchus and the descending aorta toward the hilus of the left lung. There are many varieties in the subdivision of the pulmonary vessels."

PULMONARY EMBOLISM

Howard Lilienthal, in a paper before the surgical staff conference of Mount Sinai Hospital, said, in speaking of pulmonary embolectomy:

"Six per cent of all deaths following surgical operations are caused by pulmonary embolism. My authority for the above statement is a paper by Mahorner and Ochsner, as well as a letter from Dr. Alton Ochsner giving references to

[1] Annals of Surgery, Vol. 58, 1913.

the literature with calculations based on an ample number of cases (more than ninety thousand). He also saves me a bit of literary investigation by telling me that not a single successful pulmonary embolectomy has been performed and recorded in the United States.

"Long before these striking statistics were brought to my notice, I had resolved to do whatever was in my power to arouse interest in this subject so that we might no longer fail to do our best in this terrible accident provided the patient is in good general condition. Refusal to act merely because the lesion happens to involve a structure rarely the site of operative procedure is unworthy of the profession of surgery.

"In 1930 an important paper was read by Gunnar Nystrom of Upsala, Sweden, on pulmonary embolectomy (Trendelenburg's operation). Up to that time fourteen patients had survived operation, of whom seven were 'discharged healed' (50 per cent). Thirty operations, more or less, had been published and probably many more had not been reported. In the discussion (loc. cit.) I stated that, even though in America we do not all have permanent first assistants residing in our hospitals, there is no reason why intensive training in this particular operation, as well as in the diagnosis of embolism, should not be given to a properly qualified House Surgeon who should also be taught to recognize the symptoms of pulmonary thrombosis so that he may at once give the alarm and have the patient transferred to the operating room. It must be remembered that patients apparently dead have been resuscitated and have fully recovered after the extraction of emboli from the pulmonary artery.

"Elliott C. Cutler states that his resident surgeons up to 1934 had operated in four cases. The operations were not successful, and Cutler believes that they were all done too late. Cutler's conclusions are practically the same as those represented by my own remarks three years earlier. The entire matter is one of preparedness. Cutler agrees with me that the resident staff of our hospitals should be authorized to attack the problem in the individual case, though he qualifies his words by saying that 'any good young surgeon who has had five or six years of competent training' should be able to perform the operation.

"Dr. J. C. White in the discussion of Cutler's paper differs somewhat, saying that the procedure is not so simple as represented and that the diagnosis is not always easily made. While I admit that the recognition of the accident may not be possible in 100 per cent of the cases, yet the errors disclosed at operation have been extremely rare—much more infrequent than those found at operation in other emergencies.

"Averbuck recently pointed out the possibilities of error in differentiating acute coronary thrombosis from pulmonary embolism, and others have stressed the matter of diagnostic accuracy. Yet, following along clinical lines, it must be conceded that when life is threatened by any other acute surgical complication and the patient is otherwise a good risk, few surgeons will hesitate to act even though there be only one chance in many to save life.

"Thoracic surgeons with whom I have spoken agree in principle that the only hope in massive pulmonary embolism is by direct attack, not only in cases in which previous operation has been performed, but also in medical diseases and in obstetrics.

"Literature dealing with the technic is still scanty, but American surgeons

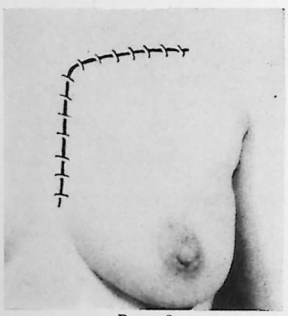


FIG. 1298

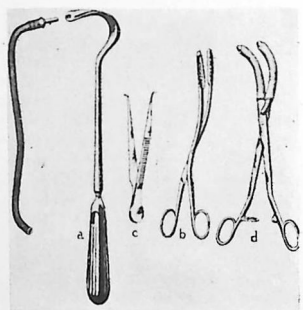


FIG. 1299



FIG. 1300

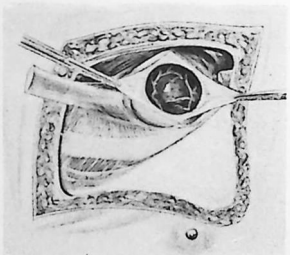


FIG. 1301

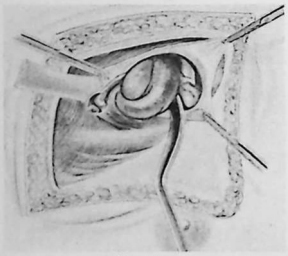


FIG. 1302

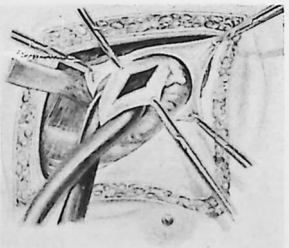


FIG. 1303

FIG. 1298. Incision in approaching the pulmonary artery in performing the Trendelenburg operation.

FIG. 1299. Instruments devised by Trendelenburg for his operation. a. Large curved sound with handle, elastic tube detached; b. blunt-pointed forceps for extraction of emboli; c. forceps with tips turned outward which lift the borders of the incised wound of the pulmonary artery (see Fig. 1305a); d. clamp with rubber covered branches, which closes the arterial wound (see Fig. 1305). (Willy Meyer.)

FIG. 1300. Trendelenburg operation. Exposure of second and third ribs.

FIG. 1301. Exposure of the pericardium.

FIG. 1302. Introduction of Trendelenburg instrument around conus arteriosus.

FIG. 1303. Tightening of rubber tube and opening of pulmonary artery.

are discussing the matter more and more freely, and results are sure to follow. Griswold presented two unsuccessful cases, one of which might have resulted in recovery but for delay. Meyer, in 1926, devised a simplified approach directly through the pericardium and was fortunate enough to save three patients.

"But this is all beside the mark. My earnest wish is that there should be no delay in mapping out a plan for this great clinical and scientific advance. The medical, surgical, and intern staffs of the hospital and the head nurses should be molded into a carefully worked out organization, and should, to use a modern expression, become 'embolectomy minded.' But whatever the plan, it is urgent that down to the last detail, things should be ready for the treatment of this emergency. The first successful case in this country will mean much to American surgery and, incidentally, to the hospital which has had the foresight to be ready for effective action."

PULMONARY EMBOLECTOMY—TRENDELENBURG OPERATION

In man, the best method known at present of obtaining access to the main trunk of the vessel is that devised by Trendelenburg. In experimental surgery upon dogs an intercostal incision in the third or fourth interspace with the use of rib-spreader suffices for proper access.

The Trendelenburg operation as finally worked out, is briefly as follows:

Step 1. A horizontal incision about ten centimetres long is made upon the left second rib, beginning at the left border of the sternum and dividing skin, fascia and fibers of the pectoralis major muscle.

Step 2. This is crossed by a perpendicular cut which starts right below the sternoclavicular articulation and passes the cartilage of the third rib about one inch outside of the sternal border; it avoids the left internal mammary artery (or the incision depicted may be used, Fig. 1298).

Step 3. The flaps with the underlying muscle are turned back.

Step 4. Isolate and divide the second rib (Fig. 1300). In raising and twisting the sternal portion of the rib the cartilage breaks; this portion of the rib is removed.

Step 5. Divide the third cartilage in a perpendicular line. Usually by this time the pleura has been opened and the use of differential pressure is of great value provided time and a sufficient number of assistants are at the surgeon's disposal. If the pleura has not been opened an incision through it, corresponding to the outer one, has to be made. The lung is allowed to collapse, somewhat, and thereby the pericardium exposed. Upon it the phrenic nerve and phrenic vessels become visible.

Step 6. Inwardly of the same the pericardium is incised at the level of the third rib and the wound lengthened in an upward and backward direction until the entire upper half of the pericardium is divided; the lower half remains closed and the heart itself remains in its normal position. All this can be done well within five minutes.

Step 7. A rubber tube with the help of Trendelenburg's sound (Figs. 1299-1301-1302-1303-1304-1305) is then quickly drawn through the transvere sinus of the pericardium around the ascending aorta and pulmonary artery, held, and pulled upon for compression by an assistant, immediately before the

surgeon punctures the vessel with a sharp-pointed scalpel. The presenting thin layer of fat with the visceral pericardium having been torn, if time permits, the wound in the arterial wall is lengthened with care between two anatomical forceps for about one centimeter (½ inch).

Step 8. Without a moment's loss of time a specially curved, blunt forceps is introduced, first into the main artery, then into its branches, the thrombus or thrombi are grasped and extracted. Only 45 seconds are at the disposal of the surgeon for this, the principal part of the operation, since observations have shown that the interruption of the circulation in this part of the body is not tolerated longer.

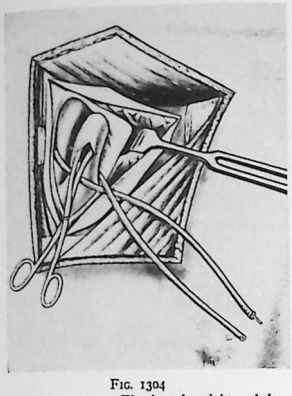


FIG. 1304

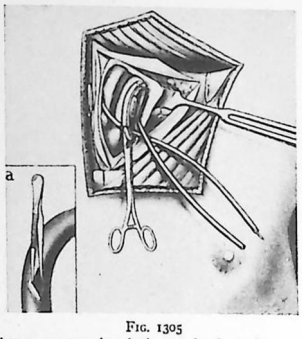


FIG. 1305

FIG. 1304. Elastic tube tightened by assistant, compressing both vessels (not shown in illustration). Pulmonary artery incised and forceps introduced for extraction of emboli. (Willy Meyer.)

FIG. 1305. Longitudinal wound in pulmonary artery clamped laterally, permitting blood circulation along side during the act of placing the interrupted sutures. FIG. a. Forceps introduced to facilitate lifting and proper clamping of artery. (Willy Meyer.)

Step 9. Now the lips of the vessel wound are lifted up by special forceps and temporarily closed by a clamp, after which the assistant interrupts the elastic compression. Circulation therewith having been re-established the heart immediately begins to contract, often violently, if the patient has not died before. If needs be, the maneuver of compression, reopening of the arterial wound and introduction of clot forceps can be repeated.

Step 10. Closure of the wound in the pulmonary artery by interrupted silk sutures is rendered easier by pulling at intervals on the elastic tube, which will put the artery at rest for a few seconds.

Step 11. Close the wound of the pericardium and chest according to ordinary surgical rules.

Prof. Trendelenburg wrote: "All new and difficult problems require much work, favorable conditions and unfaltering confidence and perseverance. This holds good also in the operation for pulmonary embolism. Twelve times have we done it at the clinic, my assistants oftener than myself, and not once with success. And yet, I would continue trying. This much we have learned from our cases, that the diagnosis in all surgical cases is easy; invariably did we find the emboli."

Trendelenburg's operation is nicely adapted to the endeavors of present times. The ideal way of dealing with an acute arterial embolism is to cut down on the seat of the thrombus after proper localization, remove it and close the rent of the arterial wall by suture. Trendelenburg deals with the most common form of embolic troubles which, if left alone, are frequently fatal. He has succeeded in overcoming the technical difficulties that seemed at first glance to block the way. The steps of his operation are clearly defined.

If it could be shown that patients can entirely recover after the operation, surgeons would, no doubt, be less inclined to temporize, but would operate as soon as the diagnosis has been made.

All surgeons speak of the enormous distention of the right ventricle of the heart after the onset of the catastrophe, which, as a matter of necessity, increases from minute to minute.

Trendelenburg's assistants, Laewen and Sievers, on the basis of experimental work, recommend artificial respiration with oxygen during the operation, and injections of adrenalin into the left ventricle, immediately after the elastic compression of the vessels has ceased. They also found that the aorta and pulmonary artery can be compressed for from six to eight minutes without endangering life, a point which had already been emphasized by Sauerbruch previously. The explanation is that in the former case the distention of the right heart is added to the interruption of the circulation. On the basis of these findings, Jeger[1] proposes compressing the two big veins, when carrying out Trendelenburg's operation, rather than the two big arteries. In his experiments along these lines he found that he could do the incision and closure of the pulmonary artery leisurely. The incision of the pulmonary artery brought immediate relief to the distended right heart. He thinks it might be still better to commence work on the heart with puncture of the right ventricle.

According to Trendelenburg, coagulation of the blood and recurrence of the embolic accident can be avoided by injections of hirudin. His assistants, Rimann and Wolf, investigated this question. They found that one milligramme hirudin prevents the coagulation of 5 cc. of blood for four and one-half hours. This would mean for a patient of average weight 1 gramme (15 grains), at present a rather expensive procedure, as the cost of one gramme hirudin is almost $20.00. The drug injected intravenously in large amounts, proved harmless.

Some authors have called Trendelenburg's operation of little practical value, because, if the embolus is large, the patients die within a few minutes, and if it is of smaller size, it often does not endanger life and the patients do not need operation.

However, according to Trendelenburg's experience, there remains a certain proportion of patients, at least 50 per cent, in whom only one branch of the

[1] Die Chirurgie de Boutgefässe u. des Herzens, 1913, p. 243.

pulmonary artery becomes obstructed at first, and death does not occur until 10-60 minutes after the onset of the embolic attack. These patients present a clear indication for his operation. At least 15 minutes are usually at the disposal of the surgeon. Assistants and nurses must be trained to recognize the attack.

A. W. Meyer[1] in an illuminating contribution pointed out that:

1. Opening of the pleura increased shock tremendously, a condition not well borne by an already damaged heart;
2. Trendelenburg's forceps which are put on the side of the pulmonary artery for the purpose of suture are too wide, therefore, encroach too much upon the avenue through which blood has to pass;
3. That the time honored rubber tube covering the forceps is not very effectual because it causes the forceps to slip;
4. The 45 seconds of strangulation to which the large vessels are subjected during the compression with the rubber tube is too long a time and causes irreparable paralysis of the respiratory center.

Meyer's studies on the cadaver have shown that:

1. Opening of the pleura may be avoided.
2. His modification of the Trendelenburg's forceps permits the circulation of the blood in the pulmonary artery to continue without much encroachment.
3. Slipping of the forceps may be avoided by gauze covering instead of rubber.

A. W. Myer's Technic

Step 1. Make the usual skin incision; expose the second and third ribs.

Step 2. Ten to twelve cm. of periosteum are stripped off from the ribs with a Doyen raspatory. Work fast but cautiously. This will avoid opening the pleura. With the index finger of the right hand introduced into the lower medial angle and palpating between the sternum and the attachment of the third rib, push the pleura and the mammary artery gently out of the way. The pericardium (a white shining membrane covered in places with fat) at once comes to view (Fig. 1306).

Step 3. Incise the pericardium (Fig. 1307) so you can introduce two fingers into it. Spread the opening of the pericardium gently, but with determination so that both fingers may be introduced with ease. By so doing, the pleura glides further out of the way and the pericardial cavity may be opened with astounding facility. On occasions, particularly when one practices on the cadaver, doubt often arises whether the vessel presenting is the aorta or the pulmonary artery. In the living subject the pulmonary artery presents itself promptly, much distended, firm and pulseless. Encircle the pulmonary artery with a Trendelenburg tube (Fig. 1308).

Step 4. Enlarge the incision in the pulmonary artery upward for about 1½ cm. while the rubber tube remains loose (Fig. 1309). Immediately dark

[1] Arch. f. Klin. Chir., 1927.

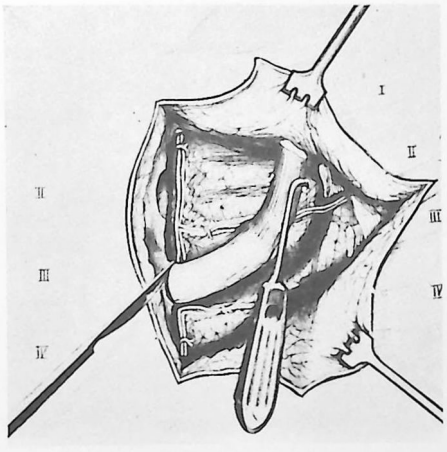


FIG. 1306. Embolectomy (Meyer). Incision. Resection of ribs. Ligation of arteries.



FIG. 1307. Embolectomy (Meyer). Pushing away of pleura. Opening of pericardium.

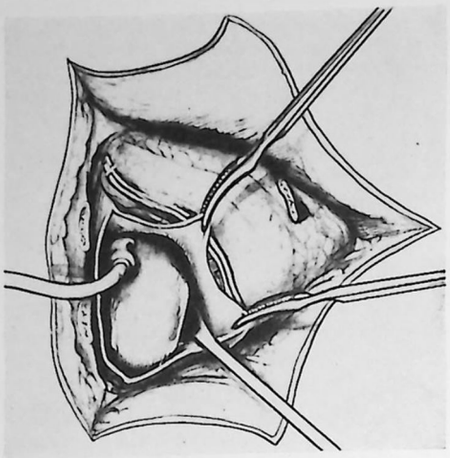


FIG. 1308. Introduction of rubber tube. (A. W. Meyer.)

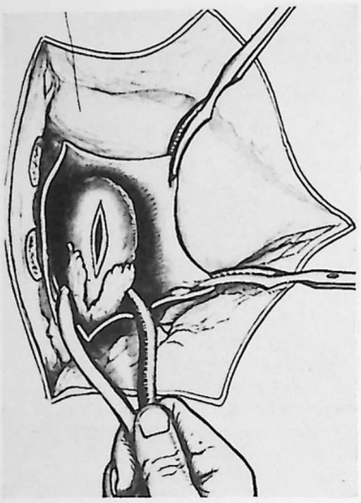


FIG. 1309. Incision into tense pulmonary artery. Tube loose. (A. W. Meyer.)

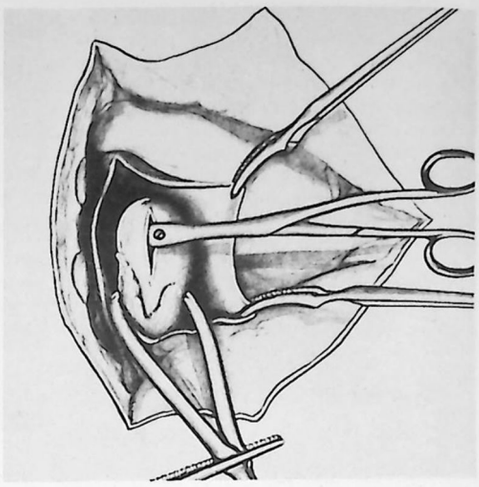


FIG. 1310. Clearing of right branch of pulmonary artery of emboli. Rubber tube somewhat tensed. (A. W. Meyer.)

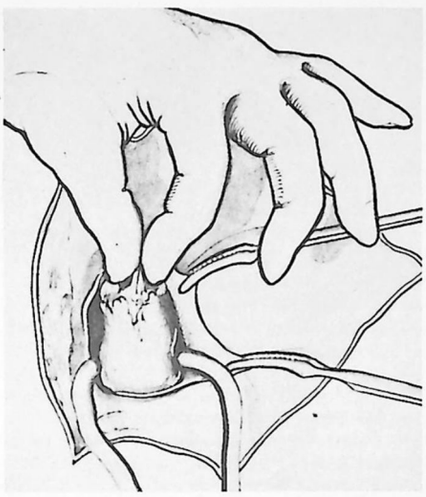


FIG. 1311. Rubber tube released. (A. W. Meyer.)

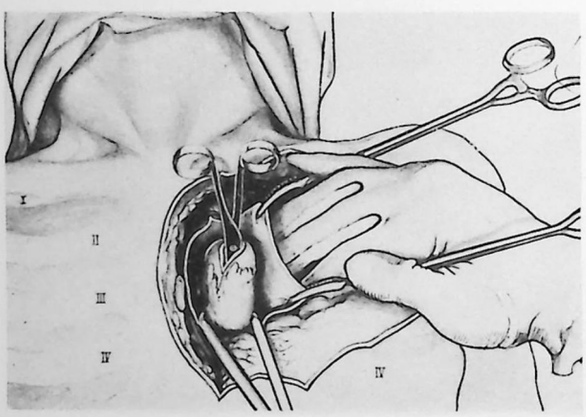


FIG. 1312. Cleaning out of the left branch of the pulmonary artery. Tube tense. (A. W. Meyer.)

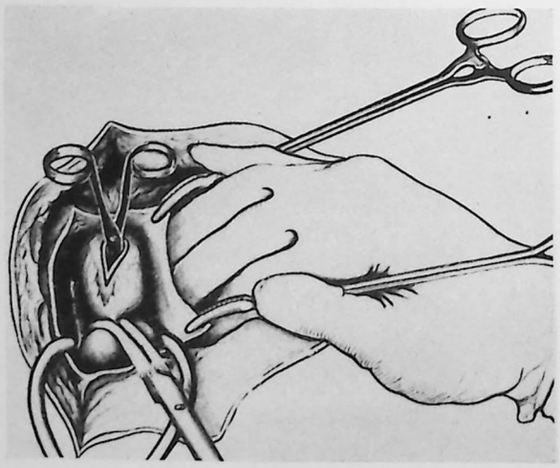


FIG. 1313. Suggested method of compression of pulmonary artery. Tube relaxed. (A. W. Meyer.)

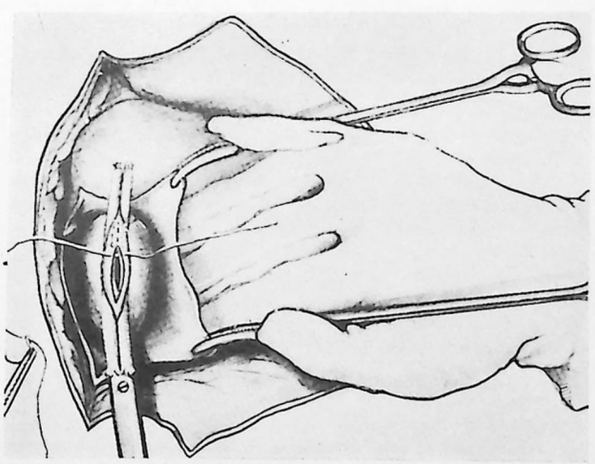


FIG. 1314. Application of vessel clamp. Suture. For clarity's sake the tube is not shown; it is removed only after the clamp is removed. (A. W. Meyer.)

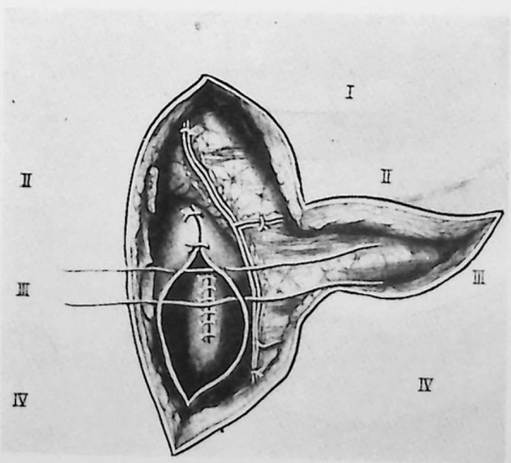


FIG. 1315. Suture of pericardium. (A. W. Meyer.)

blood will issue washing out emboli that may spring from the heart. Allow this to continue for a while for, as Schumacher has shown, this will tend to relieve the right ventricle. Now tighten the rubber tube somewhat.

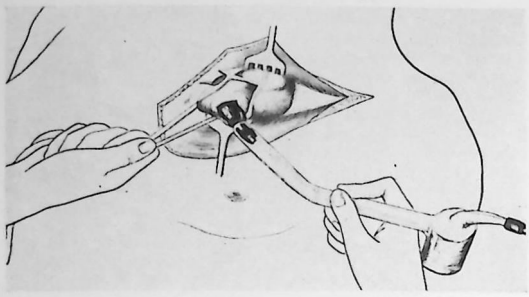


Fig. 1316. Extraction of embolus with Nystrom's suction apparatus. (From a sketch kindly sent the author by Prof. Nystrom.)

Step 5. Enter the right branch of the pulmonary artery with the Trendelenburg embolus forceps (Fig. 1310) in a horizontal position. If the right branch of the pulmonary artery is free (entering it about 3 times is sufficient), quickly grasp the opening in the pulmonary artery with the thumb and index finger of the left hand, closing it. Now release the rubber tube. Permit the blood to run through the pulmonary artery for a few seconds (Fig. 1311).

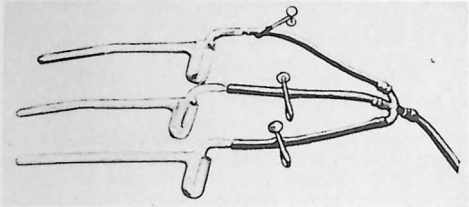


Fig. 1317. Nystrom's suction apparatus. (From a sketch kindly sent the author by Prof. Nystrom.)

Step 6. Tighten the tube (Figs. 1312-1313). Enter about 3 times into the left main branch of the pulmonary artery. Give the heart some rest now by loosening up the rubber tube and again compressing with the fingers the opening in the pulmonary artery. Now for the second time pull powerfully on the tube. With a tissue forceps in the left hand grasp the upper

end of the incision in the pulmonary artery which is pulled upward while the right hand hugs the vessel tightly. Apply vessel clamp and release the rubber tube.

Step 7. Suture the pulmonary artery with interrupted sutures. This must be done carefully in order to avoid tears in the vessel wall (Fig. 1314). One must remember that the pulmonary artery is brittle. When the suture is completed, open the forceps, pull the sutures left long upward and see if there is any bleeding. If so, reapply the forceps and introduce additional sutures.

Step 8. When everything is dry, close the pericardium. (Fig. 1315.)

Comment: Instead of forceps, Professor Gunnar Nystrom of Upsala, uses suction to clear the pulmonary artery of emboli.[1] He graciously sent me his original drawings depicting the suction apparatus and its use (Figs. 1316-1317).

[1] Annals of Surgery, Oct., 1930.

CHAPTER 29

SURGICAL APPROACH TO THE MEDIASTINUM

Anatomic Considerations. Excepting the larynx and a portion of the trachea, the thorax contains all organs of respiration. The lungs take up the largest part of this cavity extending anteriorly from the vertebrae to the sternum. The space between the pleurae is called the mediastinal space and is divided into four sections called mediastina. The superior mediastinum occupies the plane extending from the disc under the fourth thoracic vertebra to where the first and second pieces of the sternum join; the thymus, aortic arch and branches, the innominate veins and superior vena cava are found here. The trachea, esophagus, thoracic duct, the pneumogastric, phrenic and sympathetic nerves pass in it. The area under the plane referred to above is divided by the pericardial sac into an anterior, a middle and a posterior space. The heart is found in the middle mediastinum where also is found part of the roots of the lungs. The lower part of the thymus, a few lymph-nodes, fat and areolar tissue are found in the anterior mediastinum. The esophagus, aorta, thoracic duct, azygos veins, pneumogastric and sympathetic nerves are found in the posterior mediastinum.

MEDIASTINOTOMY

TRANSSTERNAL MEDIASTINOTOMY (MILTON'S OPERATION)

A description of Lilienthal's modification of this procedure follows. It is particularly applicable in substernal growths, often goitrous, but it may also be employed in dealing with infections:

Anesthesia. Ordinary inhalation anesthesia may be employed. Guard the field of operation by some form of screen. Facilities must be at hand for intrapharyngeal pneumatic pressure in case one or both pleurae be entered.

Step 1. Make a low collar incision (Fig. 1318). If the substernal mass is continuous with the thyroid tissue in the neck, work the finger carefully down, keeping close to the substernal growth; gently free the tumor from its adhesions as far as possible. If hemorrhage is encountered it will most likely be venous and will cease when the finger is withdrawn.

Step 2. Make a sagittal incision from the interclavicular notch almost or quite to the xiphoid, carrying this incision down to the bone. With a chisel, osteotome, or Schumacher's sternum shears split the sternum from the interclavicular notch as far down the gladiolus as seems necessary, judging by the estimated size of the tumor. At the end of this longitudinal incision the bone section is continued at right angles, left and right, at the level of an interspace. The sternum is apt to bleed freely. Work with dispatch.

Step 3. When the bone section has been completed, divide the retrosternal periosteum. Retract right and left with sharp-pronged retractors in the bone. Gradual exposure of the mediastinum through a cleft at least 1½ inches in width can be accomplished. Bleeding from the bone may be checked by rubbing a bit of muscle into the cut surface. Danger of injury to the internal mammary vessels is slight. If these vessels should accidentally be injured, the bleeding point must be secured by resecting a cartilage.

Step 4. Through the transsternal mediastinal exposure the tumor can be pushed

upward toward the neck and eventually delivered through the superior aperture of the thorax.

Comment: Lilienthal admonishes that in carrying out this maneuver the thyroidea ima artery, which when present usually arises from the aorta itself, must be borne in mind. The vessel is often of considerable size and can be recognized and secured before it is divided. He further remarks:

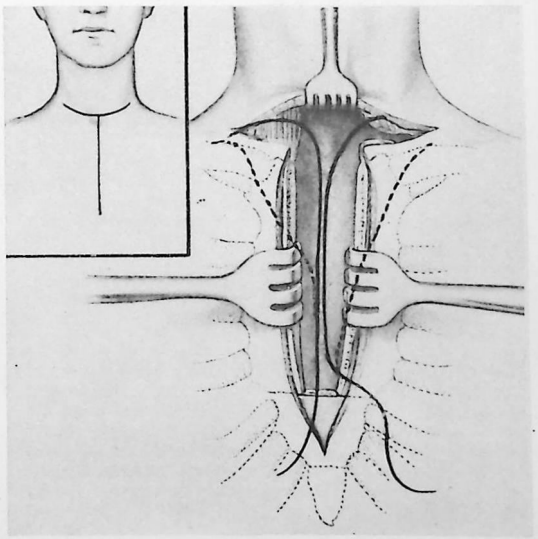


Fig. 1318. Milton's transsternal mediastinotomy as modified by Howard Lilienthal. (Courtesy of Dr. Lilienthal.)

"If ordinary inhalation anesthesia has been employed, the motion of the pleural sacs oscillating with respiration alternately away from and toward the central plane of the body will be seen, and the excursions are often so great as to be almost alarming. A little intrapharyngeal air pressure will cure this and breathing will become more placid. Through this exposure the motion of the heart within its sac can also be clearly observed. After careful inspection for hemorrhage the wound may be closed with sutures through the skin alone which, being still adherent to the sternum will draw the halves of this bone into apposition."

If the possibility of infection is suspected, drain by a thin piece of

gauze placed under the sternum before suturing and leading out through the median line at the root of the neck.

T. P. Dunhill's modification of the transsternal operation consists of creating a trap door of half of the sternum from the suprasternal notch as far down the gladiolus as necessity demands. The flap consists of the sternal portion, together with part of the clavicle and the required number of ribs.

PARASTERNAL (ANTERIOR) MEDIASTINOTOMY

In draining the anterior mediastinum when an effusion or exudate pushes its way to one side or the other of the sternum, thus stripping the pleura away, the anterior mediastinum may be reached without perforating or splitting the sternum.

Technic. A T-shaped parasternal incision is made and one or more costal cartilages are resected mesial to the internal mammary vessels. For drainage, the removal of a section of only one cartilage will give a wide exposure. This operation is applicable when encapsulated fluid (cold abscesses) is to be attacked.

Tuffier[1] explored the upper part of the anterior mediastinum through an incision in the third intercostal space; he pushed the pleura aside and palpated the lung through the unopened pleura after peeling it away from the chest wall in search of tumors which he recognized by the increased resistance of the tissues.

SURGICAL APPROACH TO THE POSTERIOR MEDIASTINUM

Lilienthal's Operation

Any part of the mediastinum may be approached posteriorly without entering the pleura. The operation is indicated when drainage is sought, for the removal of neoplasms or other pathological entities and as an exploratory measure.

Nasiloff, Bryant, Enderlen and others enter the posterior mediastinum by multiple rib resections or by making a trap door of ribs and soft parts swinging upon a sagittal hinge. Lilienthal found the best approach to the posterior mediastinum to be one which depends upon the retraction of the divided ribs at right angles to their long direction, shingling them one on the other, making the deep exposure from below upward, the extent of available space being determined by the length of the wound, especially that portion which divides the intercostal extrapleural structures.[2]

The patient should be placed upon the side opposite the proposed approach, and turned about 30 degrees toward the front so as to bring the field of operation to the most convenient position for the surgeon. The thighs should be flexed and held by straps passed under the table (Fig. 1264). The arm beneath may be a little behind the patient, the other drawn forward and a little upward. The position of the body must be maintained by means of large sand-pillows. A pillow or the bridge of the operating table will raise the body into a moderate scoliosis.

Ether or nitrous oxide and oxygen or a combination of both should be

[1] Rapport au Congrés, International de Chirurgie de Londres, August, 1913.
[2] Howard Lilienthal, "Thoracic Surgery," W. B. Saunders Co., 1925.

used as an anesthetic. If a general anesthetic is used preparations must be made for the immediate application of differential pressure, because of the danger that both sides of the chest may be opened when stripping the pleura forward. At the level of the eighth and ninth dorsal vertebrae the right pleura often sends a fold across the median line for an inch or more into the left chest, and if the left pleura has been accidentally torn and the right is also opened, death will quickly follow unless there is positive pressure in the air passages or negative pressure at the wound. If neither pleural sac is injured ordinary inhalation narcosis is all that is necessary.

Posterior mediastinotomy may be performed on the left or the right side and it may be divided into two main types, low and high.

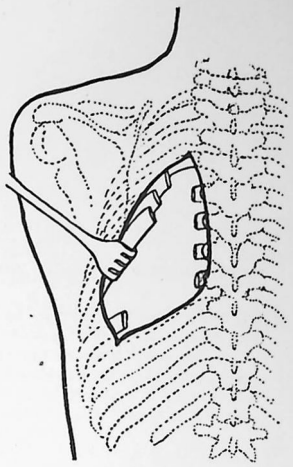


Fig. 1319. Posterior mediastinotomy by Lilienthal's method. Resection of only one rib. Division of three others with retraction and shingling of ribs over each other. Almost no loss of chest capacity. (From Lilienthal, Thoracic Surgery, W. B. Saunders Co.)

Low Posterior Mediastinotomy

Step 1. Make an incision upon the ninth rib beginning 7 or 8 inches from the spine and running backward along the rib to the edge of the long spinal muscles, then curving upward parallel with the spine for four or five interspaces.

Step 2. Resect the ninth rib subperiosteally as far as the wound will permit. (Figs. 1319-1320.) Simple access to the posterior mediastinal space can be accomplished with a much shorter resection or possibly even by merely dividing the ribs. The normal pleura is extremely thin and will easily tear.

Step 3. Insert the finger slowly between the posterior unresected part of the rib and its periosteum, peeling this membrane and the pleura forward away from the posterior chest wall. Stripping in this region is easier because the attachment of the pleura to the parietes is much less intimate here than more anteriorly. After the pleura has been separated from the eighth rib this bone can be divided with powerful cutting forceps; the finger passing under the rib acts as a guard.

Step 4. Separate the pleura, beneath which the lung can be seen smoothly gliding, still farther forward, using two or three fingers of the right hand for the purpose. The seventh rib is treated as was the eighth. The stripping becomes easier as it proceeds upward and often the pleura literally falls away from the mediastinum, especially above.

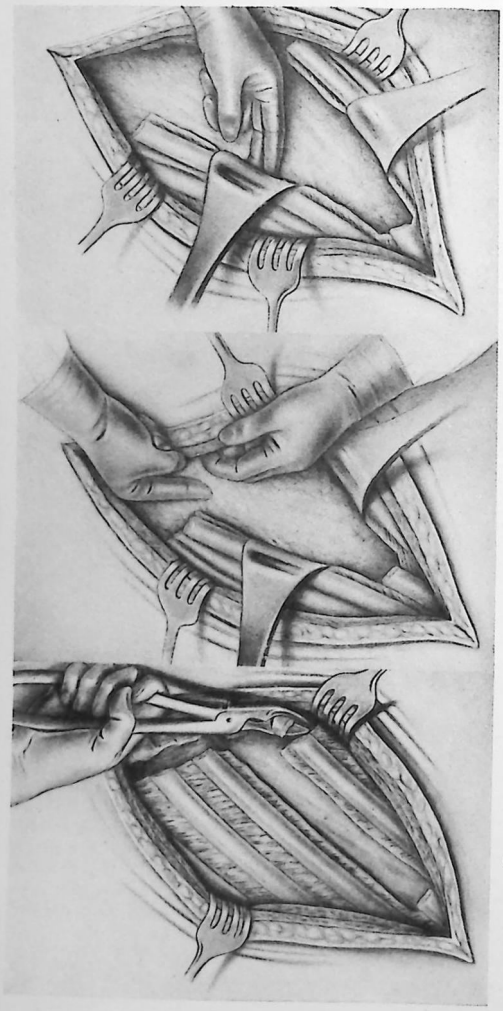


Fig. 1320. Posterior mediastinotomy, with rib resected.

Fig. 1321. Retraction of ribs at right angles to their long axes. Left hand peeling pleura away from posterior chest wall. Note shingling of ribs by retractor. Pleura unopened. Hands depicted small to expose more of wound.

Fig. 1322. More exposure by rib retraction. Hand is peeling pleura from ribs anteriorly. (Lilienthal: Thoracic Surgery, W. B. Saunders.)

Fig. 1322. Seventh, eighth, ninth and tenth rib divided. The tenth rib is shortened toward the spine by the forceps.

Step 5. Divide as many of the next upper ribs as may be required close to the spine; strip the pleura and lung forward with increasing gentleness until it appears that enough space has been made (Fig. 1321). Exert a firm pull with a broad blunt retractor against the lower edge of the eighth rib at right angles to the rib exposing the first landmark, the great splanchnic nerve, as it lies upon the posterior chest wall part way up the elevation formed by the bodies of the vertebrae. (Fig. 1322.)

Step 6. Press the pleura still farther forward; feel the descending aorta and



Fig. 1323



Fig. 1324

Fig. 1323. Peeling the pleura from the descending aorta. Note intercostal arteries and great splanchnic nerve.

Fig. 1324. Showing lung within pleura; pericardium unopened, spine, great splanchnic nerve, esophagus and aorta. Blunt retractor is drawing aorta a little away from spine. (Lilienthal: Thoracic Surgery, W. B. Saunders.)

lay it bare together with the fascia-covered left part of the vertebral bodies (Fig. 1323). In front we now have the esophagus with the pneumogastric nerves, the right, more posterior one, being easiest to locate (Fig. 1324). The recognition of the esophagus by sight or touch is not easy, even when a good-sized stomach tube has been inserted through the mouth as a guide. Lilienthal therefore devised a diaphane which consists of a rubber tube, 32 to 40 French caliber, into the end of which is fitted a little electric lamp, the wires passing through the tube to a small hand battery. This is passed into the gullet through the mouth by an assistant and the light on being flashed shows through the tissues with a bright crimson glow, instantly indicating the location of the lumen of the organ. The esophagus is nearly always carried forward with the pleura and pulmonary ligament much as the ureter is drawn forward with the peritoneum.

Step 7. There is a net-like layer of tissue which holds the esophagus and the descending aorta together and is continuous with the adventitia of the artery and probably with the pulmonary ligament. This may be lifted from the vessel with forceps, divided with scissors, and partly stripped away to facilitate orientation of the esophagus. Rolling the aorta from its position is dangerous; its intercostal branches on the far side may be torn and the resulting hemorrhage may be difficult to control.



FIG. 1325



FIG. 1326

FIG. 1325. Left posterior mediastinotomy with high exposure showing the structures seen from this angle. Innominate vein not shown. Subclavian artery appears vertical at operation. Recurrent laryngeal nerve exposed.

FIG. 1326. Posterior mediastinotomy showing possibility of reaching thymus by this route (drawing from cadaver). (H. Lilienthal: Thoracic Surgery, W. B. Saunders.)

In exposing the esophagus guard against vagus shock and avoid entering the pleura. The vagus may be temporarily blocked (Torek) by applying to the region above the place where the dissection proceeds 5 per cent cocaine on a cotton pledget. To keep the pleura intact gentleness in manipulations is essential. Every effort must be made to identify the right pleural reflection. The outer layer of the esophagus consists of muscle which can easily be torn by rough handling and the lumen of the gullet accidentally entered.

Step 8. Identify the right, more posterior vagus with its plexus gullae and divide the nerve branches of the plexus with scissors if it is desired to isolate the esophagus. The left vagus is usually not seen.

Step 9. Draw aside the pleura and lung with a large broad retractor and expose the posterior wall of the pericardium.

In freeing the esophagus downward it, and the nerves accompanying it, may

be followed forward to the hiatus in the diaphragm. It is not always easy nor possible to peel the pleura away from the central portion of the diaphragm.

High Posterior Mediastinotomy. This operation is carried out on the same general plan as the preceding operation just described (Figs. 1325-1326).

Step 1. Here the seventh or even the sixth rib is first resected, and the fifth, fourth, and third are divided posteriorly. At this level the approach may be from right or left, but in contemplated operations upon the esophagus the right side is preferable.

Step 2. The trapezius and rhomboid muscles are divided and the scapula drawn far forward.

Step 3. The separation of the pleura from the chest wall is distinctly easier than it is below, and this sac with its contained lung may be pressed downward from the superior opening of the thorax, exposing the entire aortic arch with its branches. The trachea and its bifurcation, the esophagus, and the other structures of this region can be seen and handled with facility. The operation now proceeds above the cardiac branches of the vagus, so that cocainization of the pneumogastrics is more important here than it is below. In the right-sided operation the azygos vein must be ligated and cut. The esophagus is then easily found where it passes behind the aortic arch.

Comment: In diffuse infections of the posterior mediastinum, even when the condition extends to the superior portion, drainage must be of the widest kind and at the time of operation. Vaselined gauze or rubber dam with gauze placed upon it is used (Mikulicz). Tubes should be avoided except for draining pockets. Here soft black rubber tubes may be cautiously employed. Do not disturb the original packing for four or five days or even longer. In about ten days the dressings must be changed daily. Be sure that there are no undrained pockets.

Accidental opening of one pleura does not necessarily mean that the operation must be immediately abandoned. Differential air pressure permits the operation to be continued. When the wound in the pleura is too large for suture or the pleura is too fragile to hold the sutures, cover the rent with gauze or rubber dam; pack the remainder of the mediastinum and close the external wound. In a few days the lung will expand and seal off the rent in the pleura.

CHAPTER 30

SURGERY OF THE ESOPHAGUS

Historical Notes on the Surgery of the Esophagus. It is interesting to follow the development of esophagoscopy. In Athens sword swallowers, about 2,000 years ago, passed hollow tubes down their esophagi into their stomachs. To Stork (1861) belongs the credit to first having passed a rigid tube down the esophagus of a patient. Kussmaul in 1868 performed direct esophagoscopy under a general anesthesia thus diagnosing carcinoma in the thoracic portion of the esophagus. The author was pleased to have the son of Leiter, the instrument maker of Vienna, show him models of an esophagoscope his father made for Mikulicz in 1881 in which proximal illumination was a feature. Gottstein (1891) advocated esophagoscopy under cocaine anesthesia. Killian (1902) did much to elaborate esophagoscopic procedure for diagnosis and removal of foreign bodies from the esophagus. In 1902 Einhorn had constructed an esophagoscope carrying an auxilliary tube in the main tube, the former carrying the lighting bulb to the distal extremity of the tube. Chevalier Jackson (1904) combined the Einhorn principle of illumination with Killian's tube.

Though it is usually stated that Mondiére was the first, in 1883, to describe an esophageal condition clearly, priority must certainly be claimed for Sir Charles Bell. The latter, in 1816, recorded a case of difficulty in swallowing which was temporarily relieved by the passage of esophageal bougies. The diagnosis was verified by autopsy. Bell not only pointed out the pharyngeal origin of the diverticulum but also offered the explanation which has proved the most plausible one. He reasoned that the difficulty in swallowing is due to a spasmodic contraction of the sphincter at the lower part of the pharynx; hypertrophy and fasciculation of the pharyngeal musculature results and finally herniation of the mucosa which so frequently occurs in the hypertrophied bladder due to urethral obstruction. Bell also suggested the possibility of alleviating such conditions by the establishment of a cervical fistula.

Rokitansky classified such pouches according to whether they originated primarily from pressure from within or traction from without, and hence the terms "pulsion" and "traction" diverticula. Zenker, in 1877, laid the foundation for the symptomatology, diagnosis, and morbid anatomy of this condition. It is of interest to recall his prediction with regard to the operative possibilities of diverticulae stating: "The radical cure of diverticula by surgical operation from without is at present one of our vain wishes, yet we are hopeful that even this operation, conducted on Lister's plan, may at some future day be performed without danger."

The first recorded operation was that by Nicoladoni in 1876, which consisted in establishing a fistula. The patient died on the sixth day from pneumonia. Von Bergmann, in 1890, successfully excised a diverticulum with, however, the formation of a temporary fistula. Kocher in 1892 performed the operation, with healing per primam.

Anatomic Considerations. The esophagus begins at the level of the cricoid cartilage; this is located opposite the sixth cervical intervertebral disc; it terminates at the cardiac end of the stomach opposite the eleventh thoracic vertebra. The total length of the esophagus in normal adults is about 25 cm. (10 inches). In the neck the esophagus is located behind the trachea in the visceral compartment and in front of the prevertebral fascia and longus colli muscles. It deviates slightly to the left and is in lateral relation with the thyroid gland, carotid sheath, thyroid arteries and recurrent laryngeal nerves.

In the thorax the esophagus passes down behind the trachea and the arch of the aorta; it traverses the posterior mediastinum along with the descending aorta; crosses the aorta superficially from the right to left at about the level of the eighth thoracic vertebra. It is in contact with both pleural sacs.

Relations. The left bronchus lies in front of it and the thoracic duct and a variable portion of the vena azygos major are behind. The thoracic duct crosses behind the esophagus opposite the aortic arch and then ascends along its left margin.

The two vagi nerves form a plexus known as the plexus gullae which is situated around the esophagus. As the esophagus passes through the diaphragm, the left vagus lies in front of it and the right vagus behind it. It courses the abdomen downward for about half an inch and opens into the stomach. The abdominal portion of the esophagus is covered in front and to the left by the peritoneal sac. On its right aspect and posteriorly it is not covered by peritoneum.

The Course of the Esophagus in the Thorax. From the fourth to the seventh thoracic vertebrae the esophagus is in the median plane; above and below these levels it is to the left of the median line.

The constricted portions of the esophagus are favorite loci for the arrest of foreign bodies, viz.: (1) The cricoid cartilage—about 15 cm. (6 inches) from the incisor teeth. (2) Opposite the left bronchus—about 25 cm. (10 inches) from the incisor teeth. (3) At the diaphragm—about 40 cm. (15-16 inches) from the incisor teeth.

Congenital Anomalies:

1. Absence of the lower part.
2. Tracheo-esophageal fistula.
3. Esophagus duplex.
4. Congenital strictures.

Diverticulae are usually in the upper part of the esophagus and are acquired and occasioned by a herniation through the inferior constrictor muscle (Mosher).

Blood Supply. The arterial supply to the esophagus is derived from five sources, viz.: inferior thyroid, bronchial arteries, descending (thoracic) aorta, coronary (left gastric) and left inferior-phrenic arteries.

Veins. The venous radii terminate in the venae azygos and coronary veins.

Lymph drainage is taken up by the lower group of the deep cervical chain and posterior mediastinal nodes.

Nerve Supply; From Two Sources. 1. Parasympathetic, through the vagus and recurrent laryngeal nerves. 2. Sympathetic, through the cervical and thoracic portion of the sympathetic chain.

Strictures of the Esophagus. (a) Spasmodic (neuroses); (b) Fibrous (inflammatory); (c) Malignant (carcinoma).

ESOPHAGOSCOPY

Many years ago Bland Sutton considered the esophagoscope an instrument requiring the "instinct of a sword swallower and the eye of a hawk." Today it is used routinely in conditions where pathology of the gullet is suspected.

Esophagoscopy may be done under local or general anesthesia. Local anesthesia is applied as previously described. However, general anesthesia will often give a greater relaxation, especially of the crico-pharyngeal muscles.

The position of the patient is that described for bronchoscopy. The larynx and hypopharynx are first examined with a laryngoscope to determine if any pathology is present around the mouth of the esophagus. The esophagoscope (Fig. 1327), either the Mosher or Jackson type, is passed down the right side of the tongue and into the right pyriform sinus. This is done under direct vision, care being taken to avoid injury to the posterior pharyngeal wall. When the tip of the esophagoscope is well into the pyriform sinus it is swung to the midline; it is then behind the arytenoid cartilage. The opening of the esophagus will be seen to be "winking" at the operator. The passage through the crico-pharyngeal constriction is the most difficult part of esophagoscopy. A small amount of steady pressure will allow the esophagoscope to enter the esophagus. Care is essential as an abrasion of the mucous membrane may lead to a fatal mediastinitis. After the instrument is in the esophagus it will pass

rather easily all the way to the cardia. However, this should be done slowly under direct vision, keeping all the walls of the esophagus in clear view to avoid any injury. No undue force should be exerted. If a constriction is encountered it should be investigated with a small bougie and the esophagoscope should not be forced into the opening.

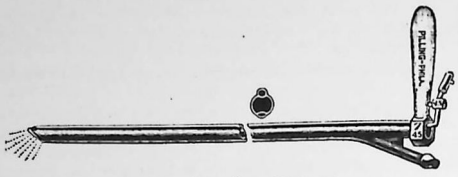


FIG. 1327. Jackson's esophaguscope.

OPERATIONS ON THE ESOPHAGUS

REMOVAL OF FOREIGN BODIES

This is indicated in removing obstructions (foreign bodies) in the cervical and upper dorsal portions of the esophagus.

Step 1. The position of the foreign body is ascertained by the passage of a good sized esophageal bougie (Fig. 1328), supplemented by, if conditions permit, x-ray or the esophagoscope.

Step 2. Expose the sheath of the carotid vessels. Displace the carotid vessels outward; raise the thyroid gland and draw it inward. The skin incision should be liberal.



FIG. 1328. Esophageal bougie for strictures of the esophagus.

Step 3. Identify and outline the pharynx. Draw it forward and search by palpation for the obstructing foreign body. If not found, pass a substantial sized bougie down the esophagus to the point of obstruction. The bougie distends the esophagus. Identify the latter.

Step 4. Pick it up with a pair of Allis or tissue forceps and incise it longitudinally. Avoid injuring the recurrent laryngeal nerve. Locate the obstruction by probing.

Step 5. Grasp the foreign body with forceps and remove it aided by manipulation from without. If the incision in the esophagus is found too small for the manipulations necessary to dislodge the obstruction, enlarge it sufficiently to permit careful and successful manipulations.

Step 6. Close the opening in the esophagus with two rows of fine catgut sutures, the inner embracing the mucous membrane only, and the other suture superimposed. Do not attempt completely to close the opening in the esophagus if the mucous membrane has been damaged during the extraction of the foreign substance.

Step 7. Drain. Pack lightly with gauze. Keep the wound clean.

Precautions. Do not mistake the foreign body for an enlarged and calcified lymph-node, or the esophagus for the longus colli muscle. Remember that the respiratory distention and collapse of the esophagus help to identify it. If in doubt, explore upward and downward until the foreign body is located. Control all bleeding points promptly during the operation. It is wise to orient one's self as to the position of the inferior thyroid artery, anterior jugular vein and recurrent laryngeal nerve in order to avoid injury to these structures. The latter is avoided if the incision in the esophagus is made as far posteriorly as practicable. According to Richardson, the index finger may be introduced into the esophagus through a low cervical incision (low cervical esophagotomy), passed to the arch of the aorta, or even beneath it, and if the other index finger is introduced through a gastrotomy opening into the stomach and projected upward, the first index finger may be met. This is a valuable method in impacted foreign bodies. If the latter be of compact structure, it may be fractured with bone forceps and the fragments extracted. Where esophagotomy has been done through edematous and inflamed tissues, no attempt at closure of the wound should be made; the wound should be permitted to heal by granulation. Prevent egress of fluids or food through the opening in the esophagus during the healing process by feeding the patient through a tube passed through the mouth or nose. It should be stressed that meticulous attention to asepsis is of utmost importance in these operations.

STRICTURE OF THE ESOPHAGUS

Non-malignant strictures of the esophagus may be treated by gradual dilatation with esophageal bougies passed per os. Thiosinamine injections are recommended as an aid to dilatation; the drug is credited with having a softening effect on scar tissue, thus aiding the instrumental dilatation. The composition of the drug to be used is as follows: thiosinamine, 15; antipyrin, 7.50; water 100 cc. The dose is 10.5 cc. for an injection. Usually ten doses are given.

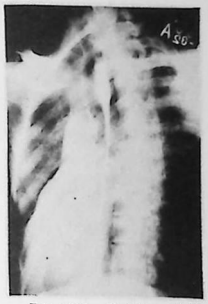


FIG. 1329. Stricture of the esophagus, the result of drinking lye.

Direct Dilatation

Locate the position of the stricture (bougies; x-ray). (Fig. 1329.) The principles underlying the procedure are the same as those of stricture of the urethra, viz., commence with the smallest size of dilator and increase the size gradually. Remember that the stricture may be so small as not to permit even a filiform to pass. A thread swallowed is of immense value in such cases (Socin's method). Pass the bougie every second or third day. Make sure that no aneurysm is responsible for the constriction before treatment is begun (x-ray of chest; Wassermann).

Retrograde Dilatation

This is used in strictures of the lower portion of the esophagus. Do a gastrostomy of proper size and locate it as near the cardia as possible. Occasionally, dilatation may be accomplished by the finger or various dilators of suitable size and shape. For the primary introduction of a dilating agent, many devices are recommended.

SOCIN'S PROCEDURE

This is very ingenious. It consists of swallowing a shot attached to a string prior to opening the stomach. The shotted end is pulled through the opening in the stomach to secure the return of a bougie or friction string. By this method, bougies of increasing size may be drawn upward and the stricture dilated.

Where the cardiac opening is nearly completely obliterated: The pathologic process may so encroach on the cardiac orifice that difficulty is experienced in locating it after opening the stomach; a finger or bougie may be used to accomplish the object. Under such conditions Silver counsels the introduction of an endoscope passed from above along a string acting as a guide. According to Lange, direct observation through an endoscope at the seat of the opening may show the entrance of fluids swallowed. Sizes of bougies passed should be increased very gradually. Leave the bougie in position for about half an hour or longer, if deemed advisable, increasing gradually the time for the larger sizes to about 24 to 48 hours. This is continued until a sound of about 20 mm. can be passed with ease. Later the intervals of bouginage are lengthened (say once every two to four weeks) and when one is satisfied that no recontraction threatens, once every six months or less frequently.

Forcible divulsion is mentioned only to be condemned. In long and narrow strictures one may find difficulty in maintaining the dilatation. Here one may muster into service laminaria tents and bougies, used by gynecologists in dilating the cervix uteri. These may be introduced into position under visual guidance and allowed to exercise continuous and gradually increasing pressure.

Abbé's Operation

The underlying principle of this procedure is division of the stricture by means of string friction. Abbé has pointed out that the pouch formed in the esophagus above the stricture is often a hindrance to the passage of bougies; this difficulty is overcome by his operation.

Step 1. Do a gastrotomy admitting two fingers.

Step 2. Pass a fine whalebone bougie from the stoma in the stomach upwards until it protrudes from the mouth. Tie two long stout threads of braided silk to the end of the bougie.

Step 3. Pull the bougie out through the stomach wound, leaving the two threads protruding from the mouth and stomach wounds. Attach the lower end of one thread to an eye at the point of a conical esophageal bougie (Billroth). By pulling on the upper end of this thread, it is easy to bring the conical tip of the bougie into the stricture and render the stricture tense.

Step 4. Persist in gentle traction thus dilating the stricture with the bougie. Simultaneously pull the second string vigorously upward and downward with a see-saw motion. The friction thus produced by the cord divides the strictures. When sufficient space is attained, the conical bougie passes upward as the continued friction wears away the stricture.

Step 5. Pass and gently force the largest suitable bougie from below upward overcoming the possible tightness still persisting at the point of the divided strictures by manipulating the bougie past the point of resistance.

Step 6. Close the gastrotomy opening.

Comment: Follow up the operation by passing suitable sized bougies once a week to once a month as required, or about a year or longer until the desired result is obtained. Begin with semi-solid and solid food feedings as soon as possible. Impress the patient with the importance of thorough follow-up treatments. The results of the operation, aided by proper after care, are good. The procedure is an old one and may find a place in surgical practice in selected cases. The late Willy Meyer stated that "Abbé's string method is the operation of choice and will in most cases be crowned with success."

Theodore Dunham[1] has designed and improved an armamentarium which the late Willy Meyer lauded much. Dunham uses a fishline for cutting. While this is being done, the stomach, the gastrostomy opening, the mouth and pharynx are protected by means of special metal tubes through the lumen of which the fishline runs. At the point where the division is to be made, a metal olive on a wire-guide is held in place by the constricted part of the esophagus. The patient is anesthetized and the stomach washed out. The operation is done in a number of séances.

Nissen points out that any violent effort at the passage of sounds, etc., may lead to perforation with lethal mediastinitis. Do not divide or stretch the esophagus beyond No. 35 or 40 French gauge. Until this is accomplished a silk thread always remains in situ, the ends of which are fastened to the cheek and the abdominal wall by means of adhesive plaster. The thread must never be drawn too taut. Abbé's procedure should be divided into a number of stages beginning with the gastrostomy and then with the steps enumerated above. The results of Abbé's operation are "most gratifying and permanent. It has to be considered the standard operative procedure," says Willy Meyer. The daily descent of the food keeps the lumen patent. Of course, this operation can only be resorted to (a) if the stricture is permeable and (b) if a thread can be successfully passed from the mouth through the gastric fistula. Occasionally, an impermeable stricture may become permeable after a gastrostomy has been done. This is a result of recession of the inflammation about the stricture. Lotheisen observes that permanent impermeable strictures are extremely rare. In the 253 cases he observed, it occurred only once. In this small percentage of cases and as a last resort the following may be done: (a) Attempts at retrograde bouginage; (b) The formation of an extrathoracic esophagus.

Caution. When gastrostomy is performed, thiosinamine should not be administered, the reason being that the softening effect of the drug on scar tissue may affect the cicatrization in the stomach.

ELECTROLYSIS

Whenever a filiform cannot be passed, electrolysis should be resorted to under supervision of the eye. A current of 15 milliamperes should be used and applied either to one edge of the stricture (linear electrolysis) or all around it (circular electrolysis). Properly constructed electrodes should be selected (olive or ring-shaped). The conducting wire should be properly insulated to avoid its coming in contact with the esophagus. Place the indifferent electrode on the

[1] Annals of Surgery, 1901.

patient's chest. When the electrode is in position, turn on the current. Move the electrode gently in order to avoid its becoming adherent to the stricture. When the electrode has passed, either a larger one may be substituted or gentle dilatation with a soft bougie may follow. Dilatation is rendered more easy following electrolysis.

REBELLIOUS CASES

Though it rarely happens (4 out of 185 cases—Guisez), all attempts to dilate the strictured portion of the esophagus may fail. Recourse must then be had to one of the following procedures:

1. External Cervical Esophagostomy.
2. Thoracic Esophagotomy.
3. Cervical Esophagotomy.
4. Esophagogastrostomy.
5. Esophagectomy.

ESOPHAGOSTOMY

This is employed to establish a fistulous opening into the esophagus, below an impassable, incurable constriction. It is used to supply food but has been entirely superseded by gastrostomy.

ESOPHAGOGASTROSTOMY

Esophagojejunogastroanastomosis—Roux's Operation

Step 1. Laparotomy. Pick out a mobile loop of jejunum. Ligate doubly and divide four or five of the vessels passing to the loop of the jejunum. Preserve the peripheral vascular arcades intact. Make sure that sufficient vascularization is assured through the vascular arcades of the selected portion of the jejunum near its caudal end. Clamp and divide the bowel at both ends of the selected segment.

Step 2. The caudal end of the isolated loop of the jejunum is now anastomosed with the stomach, near the lesser curvature.

Step 3. Create a subcutaneous tunnel beginning at the abdominal wound and extending to the suprasternal notch. The proximal (oral) end of the segregated loop of the jejunum is pulled through the tunnel just described and its upper end is sutured to the upper end of the tunnel with interrupted sutures. A stomach tube is now introduced through the segment of bowel implanted in the tunneled chest wall, thence into the stomach. Fix the stomach tube to the opening of the bowel at the sternal end.

Step 4. The continuity of the bowel is restored by an entero-enterostomy (suture or Murphy button—the latter is preferable).

If the patient survives this rather serious operation, the cervical portion of the esophagus may then be exposed and anastomosed to the upper end of the implanted subcutaneous segment of bowel.

Jianu's Esophagoplasty

Step 1. Laparotomy. Deliver the greater curvature of the stomach.

Step 2. Divide the great omentum transversely below the gastro-epipioic ves-

sels. Ligate and divide the right gastro-epiploic vessels; this renders the greater curvature of the stomach free from the omentum. It is nourished by the left gastro-epiploic vessels.

Step 3. Place a row of mattress sutures through both the anterior and posterior walls of the stomach along the lines A and B as indicated in Fig. 1330.

Step 4. Make an incision along the lines A and B embracing both walls of the stomach. The flap of the stomach between the incised openings C and D is closed with two rows of continuous or interrupted sutures, as preferred. This converts the segment of the stomach into a closed tube open at its distal end C and continuous at the cardia at D. The left epiploic vessels

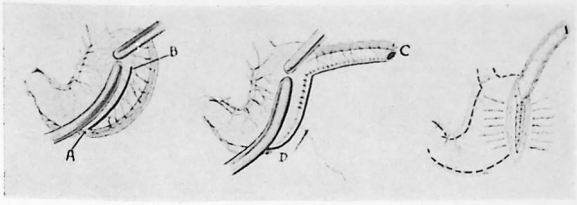


FIG. 1330 FIG. 1331 FIG. 1332

FIG. 1330. Jianu's operation of esophagoplasty (after Frungehim). After applying clamps as shown in illustration a section of the greater curvature of the stomach is separated as outlined in the illustration.

FIG. 1331. A tube thus results by closing the open gastric wall and approximating the edges of the tube as shown.

FIG. 1332. Insertion of final serous sutures into the wall of the stomach.

supply nourishment to this tube. A right-angled Connell suture buries the marginal sutures of the tube (Figs. 1331-1332).

Step 5. Fashion a subcutaneous tunnel from the abdominal wound upward and extending as in the Roux operation previously described, to about the level of the third costal cartilage. Pull the tube through the tunnel thus made and permit it to emerge through an opening in the skin overlying the sternum and suture its mucous membrane to the margins of the skin in the upper wound.

Step 6. Close the abdomen.

MEDIASTINAL ESOPHAGOGASTROSTOMY

Historical Notes. William Levy (1894) suggested that a carcinoma of the abdominal portion of the esophagus may be resected by the abdominal route and the cut end of the esophagus anastomosed with the fundus of the stomach. Krukenberg some time later demonstrated that it was possible to anastomose the divided end of the esophagus with the wound in the fundus of the stomach. Levy stated that only 2 or 3 cm. of the esophagus may be removed by a method which he suggested. He also used the Murphy button. Parceliar demonstrated, however, that 5 to 6 cm. of the esophagus might be excised infradiaphragmatically. Von Mikulicz turned up the left costal arch and displaced the diaphragm upward for the purpose of obtaining a better exposure. The diaphragm was sutured to the chest wall and the patient fed through a jejunostomy.

Völcker (1907) successfully resected a carcinoma of the cardiac portion of the esophagus by a modified Mikulicz technic. Experimental and clinical researchers in attacking malignancies of the esophagus by transpleural, transdiaphragmatic and by the abdomino-thoracic route have yielded the present day advanced methods of approach to the problem.

Biondi (1895) showed that it was possible to resect the cardiac portion of the esophagus transpleurally—transdiaphragmatic esophagogastrostomy. Gosset did some experimental work in this connection, employing a U-shaped incision similar to that used in a Schede thoracoplasty. Wendel and Sauerbruch have employed this method. Brun recommended that one should first mobilize the stomach and duodenum, and create a gastric fistula near the pylorus at the same time. The second act consists of a thoracotomy eight to ten days later. The cardia is then freed, the diaphragm split and the stomach drawn up. The tumor is then inverted into the stomach, and six to eight days later is pulled through the fistula into the stomach and resected.

Mediastinal Esophagogastrostomy—Lilienthal's Operation

In carcinomas of the lower portion of the esophagus, Lilienthal's operation is of distinct value (Fig. 1333).

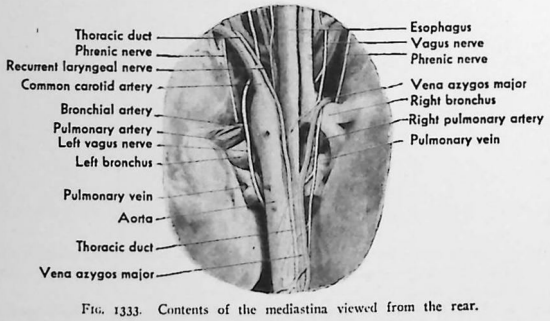


FIG. 1333. Contents of the mediastina viewed from the rear.

Step 1. Torek's incision exposes the posterior mediastinum p. 1162. Retract the pleura and lung carefully. Expose the lower end of the esophagus, upper surface of the diaphragm and esophageal opening in the diaphragm.

Step 2. Separate the esophagus by blunt dissection from the opening in the diaphragm. Enlarge this opening by an incision to the left sufficiently to permit the cardia and fundus of the stomach to be drawn into the field of operation.

Step 3. Divide the esophagus with a cautery knife between two clamps at least an inch above and below the neoplasm (Fig. 1334). Protect the surrounding area with lap sponges wrung out of hot salt solution.

Step 4. Suture and invaginate the divided end of the stomach. Draw the fundus of the stomach upward sufficiently so that it will reach a distance measurably about an inch above the remaining end of the esophagus.

Step 5. Make an incision into the stomach sufficiently large to admit of proper

implantation of the lower end of the esophagus. About one and a half inches below this incision a similar incision is made into the stomach.

Step 6. Through the smaller opening in the stomach pass a needle bearing a double suture; bring it out through the upper larger opening in the stomach.

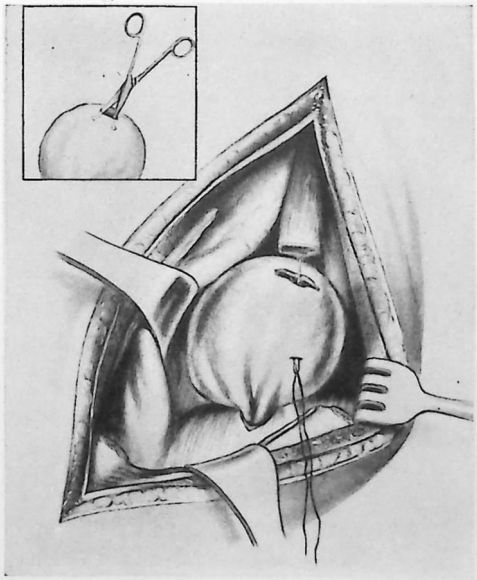


FIG. 1334. Lilienthal's esophagogastrostomy. Esophagus cut off above tumor. Greater curvature of stomach drawn into posterior mediastinum through enlargement of the hiatus of the esophagus. The needle carrying suture is being passed through the stomach and out by the way of the opening made in the fundus. Insert shows method of stretching opening in the fundus. (Courtesy of Dr. Lilienthal: Thoracic Surgery, W. B. Saunders Co.)

The sutures are now cut—four sutures are thus available. Rethread each of these onto a needle and pass each through the wall of the esophagus at four equidistant points (Fig. 1335).

Step 7. Make traction on these sutures and intussuscept the esophagus into the stomach; here it is anchored by two or three sutures which pass through the wall of the stomach and esophagus.

Step 8. Cut the traction sutures short and allow them to hang freely into the stomach. Close the smaller incision in the stomach (Fig. 1336).

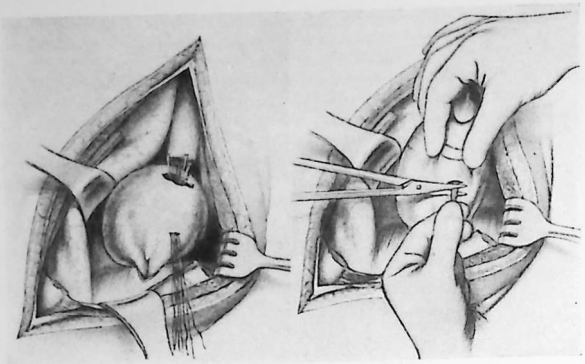


FIG. 1335 FIG. 1336

FIG. 1335. Traction sutures are now arranged in the wall of the esophagus. There are four strands.

FIG. 1336. The stomach has been drawn upon the esophagus which is held through the stomach wall to facilitate the passage of two through-and-through anchoring stitches. The scissors are cutting off the traction sutures which draw back into the stomach. (Lilienthal: Thoracic Surgery, W. B. Saunders.)

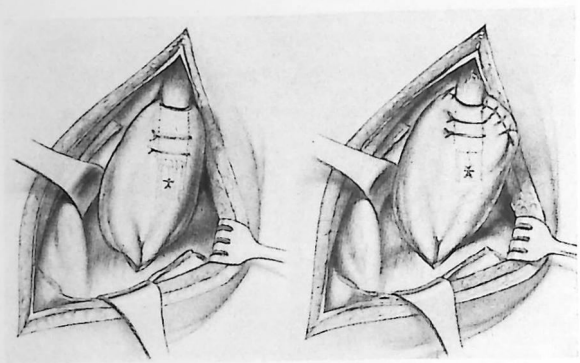


FIG. 1337 FIG. 1338

FIG. 1337. Showing the minute puncture closed with a single stitch. The esophagus held within the gastric cavity by the two through-and-through sutures.

FIG. 1338. The stomach wall has been inverted by sutures bringing the peritoneal surfaces in contact and also in contact with the esophagus. Two or three sutures may be passed to anchor the stomach to the diaphragm. (Courtesy of Dr. Lilienthal: Thoracic Surgery, W. B. Saunders.)

Step 9. Invaginate the implanted gastro-esophageal area by a series of Czerny-Lembert sutures (Fig. 1337).

Step 10. Unite the stomach to the diaphragm where it is pierced—thus frustrating the development of diaphragmatic hernia (Fig. 1338).

Step 11. Close the abdomen. Dress.

The advantages of this procedure are the following:

1. Ample exposure during the operation;
2. Conservation of chest volume and lung capacity;
3. The continuation of the alimentary canal in as near an approach to the normal as seems possible without interposition of any foreign tissue between the stomach and intestine;
4. Location of the passage in a normal position—the posterior mediastinum.

Where time permits before the mediastinal operation is undertaken a jejunostomy is often of great value.

Kirschner's operation is an antethoracic esophagogastrostomy.

ESOPHAGECTOMY—RESECTION OF THE ESOPHAGUS

Torek has pointed out that in view of the fact that the esophagus is never extirpated in toto, the usage of the term "esophagectomy" has become synonymous with "resection of the esophagus." The operation may entail removal of the involved segment of the esophagus in either its cervical, thoracic or abdominal portion. The cervical extirpation of the esophagus was first successfully performed by Czerny in 1877. Gluck and others have also reported successes. The abdominal portion of the esophagus was first successfully removed by Völcker in 1907 while credit for the first successful removal of the thoracic portion of the esophagus for carcinoma belongs to Franz Torek who in 1913 performed this operation. His patient lived for nearly 13 years following the operation and there was no recurrence. The mortality of cases of partial removal of the esophagus is necessarily high depending upon the degree of involvement and the experience and dexterity of the surgeon. The greatest mortality attends the removal of the thoracic portion of the esophagus.

Cervical Esophagectomy

In removing the affected portion of the esophagus, the surgeon frequently resorts to a concomitant resection of the pharynx, larynx and trachea, depending upon the degree of involvement. A gastrostomy should be performed preceding the operation on the neck. Any standard method of gastrostomy may be performed. A minimum of 2 cm. of the esophagus above and below the tumor should be excised. Torek admonishes that if the attachment of the esophagus to the trachea is ever so slightly firmer than the very loose normal connection, the larynx and trachea should be removed with the esophagus. As it is rare to find a connective tissue between those two organs, the classic operation consists of resection of the larynx and trachea together with the esophagus. Dissection of the cervical lymph nodes should also be done. Commenting on postoperative irradiation and leaving involved lymph nodes behind, Torek points out that it is a mistake to leave behind any affected nodes owing to the fact that radio-

therapy cannot compete with surgery despite the fact that lymphocytes are highly radiosensitive.

Anesthesia. Either infiltration block, tracheal insufflation or rectal anesthesia (Gwathmey) should be resorted to. In case the first is used, the third and fourth cervical nerves should be blocked on both sides; this is supplemented by regional infiltration. For the technic of blocking the cervical nerves see the chapter on Removal of the Thyroid Gland.

ACH'S CERVICAL ESOPHAGOPLASTY

Step 1. Outline a large triangular skin flap (Fig. 1339). Dissect it free from the underlying tissues.

Step 2. Turn the dissected flap upon itself to form a tube (Fig. 1340) with the cutaneous surface directed inward.

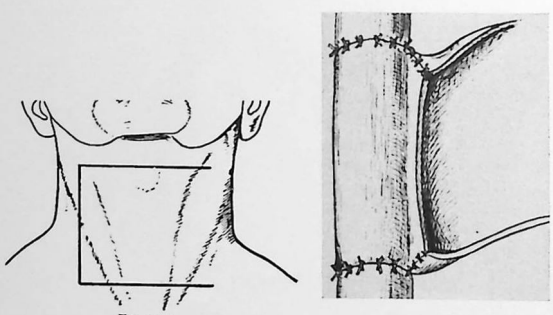


FIG. 1339 FIG. 1340

FIG. 1339. Cervical esophagoplasty. Ach's operation. Outline of incision.

FIG. 1340. Ach's operation. The flap is dissected free from the underlying structures and turned upon itself so that a tube is fashioned in such a manner that the cutaneous surface of the skin forms the inner lining of the tube. The free edges of the tube are sutured above and below to the pharynx and esophagus respectively. Observe that where the free edge of the tube meets the flap near its pedicle (right side of illustration) the tube is open, to be closed at a subsequent stage.

Step 3. The tumor, of course, has been removed previously. The upper end of the tube thus formed is sutured to the upper and lower divided ends of the esophagus respectively. The continuity of the esophagus is thus restored except laterally where the edge of the flap is turned back upon the flap. Tampon the raw surface remaining.

Step 4. Two or three weeks later the defect is closed. The raw surface is covered by a plastic procedure.

VON HACKER'S OPERATION

Step. 1. Make a longitudinal incision beginning at the hyoid bone and extending down to the sternum (Fig. 1341). To this longitudinal incision two transverse incisions are added, one at each end of the central cut. The longitudinal incision is made somewhat away from the median line.

Step 2. Bluntly separate the sternohyoid muscles from the larynx, thyroid gland and trachea.

Step 3. Divide the isthmus of the thyroid gland. Draw its lateral halves to either side. Attend to careful hemostasis.

Step 4. Divide the constrictor muscles of the pharynx and the sternothyroid muscles close to their insertion at the thyroid.

Step 5. Dissect the trachea bluntly from the esophagus and at a properly selected point divide it. If the trachea is not involved in the neoplasm it is divided between the first and second tracheal rings. First make a small incision anteriorly and inject some cocaine into the mucosa of the trachea upward and downward. Novocain will not answer the purpose (Torek).

Step 6. Insert a few guy sutures in the anterior part of the trachea below the incision to prevent it from slipping away after it is completely divided.

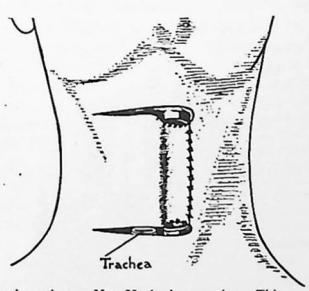


FIG. 1341. Cervical esophagoplasty. Von Hacker's operation. This represents the flap of skin forming the posterior half of the new esophagus.

Step 7. Insert a tracheotomy cannula into the open trachea and cover it with gauze. Tampon the upper stump of the trachea with gauze to prevent soiling of the wound.

Step 8. Select the site for dividing the esophagus which may be well down in the mediastinum. In one case Torek divided the esophagus 5 cm. below the sternal notch. Separate the esophagus from the vertebral column (this usually presents no difficulties).

Step 9. Divide the esophagus at a safe distance from the tumor. Should this division be too low to permit of subsequent plastic repair, ligate the stump and let it slip back. Carry a tampon into the mediastinum to prevent infection. If the esophagus is divided in the vicinity of the jugulum, attach it temporarily to the lower edge of the wound in the skin or secure it with guy sutures.

Step 10. The involved mass (larynx, pharynx, trachea and esophagus) is now separated from the anterior surface of the spinal column. The thyrohyoid muscles are separated from the larynx and the other anterior attachments are divided. The epiglottis is usually allowed to remain.

Step 11. Do a block dissection of the cervical lymph nodes (which see). If no

plastic reconstruction is contemplated, proceed to close the pharynx with a chromic catgut suture. If a plastic on the esophagus is to be performed, it is left open and the sternohyoid muscles are not brought together in the midline but the divided ends of the thyrohyoid muscles may be sutured to the divided end of the sternothyroid on each side if this can be accomplished without tension. Otherwise, this step is omitted.

Step 12. Suture the trachea to the skin.

Step 13. Insert a small iodoform and cigarette drain on each side extending down to the mediastinum.

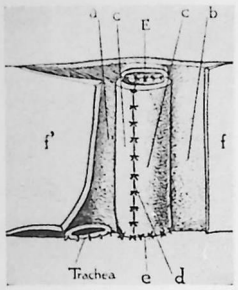


FIG. 1342

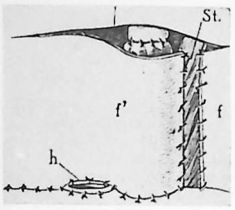


FIG. 1343

FIG. 1342. From the surfaces a. and b., the flaps c.-c. have been dissected free and joined by a suture d., thus forming a tube with the cutaneous surface pointing inward; the tube thus formed is sutured to the lower stump of the esophagus; f. and f.' are undermined flaps which are used to cover the new tube. Below and to the right is the trachea; above the esophagus E still remains open anteriorly.

FIG. 1343. Final stage in Von Hacker's esophagoplasty, f'., the larger flap and f. the smaller flap are sutured to the sternocleidomastoid muscle (St.). h. shows the skin flap sutured to the trachea.

Step 14. Suture the two skin flaps together. Since the incision has been made off center, the suture line will lie somewhat laterally. This skin bridge will form the posterior part of the new esophagus and is sutured above to the posterior wall of the pharynx and below to the posterior wall of the esophagus. Tampon the remaining opening in the pharynx with iodoform gauze.

Postoperative Care. Complications following this procedure are usually aspiration pneumonia, secondary hemorrhage and mediastinitis. These should be guarded against by proper measures.

When the tissues have healed satisfactorily, when no more discharges are present and granulation has proceeded to its optimum reconstruction of the esophagus is done.

VON HACKER'S ESOPHAGOPLASTY

Step 1. Divide the longer flap a second time by an incision which runs parallel to its original end, in such a manner that when reflected a tube of sufficient caliber may be fashioned. (Fig. 1342.)

Step 2. Again divide the original suture line between the longer and shorter

flap and suture its mesial edge to the newly reflected flap which is also sutured to the pharynx above and the esophagus below, in this manner completing the connection between the mouth and the esophagus.

Step 3. Thoroughly undermine and separate the remaining portions of the original flaps from the underlying tissues which unite them in front of the new esophagus. Should this not be readily accomplished, the flap which was not used for making a new esophagus is drawn over and attached to the sternocleidomastoid muscle of the opposite side and the remaining defect covered by a Thiersch graft (Fig. 1343). The legends on the illustration explain the operative steps just outlined.

Since the nutrition of the newly shaped tube depends entirely upon recently established vascular connections supplying the spinal column, behind the pharynx

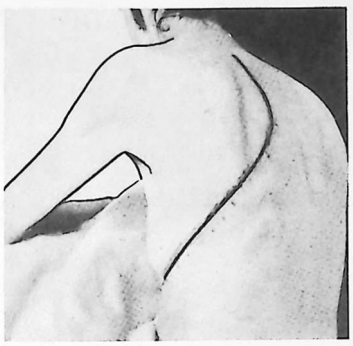


FIG. 1344. The skin incision outlined with silver nitrate on the day preceding the operation of Torek's transpleural esophagectomy.

above and the esophagus below, sufficient time should elapse before the final step of the operation is undertaken.

The restoration of the esophagus may also be accomplished by Ach's method (p. 1180).

TRANSPLEURAL ESOPHAGECTOMY

Torek's Operation

Step 1. On the day before the operation outline the course of the incision with silver nitrate (Fig. 1344). It must be recalled that the esophagus stands out more prominently on the right than on the left because it is covered by the right pleura; the aorta is not in the way. Nevertheless approach to the lower third of the esophagus from the right side is unfeasible because of the position of the liver.

Step 2. Perform a gastrostomy. With the patient on his side and supported by

sandbags (if it be the right side, the left arm is held upward and forward to displace the scapula from the line of incision) begin the incision in the seventh intercostal space and carry it over the entire length of that space. At its posterior end, carry it vertically upward to the third interspace. Turn the skin flaps backward. Protect them with towels.

Step 3. Resect the fourth, fifth, sixth and seventh ribs. Open the pleura. Retract with a rib spreader. Free the lung from adhesions and lay it over toward the front part of the mediastinal tissues. The esophagus appears as a slight bulging in the parietal pleura to the side of the aorta. Divide the pleura and connective tissue covering the esophagus at some portion where

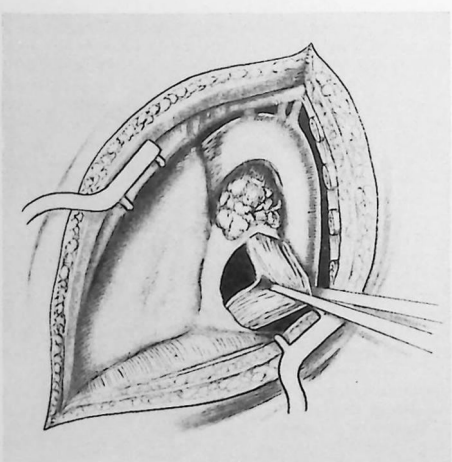


FIG. 1345. Torek's transpleural esophagectomy. The mediastinal pleura has been incised and the esophagus lifted out with the aid of a tape. The tumor is seen beneath the aortic arch.

the latter is not involved. Lift the esophagus out of its bed. Draw it forward with a tape or to the side (Fig. 1345) while the dissection progresses upward to the thoracic aperture and down to the diaphragm. When the neoplasm is situated high up the dissection need not, of course, extend to the diaphragm. "To determine," says Torek, "the extent of the dissection of the diaphragmatic end, we determine at what place below the tumor the esophagus is to be divided and allow about 3 cm. more for the invagination of the stump." The dissection is best done with the aid of a blunt instrument like Kocher's goiter sound or a long Mayo dissecting scissors which is inserted between the esophagus and the tissues lying over it. The fact

that some of the vagus branches crossing the esophagus must be divided in the course of this procedure need not deter the surgeon.

It must ever be kept in mind that the esophagus must not be compared with the bowel as far as healing propensities are concerned, the latter tending to prompt agglutination by reason of its peritoneal investure which the esophagus does not possess. Hence, even though an accurate apposition and axial union is attained, suppuration, pleuritis and mediastinitis are the usual sequence.

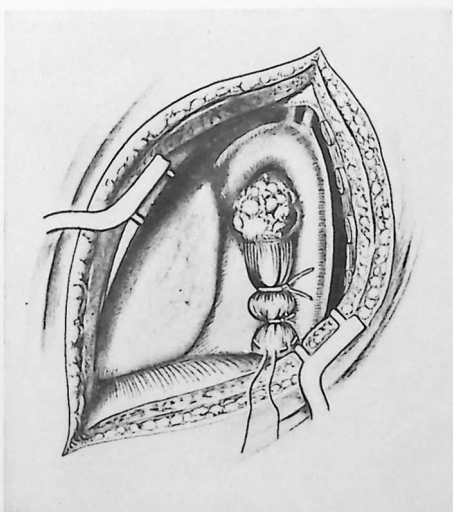


FIG. 1346. Torek's transpleural esophagectomy. Double ligation of the esophagus previous to cutting it. For the lower ligation, a thinner silk facilitates the invagination of the stump. A purse-string suture is placed to cover the invaginated stump.

The part of the esophagus lying beneath the aortic arch is the most difficult to dissect.

Step 4. At this point the esophagus must be freed from the left bronchus by blunt dissection. Avoid kinking the aortic arch for fear of sudden cardiac collapse. The finger or dissecting instrument is pushed by blunt dissection until the anterior border of the sternomastoid muscle is reached at the level of the upper thoracic aperture. Make an incision at this point through which the esophagus is later to be delivered.

Step 5. Ligate the esophagus doubly (Fig. 1346). Divide it with cautery or

knife. Invaginate the stump and suture it over. When it is close to the diaphragm it may become necessary to use the cardiac end of the stomach to cover the stump should the latter not be long enough.

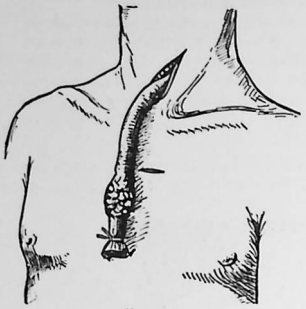


Fig. 1347

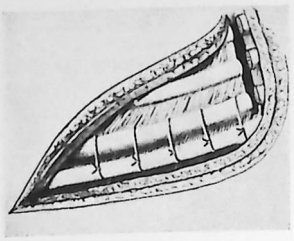


Fig. 1348

Fig. 1347. Torek's transpleural esophagectomy. Esophagus, with the tumor attached, brought out at the border of the sternocleidomastoid muscle. Corresponding to the site of proposed amputation a transverse incision is made in the skin of the chest, from which a subcutaneous tunnel is dug to the incision in the neck. This tunnel is to receive the esophagus
Fig. 1348. Torek's transpleural esophagectomy. Chest closed by a few pericostal sutures.

Step 6. Cauterize the distal end of the esophagus. Pull it up and out through the wound in the neck. The delivery of this end of the esophagus is facilitated by tying a piece of tape around its end and guiding it to the surface (Fig. 1347).



Fig. 1349. Tube connecting lower end of esophagus with gastrostomy opening. The two light stripes on the rubber tube in this and the following figure are remnants of adhesive plaster which was removed before taking the picture. (Torek.)

Step 7. Close the chest by bringing the ribs together by Sauerbruch's pericostal sutures, which pass either through the ribs or around them (Fig. 1348). The intrapulmonary pressure should be increased sufficiently during the last stages of the closure to keep the lung in contact with the chest wall. A minor degree of pneumothorax is of no moment.

Step 8. After thorough healing of the free end of the esophagus has taken place the upper end of a gastrostomy tube is inserted into it when nourishment is to be given to the patient. During the act of swallowing, slight pressure is exerted at one side of the tube to prevent leakage. The food when swallowed passes through the tube into the stomach (Figs. 1349-1350-1351). The pleura is closed without drainage. Willy Meyer believes that drainage should always be instituted. Sauerbruch does not drain.

ESOPHAGEAL DIVERTICULAE

Diverticulae of the esophagus (Figs. 1352-1353) are classified according to their location.

1. Pharyngoesophageal.
2. Below the upper opening of the esophagus.

In a general way the upper (tracheal) curve is most liable to diseased conditions; the lower (aortic) curve being relatively full.

Types

1. Pressure diverticula—due to pressure or pulsion from influx within the esophagus.
2. Traction diverticula (inflammatory)—extrinsic factors causing traction.
3. Pressure—traction diverticula (combined factors).

Historical Notes. Leuker and Lienisser described esophageal diverticula in 1877. The condition was noted by Cruveilhier in 1852.

Operations: About 1830 Sir Charles Bell thought of establishing a fistula leading from the diverticulum to the surface. Klugs (about 1850) thought of extirpation of these diverticular outpouchings. Nichous was first to perform the operation in 1884. The methods of procedure are:

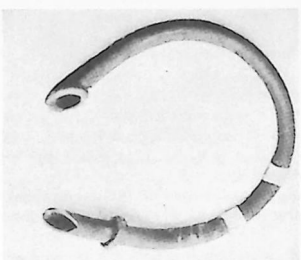


Fig. 1350



Fig. 1351

Fig. 1350. Note the beveled and thickened upper end of the tube and the rubber ring near the lower end.
Fig. 1351. Torek's operation. Illustration shows patient 12 days after operation. The upper end of the esophagus is visible under the skin of the chest. The rubber tube leads the food from the upper end of the esophagus into the gastrostomy opening during the act of swallowing.

1. Invagination.
2. Diverticulopexy.
3. Extirpation in two stages.
4. Extirpation in one stage.

Invagination

This operation was first proposed by Girard in 1896. In 1917 Bevan completed the idea of Girard in treating small diverticulae by simple invagination. Those of larger size are invaginated by a number of superimposed layers.

Diverticulopexy

Schmidt in 1912 conceived the idea that in order to prevent the entrance of food into the diverticulum, he would dissect the pouch free, and isolate and fix it

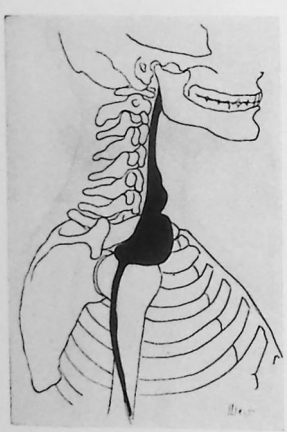


Fig. 1352

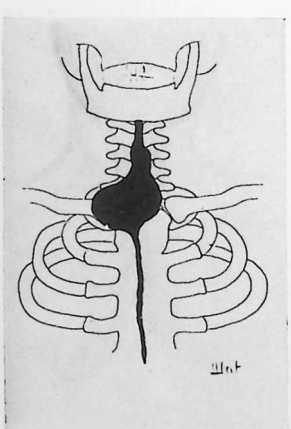


Fig. 1353

Fig. 1352. Diverticulum of the esophagus; lateral view. Reconstructed from x-ray.
Fig. 1353. Diverticulum of the esophagus; front view. Reconstructed from x-ray.

it such a manner that its fundus was placed on a lower level than its orifice communicating with the pharynx.

Extirpation in Two Stages

Goldman advised liberating the diverticulum at the first stage, then ligating it at its base after which it was permitted to remain in a tamponed area. Deprived of its vascularization, the pouch necroses and sloughs off. A fistula forms which closes spontaneously after a few weeks. Lecéne considers this procedure not in line with modern surgical thought because of the sphacelation which the method causes. Murphy, in 1916, exteriorized the pouch and fixed it in a twisted position. Two weeks later he resected the diverticulum.

Charles Mayo emphasized the importance of emptying the pouch previous to operation and using local anesthesia.

Bartlett, quoted by Mayo, suggested that when the dissection in the region

of the neck of the diverticulum is complete, the patient, under local anesthesia, is "instructed to close the lips and distend the mouth and pharynx with air," thus distending the sac. The latter is identified not only by its location, but by its having a lighter color than the surrounding tissues.

Wilkies' modification[1] consists essentially of freeing and bringing out the sac at the first operation, and of a submucous excision of the lining at the second sitting, the tunica propria being left adherent to the skin and the planes of the neck being left undisturbed.

Extirpation in One Stage

The one-stage operation consists of isolating the sac, removing it and variously dealing with the neck. Kocher's method is a "cuff" operation, similar to dealing with an appendix stump. Perthes divides the neck of the sac between clamps, and deals with the stump after the Moynihan method of closing the duodenum in a pylorectomy, the suture-line being vertical. Lexer conserves a pedicle which he invaginates so as to form a valve-like internal protrusion. Wilkie warns about division of the neck. "Unless great care be taken," he says, "traction on the sac may pull out a portion of the normal pharyngeal wall which may be mistaken for the neck of the sac. In a case recorded by Downes, all save a narrow strip on the right lateral wall of the upper end of the esophagus was inadvertently removed with the sac, and it was found necessary to excise the remaining portion and to do an end-to-end suture."

While the one-stage operation appealing to the surgical instinct, is, of course, the ideal procedure from the surgical and anatomic standpoint, and in favorable cases has much to commend it, the more tedious two-stage operation is to be recommended for safety's sake.

Grégoire operated on 132 cases (up to 1935) in one stage, with 3 deaths the result of septic cellulitis of the neck or mediastinum. Grégoire states that with improved technic, casualties should be rarities. The procedure consists of exposure of the diverticulum, its isolation, exteriorization, its division at the base and its implantation and reinforcement by two layers of sutures to avoid the escape of liquid contents from the esophagus. The first row of sutures is inverted and is superimposed by another row of sutures.

Grégoire's Operation

Step 1. Make an incision close to the anterior edge of the sternocleidomastoid muscle which extends from the level of the hyoid bone almost to the clavicle (Fig. 1354). Divide the tissues.

Step 2. Draw the sternomastoid muscle outward and the laryngeal depressor muscles inward. If the omohyoid muscle is in the way, divide it.

Step 3. Incise the fascia. The blunt retractor which holds the sternomastoid muscle should displace the great vessels of the neck and the descendens noni nerve outward. The longus colli muscle will now be seen covering the bodies of the vertebrae.

Step 4. Identify the inferior thyroid artery where it crosses the field of operation emerging from behind the common carotid artery. It may be saved but Lilienthal believes it is best to divide it between two ligatures.

Step 5. Identify the esophagus by passing a full-sized stomach tube through the

[1] Brit. Jour. of Surg., Nov., 1922.

mouth. The recurrent laryngeal nerve should also be identified and drawn out of the way.

Step 6. Find the neck of the diverticulum behind the esophagus and dissect the sac carefully; the neck is rarely, if ever, narrow but is usually as wide as the esophageal opening itself (Fig. 1355). Guard against perforations. Large diverticulae which extend into the superior opening of the thorax must be gradually drawn upward, a finger in the mediastinum gently aiding. At this

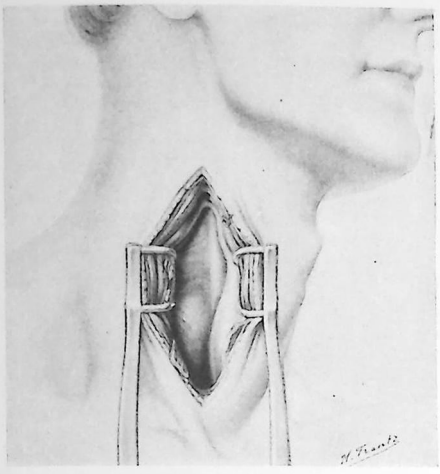


Fig. 1354. Grégoire's method of removing diverticulum of esophagus. The diverticulum is shown at the base of the wound. The vascular nervous bundle of the neck as well as the trachea have been displaced. The diverticulum appears situated against the vertebral column covered by the external layer of its visceral sheath. (Courtesy of Prof. R. Grégoire, Chirurgie de L'Oesophage, Masson et Cie, Paris, 1935.)

point there is serious danger that putrid mucus or remnants of food may be milked out of the pouch into the pharynx and aspirated into the air passages. A continuous-suction tube should be used to keep the pharynx free. Sponging is of no use and may even prove dangerous by forcing matter from the infected sac into the air passages (Lilienthal). Once the diverticulum is fully exposed determine (1) whether it is wise to proceed at once with its extirpation; or (2) to tampon the operative field and wait five or six days for the areolar tissue to become walled off.

Treatment of the Sac. A narrow neck may be safely ligated with stout chromicized catgut and the sac firmly clamped and divided with the thermocautery or scalpel dipped in carbolic acid. The stump should be buried with

two rows of catgut sutures snugly approximated but not strangulating. (Fig. 1356.)

Step 7. Close the upper part of the skin wound. Pack the remainder with gauze. Leakage and infection may occur in spite of the most careful technique (Lilienthal). If the neck of the sac is narrow and thin, the greatest care must be exercised lest it be cut by the ligature.

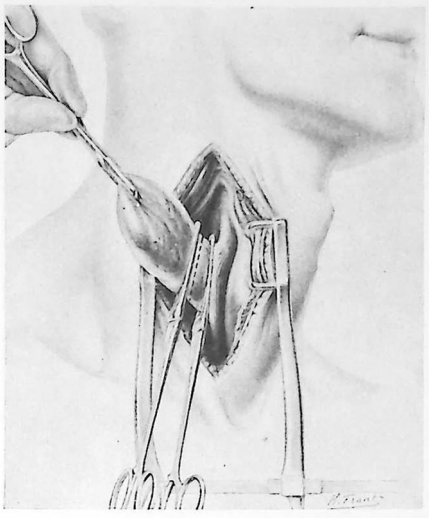


Fig. 1355. Grégoire's method of removing diverticulum of the esophagus. The diverticulum is held by forceps before its resection. The dotted line indicates the line of section. (Courtesy of Prof. R. Grégoire, Chirurgie de l'Oesophage, Masson et Cie, Paris, 1935.)

Comment. Attention has been principally directed to the removal of the sac. The sac, however, is a secondary condition. To effect a radical cure the primary cause must be effectually remedied (organic stenosis of the esophagus calls for dilatations first). In very early cases bouginage may arrest the development of the sac (even in functional cases). In late cases such dilatation should supplement the extirpation of the sac (Wilkie).

Removal of the sac, despite the recorded series of successful operations, is nevertheless a serious undertaking (advanced years; sac contains infectious microorganisms and communicates with a septic channel, and is situated in a cellular bed ill fitted to deal with infection and is continuous with an inaccessible space, the posterior mediastinum).

A primary gastrostomy has been strongly advocated by some and is undoubtedly advantageous in late cases and in debilitated patients. Oral asepsis should be aimed at. Lavage of the sac with a mild antiseptic should be resorted to preoperatively. An empty sac is an essential for a safe operation (Wilkie).

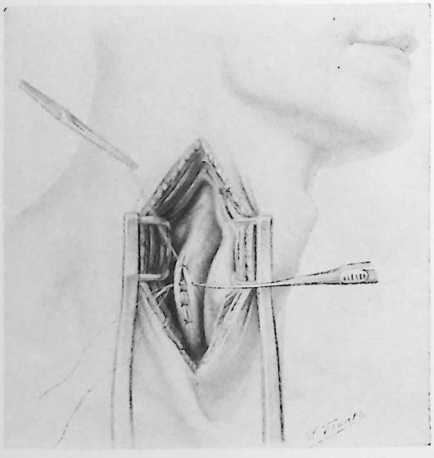


Fig. 1356. Gregoire's method of extirpating diverticulum of esophagus. Suture of the wound in two layers closing the breach resulting from the removal of the diverticulum. (Courtesy of Prof. R. Grégoire, Chirurgie de l'Oesophage, Masson et Cie, Paris, 1935.)

SHALLOW'S TECHNIC OF COMBINED, ONE STAGE, CLOSED METHOD FOR THE TREATMENT OF PHARYNGEAL DIVERTICULA

Thomas A. Shallow[1] recommends the following technic in treating pharyngeal diverticula:

Prepare the patient in the usual manner employing rectal ether anesthesia; intratracheal or avertin may also be used.

Step 1. Make an incision on the involved side along the anterior border of the sternomastoid muscle. The incision should begin at the level of the hyoid bone and extend to 1 inch above the sternum; penetrate the skin, platysma and deep fascia, thus exposing the anterior belly of the omohyoid muscle which is either divided transversely or retracted. If the external jugular vein is exposed, it should be ligated and divided.

Step 2. Expose and retract the common carotid artery and the internal jugular vein. If the thyroid gland is much enlarged, ligate and cut the superior thyroid artery.

[1] Surg., Gynec., and Obst., March, 1936, Vol. 62.

Step 3. Incise the sheath which encases the trachea and esophagus, exposing the latter in the posterior part of the wound and the trachea anteriorly. Retract the trachea and thyroid toward the midline.

Step 4. Introduce an esophagoscope; aspirate the contents of the diverticular sac. Apply an antiseptic solution to the interior of the pouch and lower

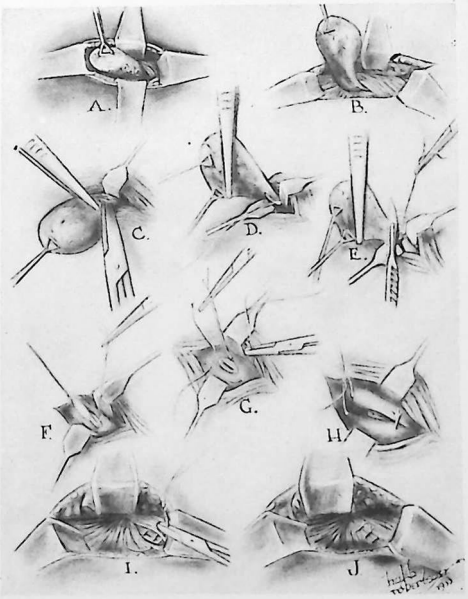


Fig. 1357. Shallow's technic of combined, one stage, closed method for treatment of pharyngeal diverticulae.

pharynx. Insert the esophagoscope into the fundus of the diverticulum and transilluminate the sac; rotate the sac into the wound (Fig. 1357A). Grasp the sac with intestinal forceps and draw it upward and outward (Fig. 1357B). Withdraw the esophagoscope from the pouch. Free the sac to the junction of the diverticulum with the pharynx (Fig. 1357C). Free all muscle fibers from its neck; a neck more than one-half inch in diameter usually means incomplete dissection.

Step 5. Transfix the sac at its junction with the pharynx with a small intestinal

needle carrying No. 1 chromicized catgut (Fig. 1357D). Excise the neck of the sac close to the pharynx (Fig. 1357E).

Step 6. Cauterize the stump with pure phenol (Fig. 1357F). Place mattress sutures of No. 1 chromicized catgut one above and one below the stump (Fig. 1357GH). Penetrate only the submucous coat of the pharynx. Bring together with sutures over the invaginated area, the cricopharyngeus and the inferior constrictor muscles. If the pouch originates at Killian's slit, join the cricopharyngeus and the upper circular fibers of the esophagus.

Step 7. Close the incision in the neck in layers. Place a small rubber tissue or cell-silk drain under the deep fascia (Fig. 1357I).

Shallow summarizes:

"1. In a series of 76 pharyngeal diverticula, all operated on by the one stage method, there were 2 deaths.

"2. Seventy-four patients had complete recovery.

"3. None of the cases was complicated by mediastinitis.

"4. None of the cases required postoperative esophageal dilatation.

"5. The use of the esophagoscope prevents angulation, stenosis, and atresia of the esophagus.

"6. Hoarseness is often a chief complaint.

"7. There are 3 areas of the pharynx from which diverticula may arise.

"8. The one stage method of operation is the reasonable method of treatment of pulsion diverticula of the pharynx.

"9. The results depend upon rational surgical procedure and accurate approximation of tissues.

"10. Moynihan[1] believes that there is no need for operations in two stages. He has operated upon 15 cases and has 'never had any difficulty in obtaining healing by first intention.'

"11. Torek[2] says: 'Thirty years ago the mortality was very high with the one stage procedure, but in the last 5 years, 60 cases have been recorded with a mortality of only 1.'"

SURGICAL TREATMENT OF MEGA-ESOPHAGUS

The surgical treatment of mega-esophagus is aimed toward the removal of the obstacle at the abdominal part of the tube caused by anatomico-pathologic changes in the organ. Anatomic and physiologic studies have demonstrated that the obstacle here is localized in the subdiaphragmatic part and that relief may be obtained by destruction of the sphincteric apparatus at this site.

The surgical methods in use for the treatment of mega-esophagus may be divided into the bloodless and incisional.

The bloodless methods include slow and rapid dilatation. Slow dilatation is accomplished in the usual way by successive introduction of sounds of varying diameters. The rapid dilatation is accomplished by the introduction of rubber bags which are then distended by hydrostatic pressure (method of Gottstein and Plummer); by air distention (Finschietto's method) or by Starck's expansible metallic apparatus.

[1] Surg. Gynec. and Obst., Vol. 54, 1932.
[2] Ann. Surg., Vol. 97, 1933.

"The rapid dilatation method is considered to give better permanent results than the slow method. It is the most benign of all methods and is reported to give fairly good permanent results in at least 75 per cent of cases. The only danger is that of rupture of the esophagus with resulting mediastinitis and fatal peritonitis. This danger occurs with both the hydrostatic and metallic dilators; but in the latter, in addition, there is a greater possibility of injury to the lining of the esophagus." (Vasconcelos and Botello.)

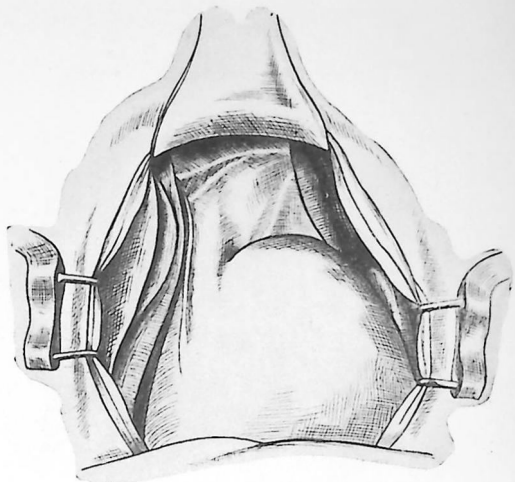


FIG. 1358. Abdomen opened. Balfour's separator is in position. The anterior surface of the dome of the stomach is seen and part of the mediogastric region. There is ample exposure of the abdominal segment of the esophagus, of the gastrohepatic branch of the pneumogastric nerve; also, a limited portion of the inferior surface of the diaphragm and the inferior diaphragmatic arteries are seen. (Vasconcelos and Botello.)

The incisional surgical methods include intragastric dilatation, Heller's cardiolysis, esophago-cardioplasty by the abdominal route, Heyrowsky's esophago-gastroanastomosis and trans-thoraco-abdominal methods of esophagogastroanastomosis.

The intragastric dilatation method was introduced by Mikulicz in 1907 and the operation has been done by a number of surgeons. It should, however, be regarded as an exceptional method when direct dilatation is impossible.

Heller's Cardiolysis

This operation was introduced by Heller in 1913 and he gave it the name of extramucosal cardioplasty. The technic is as follows:

Step 1. Make a long incision parallel to the left costal border, thence to the xiphoid appendix, all planes being divided. The cartilages of the 7th, 8th and 9th ribs are uncovered and they are sectioned, care being taken at the 7th rib not to incise the pericardium. This gives access to the cardia. Some prefer a median xipho-abdominal incision, as giving an easier cardial approach.

Step 2. Following opening of the abdomen, Balfour's separator is applied and the retraction gives ample view of the operative field (Fig. 1358). The left lobe of the liver, which covers the cardia, is displaced by sectioning the triangular ligament and, if necessary, the left part of the coronary ligament. This uncovers the abdominal part of the esophagus. The liver is held back by a retractor.



FIG. 1359. Esophagocardiotuberosity branch. 1. Anterior esophageal; 2. cardial branch; 3. tuberosity; 4. left gastric artery. Reproduced from one of the specimens in the author's laboratory. (Vasconcelos and Botello.)

Step 3. The stomach is seized between the fingers and pulled in a cranio-caudal sense, drawing the cardioesophageal segment downward. Examine the region for any periesophageal inflammation. Search carefully for the gastrohepatic branch of the pneumogastric nerve and verify the position of the inferior diaphragmatic arteries, as well as the esophago-cardiotuberosity artery. The peritoneum is incised vertically avoiding nerves and vessels (Fig. 1359).

Step 4. The peritoneal folds are dissected so as to completely expose all of the abdominal esophagus which is then mobilized (Fig. 1360). All the tissue bands which connect the esophagus to the diaphragm are cut away and the posterior surface of the esophagus exposed. A piece of gauze is wound around the esophagus which facilitates traction. In this way the dilated part of the organ and the strictured abdominal part are brought into the operative field.

Step 5. This is the most delicate part of the operation. It consists of sectioning all the muscular layers of the esophagus by a vertical incision which begins about 2 to 3 cm. above the strictured zone and terminates from 2 to 3 cm.

below it. One incision is made in the anterior wall and another identical one in the posterior wall. These incisions should not include the mucosa. Following these incisions, the muscular fibers retract and the abdominal esophagus expands immediately.

Step 6. Restoration of displaced organs and closure of the abdominal cavity without drainage complete the operation.

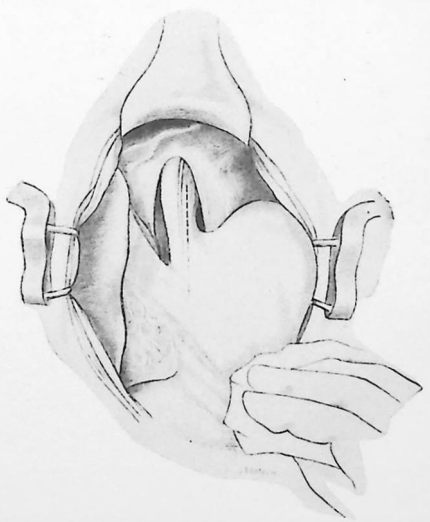


FIG. 1360. The peritoneum is dissected permitting a clear view of the pillars and esophageal hiatus of the diaphragm, the abdominal segment of the esophagus and the anterior pneumogastric nerve are seen. The stomach is held in downward traction by an assistant. The dotted line shows Heller's incision. (Vasconcelos and Botello.)

Heyrowsky's Esophago-Gastroanastomosis

This operation was practised for the first time by Heyrowsky in 1913. The technic is as follows:

Steps 1 to 4. The preliminary stages of this method are the same as those in Heller's operation up to the time when the exposed esophagus is invested in a fold of gauze and pulled into the operative field (Fig. 1361).

Step 5. The lower part of the thoracic esophagus is pulled down and a complete view of the dilated part obtained. The essential procedure in this operation is to make an anastomosis between the esophagus and stomach, an opening in the dome of the stomach about 3 to 4 cm. being made. The stomach is



FIG. 1361. Heyrowsky's operation. After the abdominal segment of the esophagus is thoroughly isolated from its diaphragmatic connections it is enmeshed in a strip of gauze and passed to an assistant. The dotted lines show the incisions for esophagogastric anastomosis. (Vasconcelos and Botello.)

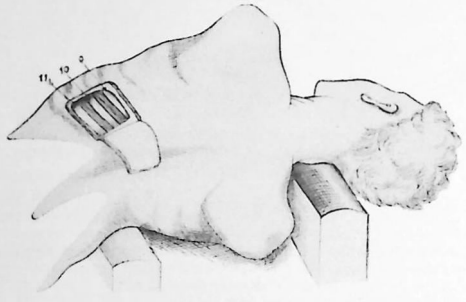


FIG. 1362. Showing the incision and raising up of the superficial planes. (Vasconcelos and Botello.)

for surgical reasons. The technic of the method devised by Vasconcelos and Botello[1] follows:

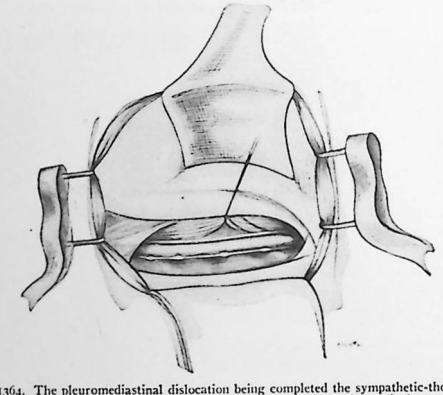


FIG. 1364. The pleuromediastinal dislocation being completed the sympathetic-thoracic chain, the aorta, the thoracic esophagus and part of the superior surface of the diaphragm are clearly seen. The lung and the pleura are also held in place by means of a retractor. (Vasconcelos and Botello.)

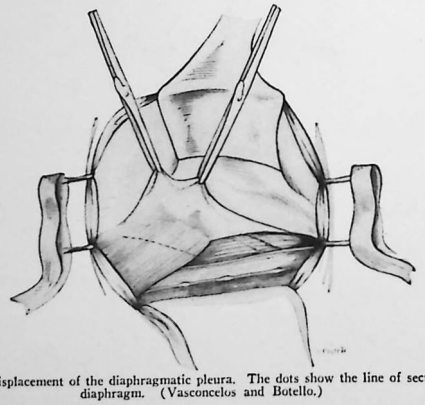


FIG. 1365. Displacement of the diaphragmatic pleura. The dots show the line of section of the diaphragm. (Vasconcelos and Botello.)

Step 1. Place the patient on the right side with a cushion under the dorso-lumbar region. The left arm is kept elevated. Make a U-shaped incision

[1] "Cirurgia do Megaesofago," Comp. Ed. Mar., Sao Paulo, 1937.

held by a gauze compress and kept maintained under traction by an assistant. The esophagus is similarly held under traction by another assistant. The superior part of the strictured esophagus is approximated to the dome of the stomach.

Step 6. The anastomosis is made at selected points in both structures. Supporting sutures are first placed at the extremities to maintain the positions while the anastomosis is being made. Then the esophagus and stomach are

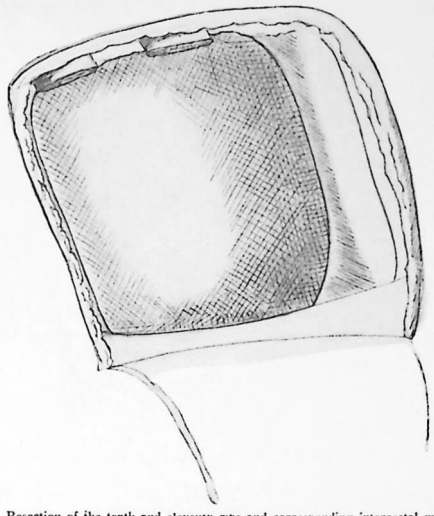


FIG. 1363. Resection of the tenth and eleventh ribs and corresponding intercostal muscles, permitting the parietal pleura to be seen. (Vasconcelos and Botello.)

joined by musculo-muscular suture, beginning posteriorly. Proceed to finish the suturing, beginning the suture by closing the anterior segment.

Step 7. The stay sutures are kept in place to prevent re-entrance of the stomach into the thorax through the diaphragmatic hiatus. The gauze strips are removed and the viscera restored to place. Opinions vary regarding the necessity for drainage.

Thoraco-Abdominal Approach to the Esophagus. Vasconcelos and Botello Technic

Several methods of thoraco-abdominal approach to the esophagus have been described in the literature, that through posterior mediastinotomy being preferred

with unequal limbs. The medial limb of the incision commences at the level of the eighth rib and extends to the twelfth (Fig. 1362). The second vertical

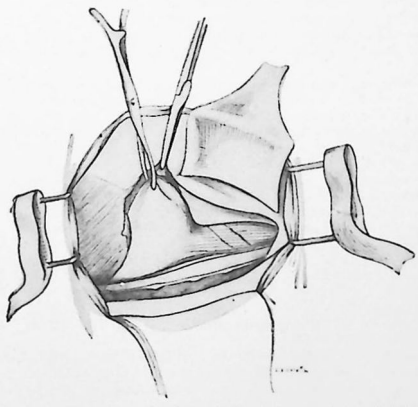


FIG. 1366. The diaphragm being sectioned, the dome of the stomach is pulled into the thorax through this breach. (Vasconcelos and Botello.)

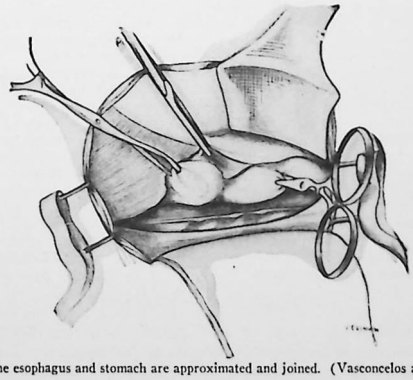


FIG. 1367. The esophagus and stomach are approximated and joined. (Vasconcelos and Botello.)

limb ascends along the posterior axillary line to the eighth rib. The incisions are carried to the skeletal plane and the flap raised, uncovering the ribs.

Step 2. Resect the twelfth rib; section the tenth and eleventh ribs through their extremities (Fig. 1363). Resect the intercostal muscles. Expose the parietal pleura and fundus of the costodiaphragmatic space. Detach the pleura from its connections with the vertebral column and aorta. This gives easy access to the mediastinum. The most delicate step of the operation is the detachment of the diaphragmatic pleura which adheres more or less strongly to the muscular lamina.

Step 3. Detachment of the mediastinal pleura exposes the sympathetic-thoracic ganglionary chain, the aorta and the thoracic esophagus (Fig. 1364). The splanchnics are seen clearly and injury to them should be avoided. The

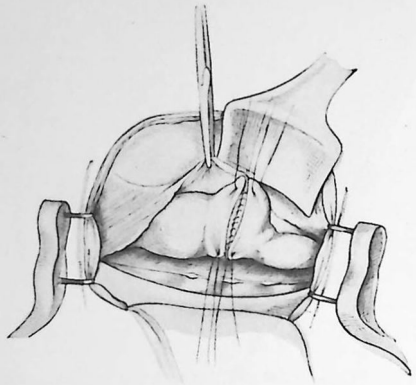


Fig. 1368. Esophagogastroanastomosis: the sustaining sutures are seen at the angles of the anastomosis. (Vasconcelos and Botello.)

diaphragmatic hiatus is isolated and the phreno-esophageal membrane being partly destroyed; the diaphragm is sectioned (Fig. 1365).

Step 4. Following section of the diaphragm, a carefully selected portion of the dome of the stomach is seen directly and is drawn into the thorax (Fig. 1366). The branches of the peri-esophageal plexus are carefully isolated and the branches of the esophago-cardiotuberositary artery are ligated.

Step 5. The esophagus is approximated to the stomach (esophagogastroanastomosis) and is being held by stay sutures while the esophagogastroanastomosis in two planes of continuous sutures is executed (Figs. 1367-1368).

Step 6. Suture the diaphragmatic breach so as to avoid transdiaphragmatic hernia of the stomach. Drain the mediastinum with iodoform gauze. Closure of the musculo-cutaneous planes concludes the operation.

CHAPTER 31

SURGERY OF THE HEART AND PERICARDIUM

PERICARDIUM

Historical Notes. Riolanus, in 1649, was the first to advocate paracentesis of the pericardium. Trephining the sternum was practiced by Skielderup (1818) and by Malle (1871). Dieulafoy recommended aspiration. Trousseau counseled open incision by knife. Sir Charles Ballance, in his Bradshaw Lecture on the surgery of the heart in 1920, asserted that the operation of paracentesis pericardii should be banished from surgical practice.

Anatomic Considerations (Fig. 1369). The Pericardium. The pericardium is the serous sac which encloses the heart and the proximal portions of the great

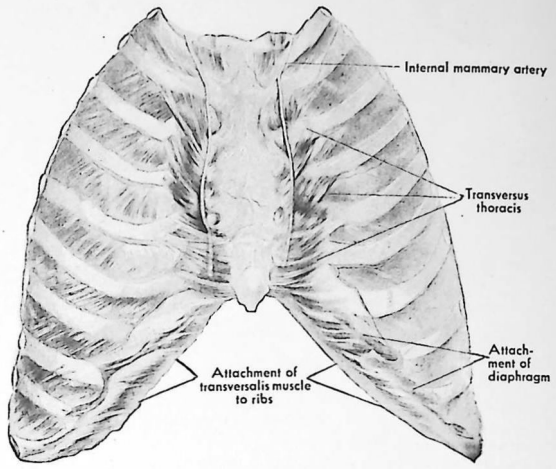


Fig. 1369. Dissection of anterior thoracic wall from behind, showing triangularis sterni and intercostal muscles.

vessels. Like other serous sacs, it consists of two layers, one of which, the visceral layer, closely invests the heart and at its base becomes continuous with the parietal layer within which it is invaginated.

The visceral layer, sometimes termed the epicardium, is an exceedingly thin membrane, and is throughout the greater part of its extent so closely adherent to the outer surface of the heart that any attempt to detach it results in injury to the superficial layers of the heart musculature. Over the right side and the anterior surface of the ventricular portion of the heart, however, a certain amount of fat occurs between the muscular tissue and the epicardium even in thin persons.

The parietal layer, much stronger than the visceral, forms a somewhat conical sac, the base of which rests upon and is attached to the diaphragm, while its apex surrounds the roots of the aortae. Notwithstanding its greater size, no cavity exists normally between this and the visceral layer, the two being in contact throughout, except below, where, towards the periphery of the base of the parietal cone, a slight space occurs that is normally occupied by a quantity of pericardial fluid (liquor pericardii).

At the sides, and to a considerable extent on its anterior surface, the parietal layer of the pericardium is united to or in close contact with the adjacent pleurae. At the upper part of its anterior surface where it covers the aorta it is free from such contact, and over a triangular area near the base of the cone the anterior surface rests upon the posterior surface of the lower part of the sternum, to which it is united by some loose areolar tissue. Posteriorly it is free from the pleurae to a considerable extent, that portion of it which covers the posterior surface of the left auricle resting upon the esophagus and the thoracic aorta. The base of the cone is firmly united to the upper surface of the diaphragm throughout its entire extent, the area of attachment corresponding to the anterior and a portion of the left lobe of the central tendon.

The parietal layer of the pericardium is in relation with an external fibrous layer which extends beyond the serous investment of the roots of the great vessels, blends with their outer coats, and is directly continuous with the deep cervical fascia, thus connecting the pericardium with two respiratory agents, the diaphragm below and the cervical muscles (omohyoid) above. When these act conjointly, as in a full inspiration, they render the pericardium tense and resisting, and minimize the pressure upon the heart by the inflated lungs.

The Heart. The outlines of the heart are as follows: A line drawn convexly outwards from the third to the sixth right chondrosternal junctions will represent the right border; a line from the sixth right chondro-sternal junction to a point in the fifth left interspace, three and a half inches from the mesial plane, corresponds to the lower border; while a line from the last point to the second left interspace, half an inch from the sternal margin, marks out the left border. The anterior surface of the heart mainly consists of the right ventricle, a portion of the right auricle, and about half an inch of the left ventricle. Of these, the right ventricle is the part most liable to injury from punctured wounds. Owing to the thinness of its wall, wounds of the right auricle are almost invariably fatal. The right auricle receives the superior vena cava, the inferior vena cava, and the cardiac veins. It opens into the right ventricle by the tricuspid orifice which is guarded by the valve of the same name. Springing from the conus arteriosus of the right ventricle is the pulmonary artery; its semilunar valves prevent regurgitation of blood from the artery into the ventricle. The four pulmonary veins terminate in the left auricle from which the blood enters the left ventricle through the mitral orifice which is guarded by the mitral or bicuspid valve. The aorta arises from the vestibule of the left ventricle. Its valve, like that of the pulmonary artery, consists of three semilunar cusps.

The heart is supplied by the coronary branches of the ascending aorta. The right coronary occupies the right auriculo-ventricular groove, and sends a descending branch along the posterior inter-ventricular sulcus. The left coronary artery runs in the left auriculo-ventricular furrow, and gives off a descending branch which lies in the anterior inter-ventricular groove.

PARACENTESIS PERICARDII

Sites recommended for paracentesis of the pericardium are: Third intercostal space (Schub and Sharp), fourth intercostal space (Karanaeff, Pirogoff), fifth intercostal space (Sievers, Dieulafoy, Rosenbach), sixth intercostal space (Delorme and Mignon, Voinitch-Sianojensky), seventh intercostal space (Beckman and Behier), and the left costo-xiphoid notch close to the ensiform cartilage (Laennec, Müller, Roberts and Allingham). Marfan's subxiphoid puncture is another approach. Important facts to remember in doing a pericardial paracentesis

are: Avoid injury to the (a) pleura, (b) the heart and (c) the internal mammary artery (Figs. 1370-1371-1372).

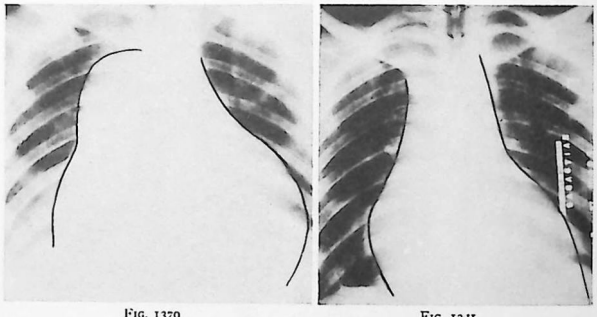


Fig. 1370 Fig. 1371

Fig. 1370. Enormous pericardial effusion.
Fig. 1371. Pericardial effusion after pericardiocentesis.

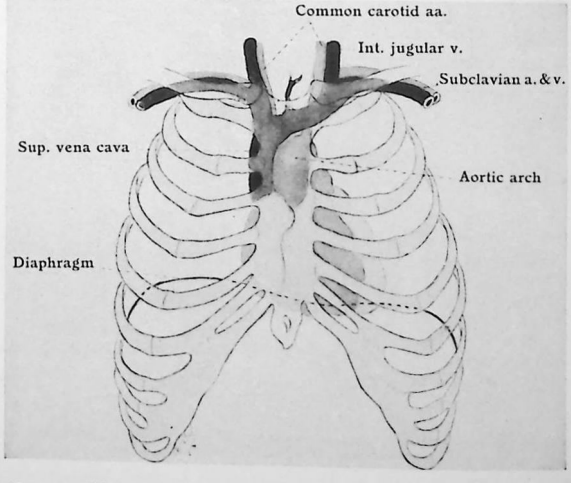


Fig. 1372. Relation of the heart and blood vessels to the anterior wall of the chest.

Voinitch-Sianojensky made an exhaustive study to determine a composite pericardial area not covered by the pleura in a large number of normal subjects.

The long axis of this space which is the resultant site of greatest safety extends from the seventh left chondrosternal articulation vertically upward to the level of the lower border of the fifth chondrosternal articulation. This line lies chiefly behind the sternum but touches upon the sixth space just at the sternal margin (Fig. 1373C).

Technic of Pericardiocentesis. This procedure is indicated both as a means of diagnosis and of treatment. If for diagnosis, use a long, aspirating needle; if for treatment, a trocar should be employed. Withdraw the fluid slowly. If pulmonary or cardiac distress supervene, stop for a while until the condition of the patient improves. It is not advisable nor necessary to withdraw the fluid completely.

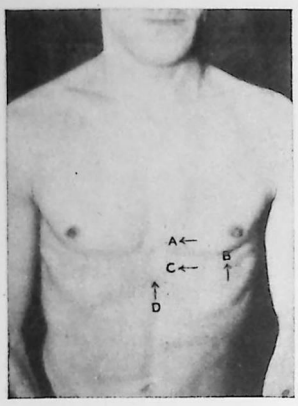


Fig. 1373. Positions for puncturing the pericardium. A. Parasternal puncture (small preliminary skin incision). B. Lateral puncture (small preliminary skin incision). C. Puncture at the inner extremity of the sixth space (Voinitch-Sianojensky). D. Marfan's subxiphoid puncture.

The usual site for introducing the aspirating needle is: the fourth, fifth, or sixth intercostal space about an inch to the left of the sternum. The last named is the safest point to avoid injury to the important structures named above.

Marfan's Method

Place the patient in a semi-sitting position. Introduce a spinal-puncture needle in the midline immediately below the xiphoid cartilage (Figs. 1373D-1374) and pass the needle obliquely from below upward along the posterior surface of the sternum for about 4 cm.; thence somewhat obliquely backward into the gap in the sternal insertion of the diaphragm, thus penetrating the pericardium at its base.

It will thus be seen that in this method the pleura and internal mammary artery are definitely avoided. According to Blechmann, the depth to which the needle ought to penetrate is approximately 4 cm. (1¾ in.) in patients less than five years of age; 5 cm. (2 in.) in those from five to ten years; 5 to 6 cm. (2-2½ in.) in those from ten to fifteen years; 6 cm. (2½ in.) in individuals more than fifteen years of age.[1] In the adult the depth to which it is necessary to penetrate will vary a little according to the shape of the thorax, the more or less marked concavity of the diaphragm, and the degree of distention of the pericardial sac; practically, however, as the puncture will always be made with a vacuum in the aspirating apparatus, the needle will be pushed in until the liquid begins to flow. This method of puncture should not be used when the xiphisternum is misshapen or when there is much abdominal distention.

[1] (Blechmann, "Les epanchements du pericarde; etude clinique et therapeutique. La ponction epigastrique de Marfan. These de Paris, 1913.)

Lateral Paracentesis

Here the puncture is made about four fingers' breadth from the sternum (Fig. 1375). Make a vertical incision about half an inch in length over the intercostal space selected. Push the needle inward obliquely almost parallel to the deep surface of the thoracic wall (Léjars). Never insert the needle deeper than about an inch from the surface (Terrier and Raymond). If no fluid issues at that depth it is best to abandon further efforts and do a pericardiotomy (p. 1208). A sharp, quick, dexterous thrust and experience are required to skillfully overcome the resistance offered by the pericardium, particularly when it is thickened or distended with fluid. Be careful not to permit the end of the trocar to

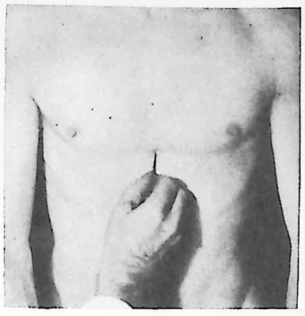


Fig. 1374



Fig. 1375

Fig. 1374. Marfan's subxiphoid puncture of the pericardium.
Fig. 1375. Lateral puncture of the pericardium.

irritate the heart (proper position of the point of the cannula). When the flow is scanty or lessened bring the patient into a sitting position.

Parasternal Paracentesis

This is more difficult to do than the preceding (Fig. 1376). Make a transverse incision in the skin about an inch long, at the inner end of the sixth left intercostal space exposing clearly the border of the sternum. Guide the trocar to the wall of the chest, direct it obliquely inward behind the sternum for about three-quarters of an inch, then point it inward and downward until the pericardium is opened.

Trans-sternal Paracentesis

DOYEN'S PROCEDURE

Step 1. A vertical median incision is made, 5 cm. in length, the center of which is opposite the fifth costal cartilages.

Step 2. The surface of the sternum is exposed with a raspatory and perforated (Fig. 1377) with a trephine, flat drill or cylindro-spherical burr of between 16 and 20 mm.

Step 3. Irrigate the wound and grasp the pericardium with clawed forceps at the time of puncture.

Step 4. Suture and tampon the wound. If drainage is indicated a soft split rubber tube is inserted after opening the pericardium.

PERICARDIOTOMY

Duval Barasty's Extrapleural Pericardiotomy

The essential steps of the operation are as follows (Figs. 1378-1379):

Step 1. Free the ensiform cartilage and remove it through a midline incision.

Step 2. Split the sternum with a rotary saw to the third intercostal space. Divide it across.

Step 3. Keep the parts retracted with a self-retaining retractor.

Step 4. Open the pericardium. Do what is indicated. Drain the lower angle of the pericardial wound and close the rest of the sac.



Fig. 1376

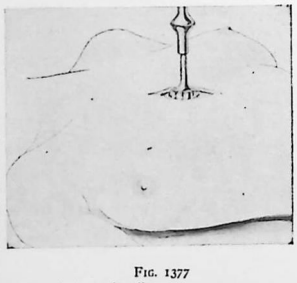


Fig. 1377

Fig. 1376. Paracentesis of the pericardium.
Fig. 1377. Doyen's trans-sternal route of approach to the pericardium. After the soft tissues have been divided the sternum is perforated with a cylindrospherical burr of 20 mm. diameter.

Délorme and Mignon's Method

Step 1. Make a vertical incision about 1 cm. from the left border of the sternum in a curved direction and extending from the lower border of the seventh to the upper border of the fourth costal cartilage.

Step 2. Resect a portion of the fifth and sixth costal cartilages.

Step 3. Dejach the insertions of the triangularis sterni muscle. Push away the loose cellular tissue from the pericardium.

Step 4. Displace the mammary vessels and open the pericardium.

Comment. Von Eiselsberg's method consists of resecting the fourth left costal cartilage.

Ollier's Operation

This is essentially a subperiosteal resection of the left fifth costal cartilage.

Step 1. Make an incision about three inches in length beginning at the midline of the sternum and extending outward over the fifth cartilage. The cartilage is divided with a knife close to the sternum. Introduce a Doyen rib elevator clearing the deep surface; raise it and turn it outward. Remove the cartilage

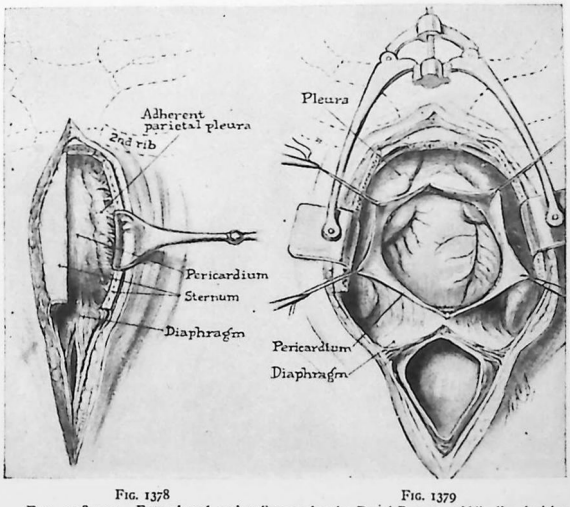


Fig. 1378 Fig. 1379

Figs. 1378-1379. Extrapleural pericardiotomy by the Duval-Barasty middle line incision. The ensiform is freed and removed. The sternum is split to the third intercostal space with a rotary saw, where it is cut across. Fig. 1378 shows the left half of the sternum retracted bringing into view the adherent parietal pleura which is freed from the chest wall with a gauze sponge. Fig. 1379 shows a self-retaining retractor in place and the pericardium opened (Lerche).

at its articulation. Retract the lips of the incision upward and downward exposing the fourth and fifth intercostal spaces.

Step 2. An incision in the intercostal tissues is made parallel with and close to the border of the sternum. Detach the triangularis sterni muscle and push it outward.

Step 3. The pleural cul-de-sac adheres only slightly to the pericardium but firmly to the muscle (Délorme and Mignon). Figure 1369 shows the attachments of the triangularis sterni muscle to the posterior surface of the sternum. The periosteal separator should, therefore, be introduced under

the sternal border parallel to the deep aspect of the bone, and the tendinous insertions and the muscle detached by working the instrument upward and downward.

Step 4. Introduce a finger through the opening made with the director, retracting the tissues and exposing the pericardium.

Rehn-Durante Method of Pericardiotomy

Step 1. Make an incision between the ribs extending from the sternum externally. In case of injury of the chest, avoid the wound inflicted by the missile or knife. The incision is usually made in the fifth intercostal space.

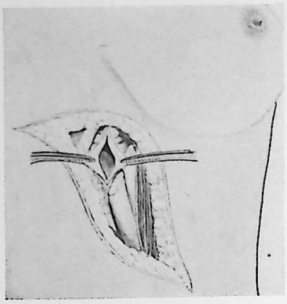


Fig. 1380. Rehn's method of pericardiotomy.

Step 2. With rib spreaders, separate the ribs forcibly.

Step 3. Open the pleura (Fig. 1380).

Step 4. Grasp the lung with appropriate forceps and displace it outward. If there is not sufficient room for the operative procedures, one should resort to resection of one or more ribs, or, if need be, partial resection of the sternum. Where one finds that the approach is beset with greater difficulties, a longitudinal median incision through the sternum should be made and the approach to the pericardium sought. In such instances, the incision should begin at the upper border of the third rib and end at the upper border of the sixth. The costal cartilages of the respective ribs are divided close to the sternum and the flap, consisting of bone and soft structures, is displaced upward or downward according to indications. Avoid injury to the internal mammary artery.

Step 5. Where there is no emergency existing one may proceed cautiously and carefully, avoiding injury to the pleura by working close to the border of the sternum and carefully separating the ribs at the sternal junction. Separate the pleura from the pericardium with great care. Open the pericardium by means of a long or transverse incision.

Binnie's Operation

Step 1. Make an incision down to the bone to the left, from the mid-line of the sternum at the level of, and following the line of, the sixth costal cartilage. If necessary, the incision may extend to the left mammary line.

Step 2. Separate the perichondrium and all the soft parts from the sixth costal cartilage. Excise the cartilage.

Step 3. Ligate the mammary vessels in the triangular muscle of the sternum and divide its tendinous insertion into the sternum.

Step 4. The exposed pericardium can now be drained and the operation ended if drainage alone is needed.

Step 5. If more room is needed, make an incision from the horizontal one upward in the midsternal line to the point desired, usually the level of the second rib.

Step 6. Separate the periosteum and soft structures from the sternum to the left of the median line. Divide the fifth, fourth and third left costal cartilages at their insertion into the sternum.

Step 7. Push the exposed margin of the pleura upward through the horizontal incision and gradually separate it from the fifth and even the fourth and third costal cartilages.

Step 8. After separating the flap from the pleura, fracture or divide the costal cartilages in the flap at their costal insertion.

Step 9. Split the pericardium along the sternal margin and laterally along the fifth interspace. This gives access to the heart from the auricles to the apex of the ventricles.

Step 10. If more room is desired, a sufficient portion of the sternum may be excised with bone forceps or by means of a rongeur.

Step 11. Wipe away any blood clots in the open pericardium. Suture the existing cardiac wounds with catgut or silk, care being taken not to suture any coronary artery.

Step 12. Close the pericardial wound with or without drainage.

Step 13. Suture or drain any pleural wounds which may be present. Don't waste time by trying to remove blood thoroughly from the pleural cavity.

CARDIOLYSIS

Decortication of the heart was first recommended by Délorme in 1898. Rehn performed the operation in a case of adhesive pericarditis. In 1902, Brauer suggested an operation to which the name cardiolysis is applied, its object being to counteract the damage resulting from adhesive mediastinopericarditis. In substance the principles underlying the procedure are:

Délorme's Operation

Step 1. Expose the heart by temporary resection of the thoracic wall.

Step 2. Open the pericardium.

Step 3. Manually break down the adhesions existing between the pericardium and heart.

Brauer's Operation

This operation is not designed to free the adhesions from the heart but to render them innocuous. This is accomplished by excision of ribs and cartilages, even a portion of the sternum to an extent called for by the existing condition (three ribs or more if necessary). After this the cutaneous flap is replaced. A suitable protection should be worn later over the site of the operation (Fig. 1381).

The reader is referred to Schmieden's thorough work on the subject. In brief, his procedure is as follows:

Step 1. Make a flap extending over the third to the sixth ribs inclusive (on the left side).

Step 2. Lift up the flap. Cut the costal cartilages (left) close to the sternum. Resect considerable portions of ribs subperiosteally depending upon the requirements of the case.

Step 3. Push back the soft tissues. Smooth the sternal margin with rongeurs.

Step 4. Carefully dissect out the scar-tissue surrounding the heart. Avoid opening the pleura.

Comments. Usually only the left heart needs decortication. If the left phrenic nerve is found imbedded in scar tissue it may be resected. Free the heart from all restraining bands (diaphragm; etc.). Work carefully on the right side because the wall of the heart is weaker here. Never attempt decortication of the auricles (Schmieden). Nissen recalls

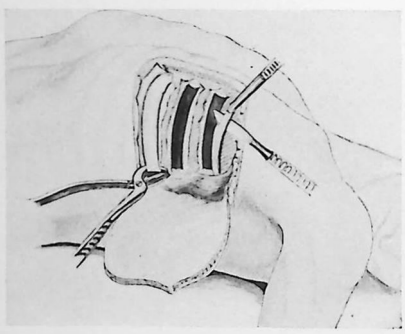


Fig. 1381. Technic of cardiolysis.

that an extrapleural resection of ribs (extrapericardial thoracolysis) is an excellent method to afford freedom of movement to the heart. It is a simple and successful procedure provided, however, the cases are well selected.

CONTUSIONS OF THE HEART

Claude S. Beck described the "steering-wheel" type of accident producing contusion of the heart which is driven against the spinal column (Fig. 1382). The usual symptoms complained of are dyspnoea and weakness. Circulatory collapse may develop. In gross injury of the heart, rupture of the auricles and ventricles may take place.

PERICARDIECTOMY

In the Treatment of the Pick Syndrome

Experiments by Claude S. Beck revealed that the essential factor in the production of Pick's disease is fibrosis and contracture of the parietal pericardium or epicardium, or both, forming a casing of scar which compresses the heart and

primarily obstructs its filling, interfering with cardiac motion. Generalized adhesions between the epicardium and the parietal pericardium are not sufficient in themselves to produce polyserositis.

Coincidental with the development and contracture of scar tissue about the heart, the clinical manifestations of the Pick syndrome in the order of their appearance are: (a) a rise in the venous pressure; (b) ascites and the development of a fibrinous exudate on the liver; (c) hydrothorax; and (d) pulmonary and subcutaneous edema. Together with the observations reported, there occurred general weakness and listlessness, a small and rapid pulse, cyanosis and a decrease in the minute volume output of the heart. It was shown roentgeno-

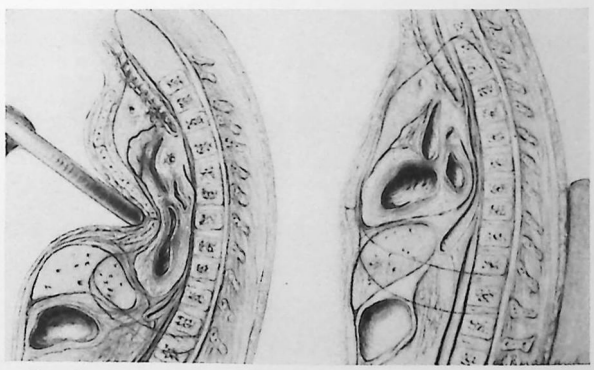


Fig. 1382. The "steering wheel" type of accident producing contusion of the heart. The heart is driven against the spine. Transient dyspnea and weakness are the usual symptoms. In the more serious cases circulatory collapse may develop. Auricles and ventricles may be ruptured. (Courtesy of Dr. Claude S. Beck.)

graphically that the heart and pericardium actually decreased in size and assumed a globular shape as the syndrome developed; after the pericardium was resected, the heart resumed its previous size and shape. Not infrequently the compression effect of the tight scar on the heart can be demonstrated fluoroscopically by the limitation of the systolic and diastolic movements of the heart.

The shift of the electrical axis of the heart with a change of position was of slight diagnostic significance in the experiments. It is of greater diagnostic significance in the determination of extrapericardial adhesions.

In tapping the ventricles for specimens of blood for cardiac output determinations, the aspirating needle encountered a definite resistance if the parietal pericardium was thickened and scarred. This may be useful as a diagnostic aid in obscure cases.

On the basis of experiment it was found that the venous pressure was the most reliable index to the development of this condition. A rise in the venous

pressure was always noted before ascites or fluid in the chest could be demonstrated.

The casing of a scar can almost always be resected. Usually a plane of cleavage can be found and separation can be carried out by blunt dissection.

Claude S. Beck's Operation

Place the patient in a semirecumbent position on the operating table; administer ether vapor anesthesia.

Step 1. Make an incision beginning at the costal margin in the midclavicular line on the left, curving medially and superiorly to the midsternum; follow

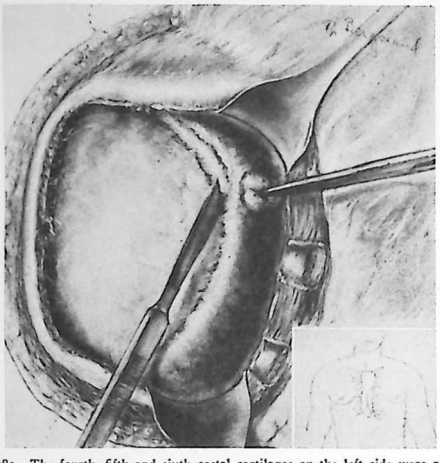


FIG. 1383. The fourth, fifth and sixth costal cartilages on the left side were resected and the sternum was partially resected. The pleural sinus on the left was dissected from the pericardium. (Courtesy of Dr. Claude S. Beck.)

the midsternum for 2 inches and curve laterally to the midclavicular line about the level of the third rib. Divide the pectoralis major at the two lateral arms of the incision, exposing the underlying costal cartilages, sternum and ribs. Separate the soft structures from the fourth, fifth and sixth costal cartilages and divide these close to the sternum.

Step 2. Separate the mediastinal structures from the sternum by blunt dissection. Remove over three-fourths of the width and 3 inches of the length of the sternum with a rongeur. Dissect the pleural sinus on the left from the pericardium (Fig. 1383).

Step 3. Incise the pericardium over its midanterior portion (Fig. 1384) and

search for a line of cleavage. Separate the pericardium from the heart by blunt dissection (Fig. 1385). Free the left ventricle before the right ventricle. Sharp dissection may be necessary here and there. Draw the



FIG. 1384

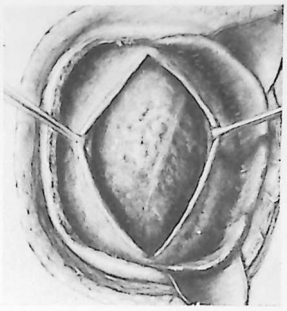


FIG. 1385

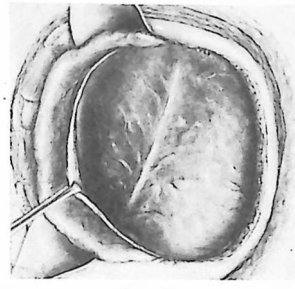


FIG. 1386

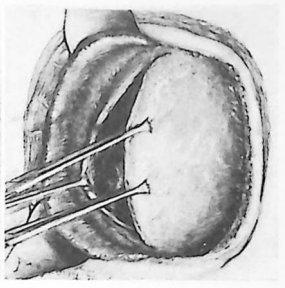


FIG. 1387

FIG. 1384. The pericardium was incised over the left ventricle. It was difficult to determine the plane of demarcation between scar and myocardium.

FIG. 1385. A plane of cleavage was found and separation was carried out by blunt dissection. The heart seemed to bulge through the opening in the scar as the separation progressed.

FIG. 1386. The pericardium over the right side of the heart was drawn to the left. The right pleural sinus was dissected from the pericardium.

FIG. 1387. The pericardium was excised as was also a plaque of epicardial scar lying over the left ventricle. The coronary vessels stand out well. (Courtesy of Dr. Claude S. Beck.)

pericardium over the right side of the heart to the left with Allis forceps. Dissect the right pleural sinus from the pericardium (Fig. 1386).

Step 4. Remove the pericardium on the right and over the base of the heart. Excise the scar on the left side down to the emergence of the pulmonary vessels.

Excision of the pericardium is now complete except for an area posterior to the heart and a small area over the right auricle where the venae cavae enter the pericardium and where the exposure of the structures is inadequate (Figs. 1387-1388).

Step 5. Place the flap of soft parts in its bed; the flap is lined with the covering of the heart and pleura.

Step 6. Suture the soft parts with two layers of silk and close the skin with silk. Place a small drain in the wound thus affording drainage of fluid or blood and preventing cardiac tamponade. Seal the wound with silver foil and cover it with a voluminous dressing.

BILATERAL EXPOSURE FOR RESECTION OF PERICARDIUM

The Duval-Barasty incision permits every aspect of the heart to be approached. In his operation for the relief of mitral stenosis, Cutler used this incision in six cases; with this experience as a background, he felt that probably this exposure was too shocking to the patient who was seriously decompensated.



FIG. 1388. The portion of the pericardium excised at operation. It varied in thickness from 1 to 6 mm. Microscopically, this structure closely resembled the scar produced experimentally. (Courtesy of Dr. Claude S. Beck.)

Step 1. Make an H-shaped incision, with the crossbar of the H extending over the midline of the sternum and the parallel arms of the H placed at the level of the third costal cartilages above and at the junction of the manubrium with the sternum below. The transverse incisions extend laterally from the midsternal incision for about 5 cm. in each direction. The midline incision is carried to the sternum. The upper transverse incision transects the pectoralis major muscle for a short distance at its origin from the sternum.

Step 2. Dissect laterally the two flaps of the soft parts thus made to expose the sternum and the costal cartilages. Resect the third, fourth, fifth and sixth costal cartilages on each side of the sternum.

Step 3. Ligate the internal mammary vessels. Dissect the pleural sinus from the pericardium on each side thus providing an excellent exposure well around on each side of the pericardium.

Step 4. The left and the right phrenic nerves should be dissected from the pericardium with the mediastinal pleura; the right may or may not be seen along the superior vena cava. The pulmonary vessels can be seen on each side.

Step 5. An almost complete resection of the pericardium can be carried out, leaving only the portion posterior to the heart.

The sternum is not disturbed. The seventh costal cartilage should not be resected in order that the movements of the diaphragm remain unimpaired. The flaps of soft parts are reapproximated.

WOUNDS OF THE HEART AND PERICARDIUM

Historical Notes. Wounds involving only the pericardium without injury to the heart are rare. The accepted dogma of the ancients that wounds of the heart were invariably fatal was challenged by Hallerius (1498-1562). In 1642 Idonis Wolf was first to describe a healed wound of the heart. This concerned a deer killed in hunt where a healed wound received previously was found by Wolf. George Fischer, in 1868, in a painstaking study of 452 cases of wounds of the heart, mainly in animals, showed that 10 per cent recovered. The first to suture wounds in the hearts of rabbits and to show that many recovered and to suggest the feasibility of such attempts in humans was Block, in 1882. Morgagni (De Sedibus et Causis Morborum) showed that a puncture wound of a coronary artery on the external surface of the heart may cause so great an amount of blood to accumulate in the pericardium as to compress the bleeding point thus arresting hemorrhage.

At the Eleventh International Medical Congress at Rome in 1895, Del Vecchio demonstrated healed wounds after suture in the hearts of dogs. The first attempt to suture the wound in the heart of a human being was made in September, 1895, by Cappelen of Christiana; the second in March, 1896, by Farina; the third, first successful attempt, is credited to Rehn (September, 1896). The latter collected, in 1907, 124 cases of suture of cardiac wounds with a mortality of 60 per cent.

Theodor Kocher as far back as 1907[1] recalled that at that time there was already too great a number of methods devised for the exposure and treatment of wounds of the heart. Thus: "that many procedures are at the surgeon's command in this phase of surgery is shown by the fact that Terrier and Raymond, in 1900, pointed out that in eleven cases of wounds of the heart ten procedures were used."

"True," Kocher says, "that in injuries of the heart the procedure must needs vary, depending on the site of injury (right or left to the sternum; above in the region of the auricle or below in the area occupied by the ventricles). Nevertheless, in an emergency situation where prompt action is paramount, the surgeon should be conversant with one method which should serve well in all cases."

CARDIORRHAPHY

Kocher's Technic

Step 1. Prepare the skin of the surface to be operated upon rapidly but thoroughly (soap and warm water; ether; alcohol; avoid antiseptics).

Step 2. Make an incision (Figs. 1389-1390) about 10 cm. in length beginning at the sixth costal cartilage and extending along it to the costochondral junction, through the skin and fascia. Divide the muscle fibers of the pectoralis major muscle at the under surface of the rib and the intercostals on both borders of the rib with knife and raspatory.

Step 3. After dividing the costal cartilage close to its attachment to the sternum,

[1] Chir. Operationslehre, 5th. Edit.

pull it up with a hook and sever it at its junction with the cartilage of the seventh costal cartilage.

The internal mammary vessels now appear about a finger's breadth from the border of the sternum. Ligate these doubly and divide them. The triangularis sterni muscle is now found under these vessels. Divide this close to the sternum.

Step 4. Displace the muscle and the pleura adhering to it laterally. The point of reflection of the pleura is frequently recognized by a pad of fat and may usually be easily separated from the pericardium. Expose the latter until its attachment to the diaphragm is visible. If at this point it appears that

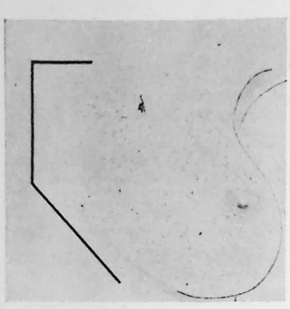


FIG. 1389

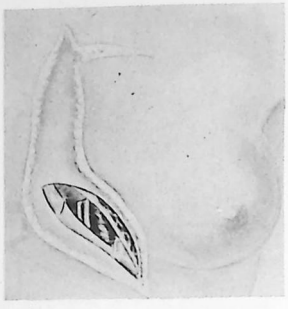


FIG. 1390

FIG. 1389. Kocher's method of exposure of the heart. Formation of osteoplastic flap.
FIG. 1390. Exposure of the heart by Kocher's method. The flap resulting from the incision shown in the previous illustration. The sixth costal cartilage has been resected. Between the divided ends of the cartilage the perichondrium is visible. The transversus thoracis muscle, the internal mammary artery and vein are exposed.

the pericardium may be promptly opened it may be done now; if not, proceed as follows:

Step 5. According to the position of the wound in the heart, enlarge the incision in the median line of the sternum upwards to the costal cartilage of the fourth, third or even second rib. Add to this vertical incision a horizontal cut about 8 cm. long dividing the fibers of the pectoralis major along their attachment to the rib, usually the third, from the upper border of which the fibers of the intercostal muscles are bluntly separated.

Step 6. Push off the pleura bluntly from the under surface of the fifth costal cartilage together with the triangularis muscle. Divide this cartilage close to its attachment to the sternum. Repeat the same procedure with the cartilage of the fourth and third ribs.

Step 7. Elevate the severed cartilages; push the triangularis muscle and pleura laterally. Break the flap consisting of the cartilages at their junction with the respective ribs, or, if necessary, by dividing the ribs further outward. Displace these outwards thus exposing the pericardium from the auricles

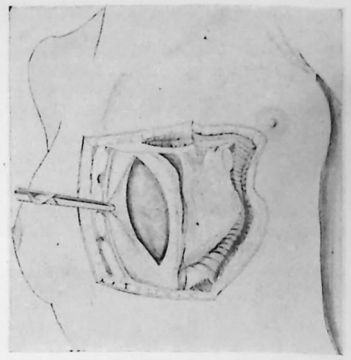


FIG. 1391. Exposure of the heart. Kocher's incision.

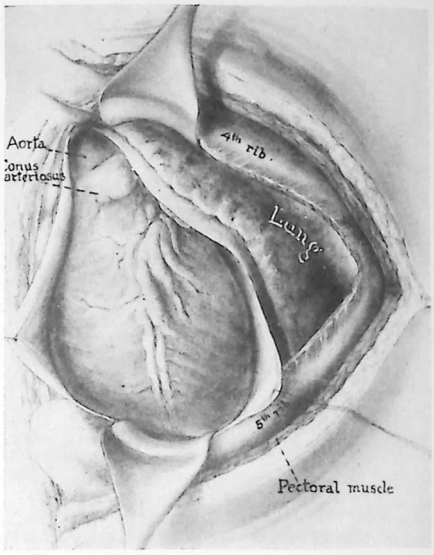


FIG. 1392. Exposure of heart by intercostochondral thoracotomy. (Courtesy of Dr. Claude S. Beck.)

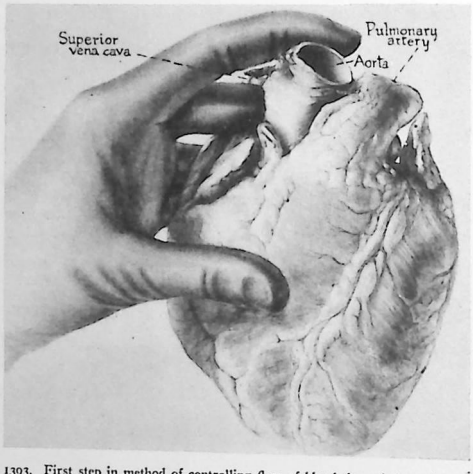


FIG. 1393. First step in method of controlling flow of blood through heart by compression of base; third finger is placed through great transverse sinus; fourth and fifth fingers are placed posteriorly in pericardial cavity; by compression with the fingers the venae cavae and the pulmonary veins can be occluded. (Courtesy of Dr. Claude S. Beck.)

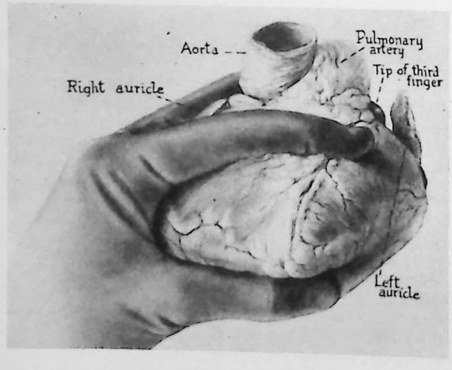


FIG. 1394. Second step in method of controlling flow of blood through heart by compression of base; the heart is steadied between the thumb and the index finger. (Courtesy of Dr. Claude S. Beck.)

(FIG. 1391) down to the apex. If the pleura is inadvertently opened, close it at once (Terrier and Raymond).

Step 8. Enter the opened pericardium and lift the heart out with two fingers. The apex is held by Museux forceps as recommended by Terrier and Ray-

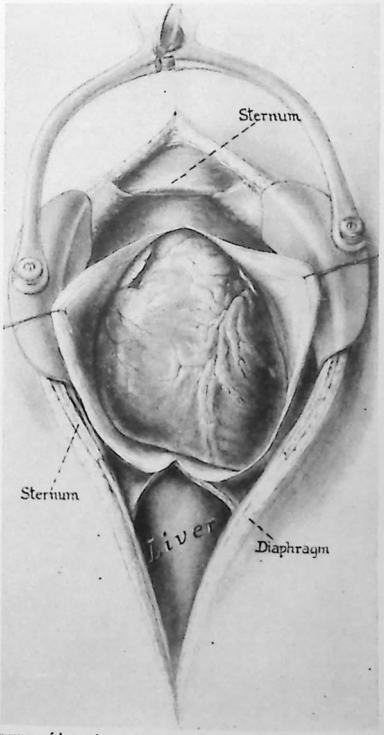


FIG. 1395. Exposure of heart by median sternotomy. (Courtesy of Dr. Claude S. Beck.)

mond. Surgeons of today use by preference a transfixion suture in the apex. The first suture introduced into the wound should be left long so that when traction is put upon it a continuous suture may satisfactorily be placed (Rehn). To put a finger into the wound of the heart is dangerous practice (E. C. Cutler). Avoid inclusion of a coronary vessel in the suture. Fine